WLAN 802.11a/b/g/n/ac X-Series Measurement Application N9077A & W9077A

Technical Overview

- 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 one-button, standard-based measurements with pass/fail tests
- Hardkey/softkey manual user interface and SCPI remote user interface
- Built-in, context-sensitive help
- Move application between X-Series signal analyzers with transportable licensing

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WLAN 802.11a/b/g/n/ac Measurement Application

The WLAN measurement application transforms the X-Series signal analyzers into IEEE 802.11 standard-based WLAN transmitter testers by adding fast, one-button RF conformance measurements that will help you design, evaluate, and manufacture your WLAN transmitter. The software's capabilities are further enhanced because it is 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. A list sequence capability speeds testing by eliminating measurement switching and reconfiguration for disparate bursts.

The Agilent X-Series is an evolutionary approach to signal analysis that spans instrumentation, measurements, and software. The X-Series analyzers, with upgradeable CPU, memory, disk drives, and I/O ports, enable you to keep your test assets current and extend instrument longevity. Proven algorithms, 100% code-compatibility, and a common UI across the X-Series 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. In addition to fixed, perpetual licenses for our X-Series measurement applications, we also offer transportable licenses which can increase the value of your investment by allowing to you transport the application to multiple X-Series analyzers. The WLAN measurement application is just one in a common library of more than 25 measurement applications.

Choosing Between X-Series Applications and 89600 VSA Software

X-Series measurement applications provide embedded format-specific, one-button measurements for X-Series analyzers. With fast measurement speed, SCPI programmability, pass/fail testing and simplicity of operation, these applications are ideally suited for design verification and manufacturing.

89600 VSA software is a comprehensive set of tools for demodulation and vector signal analysis. These tools enable you to explore virtually every facet of a signal and optimize your most advanced designs. Use the 89600 VSA software with a variety of Agilent hardware platforms to pinpoint the answers to signal problems in R&D.

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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 X-Series analyzer. Redeem a trial license on-line today:

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Real-time spectrum analysis for WLAN 802.11ac

Adding real-time spectrum analysis to a PXA or MXA signal analyzer addresses the measurement challenges associated with dynamic RF signals such as bursted packet transmissions of WLAN, and to identify interference caused by various signals in the ISM (2.4 or 5 GHz) bands.

- Accurately observe power changes for an 802.11ac signal within a 160-MHz real-time bandwidth
- Capture random interfering signals with durations as short as 3.57 µs in ISM bands for WLAN signals
- Perform fast, wideband measurements without compromising EVM, ACPR and other RF measurements
- Enhance dynamic range with 1-dB variable attenuation (< 3.6 GHz) and fine-adjustable resolution bandwidths

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 N/W9077A-2FP 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-2013 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 N9077A with single-antenna.

Table 2. Typical 1x1 (single-antenna) data rates currently supported by N9077A

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

N9077A can automatically identify the MCS value, depending on the option (–3FP for 11n or –4FP for 11ac) and signal analyzer 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.

RF Transmitter Tests

By using the X-Series signal analyzers 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 N/W9077A and 89600 VSA software

IEEE 802.11a	IEEE 802.11b	IEEE 802.11g	Transmitter test	N/W9077A Option 2FP WLAN 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 an Agilent spectrum or signal analyzer, these measurements are available as part of the spectrum analyzer mode under the power suite measurements.*
2. *For the N/W9077A 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 N/W9077A and 89600 VSA software

IEEE 802.11n	Transmitter test	N/W9077A Option 3FP WLAN 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 N9077A and 89600 VSA software

IEEE 802.11ac (D5.0)	Transmitter test	N9077A Option 4FP WLAN 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]
22.3.18.3	Symbol clock frequency tolerance	Symbol (chip) clock error[1]	Symbol clock error[1]
22.3.18.3.2	Transmit center frequency leakage	IQ origin offset[1]	IQ offset[1]
22.3.18.3.3	Transmit constellation error (EVM rms)	RMS EVM	EVM (rms)
22.3.18.3.4	Modulation accuracy test[2]	Modulation analysis	Modulation analysis

1. *For the N/W9077A 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 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 N/W9077A 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) [1]
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	●	●	●	●

1. 802.11ac is not supported on the CXA.

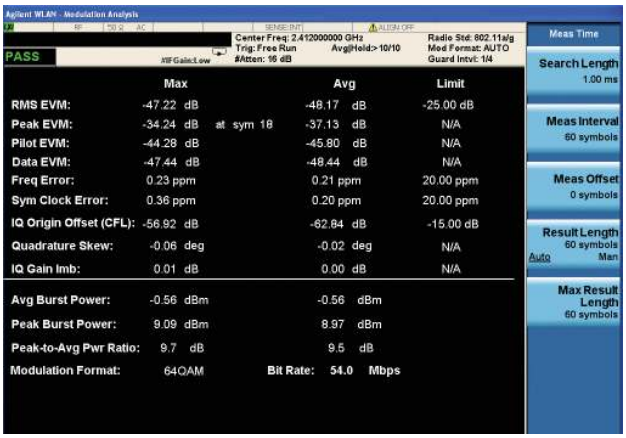


Figure 1. Numerical results summarize modulation accuracy parameters for WLAN signals.

Figure 2. "OFDM EVM" displays four traces with EVM vs. symbol, EVM vs. subcarrier, constellation, and measurement results.

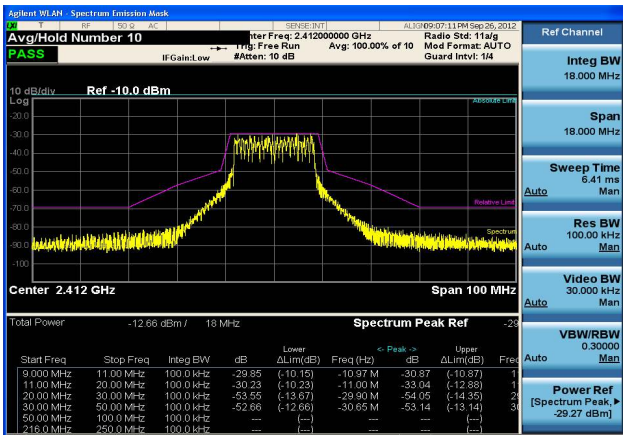


Figure 3. Transmit spectrum mask measurement showing IEEE defined limits.

Figure 4. Spectrum flatness of a 40 MHz IEEE 802.11n signal (Greenfield mode).

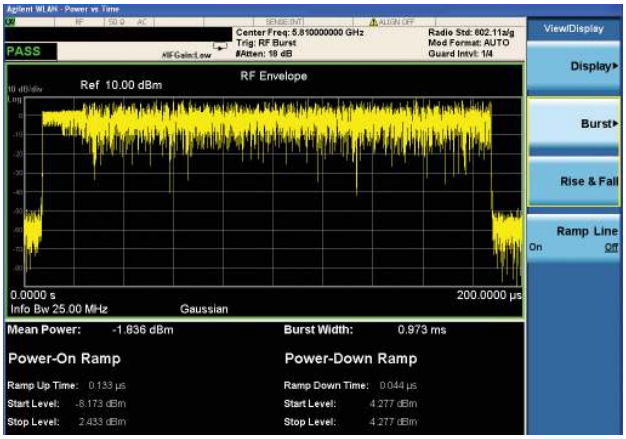


Figure 5. Time-domain view of an 802.11a burst.

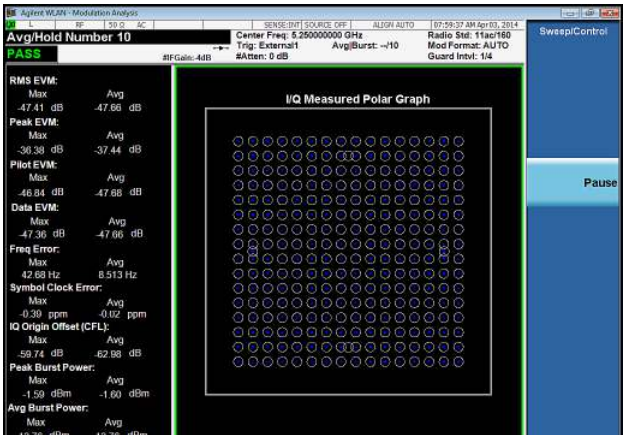


Figure 6. Modulation analysis of a 160 MHz 802.11ac signal with MCS 9 256QAM signal.

WLAN list sequence

Designed for high-volume, high-throughput manufacturing environments, N9077A-5FP WLAN list sequence accelerates the speed of test in design verification and manufacturing for WLAN components and devices compliant with 802.11a/b/g/n and 802.11ac (up to 40 MHz bandwidth). It eliminates measurement switching and reconfiguration for disparate bursts, enabling test engineers to perform large volumes of tests quickly and efficiently, while maintaining the flexibility required to calibrate, exercise, and characterize WLAN products.

Using SCPI commands, WLAN list sequence makes a single acquisition of up to 45 WLAN bursts—each burst can be configured with a different frequency, standard, power range, or trigger type. The measurement results then display the transmitter power, transmitter output spectrum/spectrum emission mask (SEM), and modulation accuracy for each burst.

Summary of features:

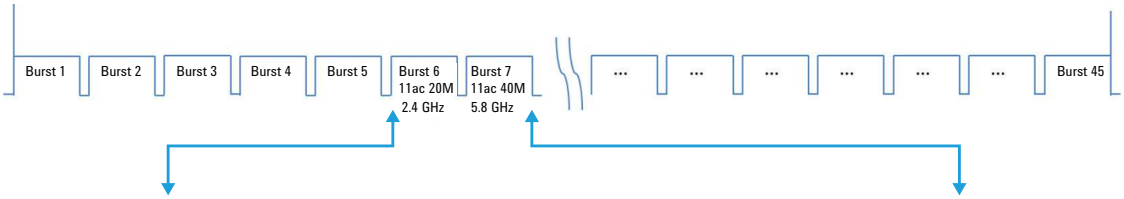
- Reduces overall test time, from initiation to results, of up to 45 WLAN bursts using a single acquisition
- Supports WLAN 802.11a/b/g/n and 802.11ac (up to 40 MHz bandwidth)
- Supports frequency hopping for broadband and multi-frequency points covering WLAN frequency bands of 2.4 GHz and 5 GHz
- Enables remote programming commands for simple automatic test software development
- Provides easy-to-read, pass/fail indicators for all transmitter power and EVM limits

Available measurements:

- Transmit power
- Transmit output spectrum/SEM
- Modulation accuracy (EVM and associated metrics)

WLAN list sequence allows you to customize WLAN burst sequences for verifying your device's transmission characteristics via a simple graphical user interface. Figure 7 shows a typical test case in which the signals under test consist of 45 bursts, each with different 802.11 standard formats and frequencies. For example, Burst 6 is an 802.11ac 20 MHz signal at 2.4 GHz, while Burst 7 is a 40 MHz signal at 5.8 GHz.

After the simple setup of combined parameters with SCPI commands, WLAN list sequence performs measurements on all 45 bursts in seconds and returns the transmitter power, SEM, and EVM results for each burst—the center frequency automatically changes to acquire the upper and lower spectrum for completing the SEM measurement. The measurement results, shown in the result list in Figure 7, can be queried using SCPI commands.



Measurement	Measurement Item	Result	P/F
	IQ Quad Error	-24.48 mdeg	---
	Overall Pass/Fail		P
Burst6 (802.11ac20M; 3.500000000 GHz)	Frequency Error	6.675 Hz	P
	Symbol Clock Error	-34.67 mppm	P
	Chip Clock Error	--- ppm	---
	Center Freq Leakage(IQ Offset)	-44.15 dB	P
	Spectral Flatness		P
	Carrier Suppression	--- dB	---
	RMS EVM	-34.22 dB	P
	Peak EVM	-25.03 dB	---
	802.11b 1000 chips Peak EVM	--- %	---
	IQ Gain Imbalance	-9.539 mdB	---
	IQ Quad Error	-164.1 mdeg	---
	Overall Pass/Fail		P
Burst7 (802.11ac40M; 5.800000000 GHz)	Frequency Error	-32.54 Hz	P
	Symbol Clock Error	-10.35 mppm	P
	Chip Clock Error	--- ppm	---
	Center Freq Leakage(IQ Offset)	-37.24 dB	P
	Spectral Flatness		P
	Carrier Suppression	--- dB	---
	RMS EVM	-35.07 dB	P
	Peak EVM	-25.74 dB	---
	802.11b 1000 chips Peak EVM	--- %	---
	IQ Gain Imbalance	-22.94 mdB	---
	IQ Quad Error	-39.53 mdeg	---
	Overall Pass/Fail		P

Measurement	Measurement Item	Result	P/F
----------TX Power----------			---
Burst1 (802.11ag; 2.412000000 GHz)	Total Power	15.04 dBm	P
	Peak PSD	3.190 dBm/MHz	P
	Overall Pass/Fail		P
Burst2 (802.11bg; 2.612000000 GHz)	Total Power	5.124 dBm	P
	Peak PSD	-3.713 dBm/MHz	P
	Overall Pass/Fail		P
Burst3 (802.11ag; 2.812000000 GHz)	Total Power	-10.14 dBm	P
	Peak PSD	-21.61 dBm/MHz	P
	Overall Pass/Fail		P
Burst4 (802.11n20M; 3.312000000 GHz)	Total Power	-15.90 dBm	P
	Peak PSD	-27.85 dBm/MHz	P
	Overall Pass/Fail		P
Burst5 (802.11n40M;5.160000000 GHz)	Total Power	-24.22 dBm	P
	Peak PSD	-38.98 dBm/MHz	P
	Overall Pass/Fail		P
Burst6 (802.11ac20M; 3.500000000 GHz)	Total Power	-358.7 mdBm	P
	Peak PSD	-12.43 dBm/MHz	P
	Overall Pass/Fail		P
Burst7 (802.11ac40M; 5.800000000 GHz)	Total Power	8.757 dBm	P
	Peak PSD	-5.925 dBm/MHz	P
	Overall Pass/Fail		P

Measurement	Measurement Item	Result	P/F
Burst7 (802.11ac40M; 5.800000000 GHz)	Overall Pass/Fail	Pass	P
	Total Power Ref	8.756 dBm	---
	Spectrum Peak Ref	-13.69 dBm	---
	Peak Freq Ref	5.813 GHz	---
	Lower A Abs Int Pwr	-24.06 dBm	---
	Lower A Rel Int Pwr	-32.82 dB	---
	Lower A Abs Peak Pwr	-37.19 dBm	---
	Lower A Rel Peak Pwr	-23.50 dB	---
	Lower A Peak Freq	-21.00 MHz	---
	Lower A Δ Limit	-3.548 dB	P
	Upper A Abs Int Pwr	-24.21 dBm	---
	Upper A Rel Int Pwr	-32.96 dB	---
	Upper A Abs Peak Pwr	-38.66 dBm	---
	Upper A Rel Peak Pwr	-24.97 dB	---
	Upper A Peak Freq	21.00 MHz	---
	Upper A Δ Limit	-5.013 dB	P
	Lower B Abs Int Pwr	-20.19 dBm	---
	Lower B Rel Int Pwr	-28.94 dB	---
	Lower B Abs Peak Pwr	-41.67 dBm	---
	Lower B Rel Peak Pwr	-27.98 dB	---
	Lower B Peak Freq	-36.25 MHz	---
	Lower B Δ Limit	-1.564 dB	P
	Upper B Abs Int Pwr	-21.26 dBm	---
	Upper B Rel Int Pwr	-30.02 dB	---
	Upper B Abs Peak Pwr	-42.08 dBm	---
	Upper B Rel Peak Pwr	-28.39 dB	---
	Upper B Peak Freq	36.26 MHz	---
	Upper B Δ Limit	-1.965 dB	P
	Lower C Abs Int Pwr	-41.16 dBm	---
	Lower C Rel Int Pwr	-49.92 dB	---
	Lower C Abs Peak Pwr	-51.66 dBm	---

Figure 7. A WLAN list sequence signal with 45 WLAN bursts.

Key Specifications

This section contains specifications for the N/W9077A 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.

Note: 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

For a complete list of specifications refer to the appropriate specifications guide.

PXA: www.agilent.com/find/pxa_specifications

MXA: www.agilent.com/find/mxa_specifications

EXA: www.agilent.com/find/exa_specifications

CXA: www.agilent.com/find/cxa_specifications

Performance specifications

Description	PXA (N9030A)	MXA (N9020A)	EXA (N9010A)	CXA (N9000A)
For N/W9077A-2FP, 3FP and N9077A-4FP				
Supported standards	802.11a, 802.11g ERP-OFDM, 802.11g DSSS-OFDM, 802.11b/g DSSS/CCK/PBCC, 802.11j, 802.11p, 802.11-a turbe mode			
	802.11n (20 MHz[5], 40 MHz[6]) HT Mixed, HT Greenfield, Non-HT, MCS=0-7			
	802.11ac 20[5]/40[6]/80[7]/160[8] MHz, 80+80 MHz[7], MCS=0-9			
Modulation formats	BPSK, QPSK, 16QAM, 64QAM, 256QAM			
Modulation accuracy (nominal)				
Center frequency in 2.4 GHz band[1]				
802.11a/g/j/p (OFDM), 802.11g (DSSS-OFDM), 802.11n (20 MHz); Code rate: 3/4; Equalizer training = channel est. seq. only, Track phase: On; RF input level = –10 dBm, Attenuation = 10 dB				
EVM floor	–53 dB (0.23%)	–52 dB (0.25%)[9]	–49 dB (0.36%)	–44 dB (0.63%)
802.11n (40 MHz); Code rate: 3/4; Equalizer training = channel est. seq. only, Track phase: On; RF input level = –10 dBm, Attenuation = 10 dB				
EVM floor	–50 dB (0.32%)	–50 dB (0.32%)[9]	–46 dB (0.47%)	Not Applicable[3]
Center frequency in 5.0 GHz band[2]				
802.11a/g/j/p (OFDM), 802.11n (20 MHz), 802.11ac (20 MHz); Code rate: 3/4; Equalizer training = channel est. seq. only, Track phase: On; RF input level = –10 dBm, Attenuation = 10 dB				
EVM floor	–50 dB (0.29%)	–49 dB (0.34%)[8]	–47 dB (0.45%)	–40 dB (0.95%)
802.11n (40 MHz), 802.11ac (40 MHz); Code rate: 3/4; Equalizer training = channel est. seq. only, Track phase: On; RF input level = –10 dBm, Attenuation = 10 dB				
EVM floor	–48 dB (0.40%)	–47 dB (0.42%)[8]	–45 dB (0.53%)	Not Applicable[3]
802.11ac (80 MHz); Code rate: 3/4; Equalizer training = channel est. seq. only, Track phase: On; RF input level = –10 dBm, Attenuation = 6 dB				
EVM floor	–47 dB (-0.45%)	–46 dB (0.50%)[9]	Not Applicable[3]	Not Applicable[3]
802.11ac (160 MHz); Code rate: 3/4; Equalizer training = channel est. seq. only, Track phase: On; RF input level = –10 dBm, Attenuation = 8 dB				
EVM floor	–46 dB(0.50%)	–45 dB (0.56%)[9]	Not Applicable[3]	Not Applicable[3]
Accuracy (EVM range: 0 to 8%)	± 0.30%			
Frequency error accuracy	± 10 Hz+tfa[10]			
802.11b/g (DSSS/CCK/PBCC); Reference filter: Gaussian; RF input level = –10 dBm, Attenuation = 10 dB				
Center frequency in 2.4 GHz band[4]				
EVM floor (Equalizer off)	–41 dB (0.80%)	–40 dB (1.00%)	–39 dB (1.03%)	–36 dB (1.49%)
EVM floor (Equalizer on)	–54 dB (0.20%)	–46 dB (0.50%)	–46 dB (0.50%)	–44 dB (0.60%)
Accuracy (EVM range: 0 to 2%)	± 0.90%			
Accuracy (EVM range: 2 to 20%)	± 0.40%			
Frequency error accuracy	± 10 Hz+tfa[10]			

1. *2.4 GHz band for radio standard 802.11a/g (OFDM), 802.11 (DSSS-OFDM), 802.11n (20 MHz or 40 MHz) is applied channel center frequency = 2407 MHz + 5xk MHz (k = 1,...,13)*
2. *5.0 GHz band for radio standard 802.11a/g (OFDM), 802.11g (DSSS-OFDM), 802.11n (20 MHz or 40 MHz), 802.11ac (20 MHz, 40 MHz, 80 MHz, 160 MHz, 80 + 80 MHz) is applied channel center frequency = 5000 MHz + 5xk MHz (k = 0,1,2,...200)*
3. *The CXA with Option B25 can only support the bandwidth of 25 MHz. EXA with Option B40 can only support 40 MHz bandwidth.*
4. *2.4 GHz band for radio standard 802.11b/g (DSS/CCK/PBCC) is applied channel center frequency = 2407 MHz + 5xk MHz (k = 1,...,13)*
5. *Requires N90x0A-B25 25 MHz analysis bandwidth option or higher*
6. *Requires N90x0A-B40 40 MHz analysis bandwidth option or higher*
7. *Requires N90x0A-B85 85 MHz analysis bandwidth option or higher*
8. *Requires N90x0A-B1X 160 MHz analysis bandwidth option*
9. *EVM specification for MXA is for instruments with serial number prefix ≥ MY/SG/US5233 (those instruments ship standard with N9020A-EP2 as the identifier). Refer to the WLAN chapter of the MAX specification guide for specification on the other MXA: www.agilent.com/find/mxa_specifications. For MXA, phase noise optimization is set to fast tuning.*
10. *tfa = transmitter frequency × frequency reference accuracy*

Performance specifications

Description	PXA (N9030A)	MXA (N9020A)	EXA (N9010A)	CXA (N9000A)
Channel power				
Minimum power at RF input		–50 dBm (nominal)		
Center frequency in 2.4 GHz band				
802.11b/g (DSSS/CCK/PBCC); Integration bandwidth = 22 MHz				
Absolute power accuracy	± 0.19 dB (95th percentile)	± 0.23 dB (95th percentile)	± 0.27 dB (95th percentile)	± 0.61 dB (95th percentile)
Measurement floor	–78.3 dBm (typical)	–76.3 dBm (typical)	–72.3 dBm (typical)	–71.3 dBm (typical)
802.11a/g/j/p (OFDM), 802.11g (DSSS-OFDM), 802.11n (20 MHz), 802.11ac (20 MHz); Integration bandwidth = 20 MHz				
Absolute power accuracy	± 0.19 dB (95th percentile)	± 0.23 dB (95th percentile)	± 0.27 dB (95th percentile)	± 0.61 dB (95th percentile)
Measurement floor	–78.7 dBm (typical)	–76.7 dBm (typical)	–72.7 dBm (typical)	–71.7 dBm (typical)
802.11n (40 MHz), Integration bandwidth= 40 MHz				
Absolute power accuracy	± 0.19 dB (95th percentile)	± 0.23 dB (95th percentile)	± 0.27 dB (95th percentile)	± 0.61 dB (95th percentile)
Measurement floor	–75.7 dBm (typical)	–73.7 dBm (typical)	–69.7 dBm (typical)	–68.7 dBm (typical)
Center frequency in 5.0 GHz band				
802.11a/g/j/p (OFDM), 802.11n (20 MHz), 802.11ac (20 MHz); Integration bandwidth= 20 MHz				
Absolute power accuracy	± 0.41 dB (95th percentile)	± 0.50 dB (95th percentile)	± 0.50 dB (95th percentile)	± 1.24 dB (95th percentile)
Measurement floor	–76.7 dBm (typical)	–76.7 dBm (typical)	–72.7 dBm (typical)	–64.7 dBm (typical)
802.11n (40 MHz), 802.11ac (40 MHz); Integration bandwidth = 40 MHz				
Absolute power accuracy	± 0.41 dB (95th percentile)	± 0.50 dB (95th percentile)	± 0.50 dB (95th percentile)	± 1.24 dB (95th percentile)
Measurement floor	–73.7 dBm (typical)	–73.7 dBm (typical)	–69.7 dBm (typical)	–61.7 dBm (typical)
802.11ac (80 MHz); Integration bandwidth = 80 MHz				
Absolute power accuracy	± 0.41 dB (95th percentile)	± 0.50 dB (95th percentile)	± 0.50 dB (95th percentile)	± 1.24 dB (95th percentile)
Measurement floor	–70.7 dBm (typical)	–70.7 dBm (typical)	–66.7 dBm (typical)	–58.7 dBm (typical)
802.11ac (160 MHz); Integration bandwidth = 160 MHz				
Absolute power accuracy	± 0.41 dB (95th percentile)	± 0.50 dB (95th percentile)	± 0.50 dB (95th percentile)	± 1.24 dB (95th percentile)
Measurement floor	–67.7 dBm (typical)	–67.7 dBm (typical)	–63.7 dBm (typical)	–55.7 dBm (typical)
Power versus Time (nominal)				
802.11b/g (DSSS/CCK/PBCC)				
Center frequency in 2.4 GHz band				
Measurement results type		Min, Max, Mean		
Measurement time		Up to 88 ms		
Dynamic range	64.0 dB	62.0 dB	58.0 dB	57.0 dB
Spectrum emission mask				
802.11a/g/j/p (OFDM), 802.11g (DSSS-OFDM), 802.11n (20 MHz); Integration bandwidth = 18 MHz, RBW = 100.0 kHz, 11.0 MHz offset				
Center frequency in 2.4 GHz band				
Dynamic range, relative	87.3 dB (typical)	84.3 dB (typical)	79.9 dB (typical)	79.8 dB (typical)
Sensitivity, absolute	–101.5 dBm (typical)	–99.5 dBm (typical)	–95.5 dBm (typical)	–94.5 dBm (typical)
Accuracy, relative	± 0.05 dB	± 0.12 dB	± 0.12 dB	± 0.12 dB
Accuracy, absolute	± 0.20 dB (95th percentile)	± 0.27 dB (95th percentile)	± 0.31 dB (95th percentile)	± 0.64 dB (95th percentile)
802.11a/g (OFDM), 802.11n (20 MHz), 802.11ac (20 MHz); Integration bandwidth = 18 MHz, RBW = 100.0 kHz, 11.0 MHz offset				
Center frequency in 5.0 GHz band				
Dynamic range, relative	85.3 dB (typical)	84.3 dB (typical)	79.9 dB (typical)	73.2 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–99.5 dBm (typical)	–95.5 dBm (typical)	–87.5 dBm (typical)
Accuracy, relative	±0.05 dB	±0.12 dB	±0.12 dB	±0.11 dB
Accuracy, absolute	±0.41 dB (95th percentile)	±0.54 dB (95th percentile)	±0.54 dB (95th percentile)	±1.28 dB (95th percentile)
802.11n (40 MHz), 802.11ac (40 MHz) @ 5 GHz only; Integration bandwidth = 38 MHz, RBW = 100.0 kHz, 21.0 MHz offset				
Center frequency in 2.4 GHz band				
Dynamic range, relative	87.3 dB (typical)	84.5 dB (typical)	80.2 dB (typical)	80.0 dB (typical)
Sensitivity, absolute	–101.5 dBm (typical)	–99.5 dBm (typical)	–95.5 dBm (typical)	–94.5 dBm (typical)
Accuracy, relative	± 0.05 dB	± 0.12 dB	± 0.12 dB	± 0.12 dB
Accuracy, absolute	± 0.20 dB (95th percentile)	± 0.27 dB (95th percentile)	± 0.31 dB (95th percentile)	± 0.64 dB (95th percentile)
Center frequency in 5.0 GHz band				
Dynamic range, relative	85.4 dB (typical)	84.5 dB (typical)	80.2 dB (typical)	73.3. dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–99.5 dBm (typical)	–95.5 dBm (typical)	–87.5 dBm (typical)
Accuracy, relative	± 0.05 dB	± 0.12 dB	± 0.12 dB	± 0.11 dB
Accuracy, absolute	± 0.41 dB (95th percentile)	± 0.54 dB (95th percentile)	± 0.54 dB (95th percentile)	± 1.28 dB (95th percentile)

Performance specifications

Description	PXA (N9030A)	MXA (N9020A)	EXA (N9010A)	CXA (N9000A)
802.11b/g (DSSS/CCK/PBCC); Integration bandwidth = 22 MHz, RBW = 100.0 kHz, 11.0 MHz offset				
Center frequency in 2.4 GHz band				
Dynamic range, relative	87.3 dB (typical)	84.3 dB (typical)	80.0 dB (typical)	79.9 dB (typical)
Sensitivity, absolute	–101.5 dBm (typical)	–99.5 dBm (typical)	–95.5 dBm (typical)	–94.5 dBm (typical)
Accuracy, relative	± 0.05 dB	± 0.12 dB	± 0.12 dB	± 0.12 dB
Accuracy, absolute	± 0.20 dB (95th percentile)	± 0.27 dB (95th percentile)	± 0.31 dB (95th percentile)	± 0.64 dB (95th percentile)
802.11ac (80 MHz); Integration bandwidth = 78 MHz, RBW = 100.0 kHz, 41.0 MHz offset				
Center frequency in 5.0 GHz band				
Dynamic range, relative	85.4 dB (typical)	84.6 dB (typical)	80.4 dB (typical)	73.4 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–99.5 dBm (typical)	–95.5 dBm (typical)	–87.5 dBm (typical)
Accuracy, relative	± 0.05 dB	± 0.12 dB	± 0.12 dB	± 0.11 dB
Accuracy, absolute	± 0.41 dB (95th percentile)	± 0.54 dB (95th percentile)	± 0.54 dB (95th percentile)	± 1.28 dB (95th percentile)
802.11ac (160 MHz); Integration bandwidth = 158 MHz, RBW = 100.0 kHz, 81.0 MHz offset				
Center frequency in 5.0 GHz band				
Dynamic range, relative	85.4 dB (typical)	84.7 dB (typical)	80.4 dB (typical)	73.4 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–99.5 dBm (typical)	–95.5 dBm (typical)	–87.5 dBm (typical)
Accuracy, relative	± 0.05 dB	± 0.12 dB	± 0.12 dB	± 0.11 dB
Accuracy, absolute	± 0.41 dB (95th percentile)	± 0.54 dB (95th percentile)	± 0.54 dB (95th percentile)	± 1.28 dB (95th percentile)

WLAN list sequence specifications - N9077A-5FP

Description	MXA (N9020A)	EXA (N9010A)
Transmit power (nominal)		
Min power at RF input	–35 dBm	
802.11a/g/j/p (OFDM), 802.11g DSSS-OFDM, 802.11n (20 MHz) or 802.11ac (20 MHz), Integration bandwidth = 20 MHz		
Center frequency in 2.4 GHz band		
Absolute power accuracy	± 0.40 dB	± 0.46 dB
Measurement floor	–76.7 dBm (typical)	–72.7 dBm (typical)
Center frequency in 5.0 GHz band		
Absolute power accuracy	± 0.74 dB	± 0.93 dB
Measurement floor	–76.7 dBm (typical)	–72.7 dBm (typical)
802.11n (40 MHz) or 802.11ac (40 MHz); Integration bandwidth = 40 MHz		
Center frequency in 2.4 GHz band		
Absolute power accuracy	± 0.40 dB	± 0.46 dB
Measurement floor	–73.7 dBm (typical)	–69.7 dBm (typical)
Center frequency in 5.0 GHz band		
Absolute power accuracy	± 0.74 dB	± 0.93 dB
Measurement floor	–73.7 dBm (typical)	–69.7 dBm (typical)
802.11b/g (DSSS/CCK/PBCC); Integration bandwidth = 22 MHz		
Center frequency in 2.4 GHz band		
Absolute power accuracy	± 0.40 dB	± 0.46 dB
Measurement floor	–76.3 dBm (typical)	–72.3 dBm (typical)
Modulation accuracy (nominal)[1]		
Transmit output spectrum		
802.11a/g/j/p (OFDM), 802.11g (DSSS-OFDM), 802.11n (20 MHz); Integration bandwidth = 18 MHz, RBW = 100.0 kHz, 11.0 MHz offset		
Center frequency in 2.4 GHz band		
Dynamic range, relative	84.3 dB (typical)	79.9 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–95.5 dBm (typical)
Accuracy, relative	± 0.21 dB	± 0.20 dB
Accuracy, absolute	± 0.41 dB (nominal)	± 0.46 dB (nominal)
802.11a/g (OFDM), 802.11n (20 MHz), 802.11ac (20 MHz); Integration bandwidth = 18 MHz, RBW = 100.0 kHz, 11.0 MHz offset		
Center frequency in 5.0 GHz band		
Dynamic range, relative	84.3 dB (typical)	79.9 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–95.5 dBm (typical)
Accuracy, relative	± 0.46 dB	± 0.52 dB
Accuracy, absolute	± 0.74 dB (nominal)	± 0.94 dB (nominal)
802.11n (40 MHz), 802.11ac (40 MHz); Integration bandwidth = 38 MHz, RBW = 100.0 kHz, 21.0 MHz offset		
Center frequency in 2.4 GHz band		
Dynamic range, relative	84.5 dB (typical)	80.2 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–95.5 dBm (typical)
Accuracy, relative	± 0.23 dB	± 0.22 dB
Accuracy, absolute	± 0.41 dB (nominal)	± 0.46 dB (nominal)
Center frequency in 5.0 GHz band		
Dynamic range, relative	84.5 dB (typical)	80.2 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–95.5 dBm (typical)
Accuracy, relative	± 0.55 dB	± 0.63 dB
Accuracy, absolute	± 0.74dB (nominal)	± 0.94 dB (nominal)
802.11b/g (DSSS/CCK/PBCC); Integration bandwidth = 22 MHz, RBW = 100.0 kHz, 11.0 MHz offset		
Center frequency in 2.4 GHz band		
Dynamic range, relative	84.3 dB (typical)	80.0 dB (typical)
Sensitivity, absolute	–99.5 dBm (typical)	–95.5 dBm (typical)
Accuracy, relative	± 0.21 dB	± 0.20 dB
Accuracy, absolute	± 0.41 dB (nominal)	± 0.46 dB (nominal)

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N/W9077A WLAN 802.11a/b/g/n/ac X-Series measurement application

Description	Model-Option		Additional information
	PXA, MXA, EXA	**CXA**	
IEEE 802.11a/b/g WLAN	N9077A-2FP	W9077A-2FP	
Add 802.11n	N9077A-3FP	W9077A-3FP	Requires 2FP
Add 802.11ac	N9077A-4FP		Requires 2FP and 3FP
Wireless list sequence	N9077A-5FP		Only available for MXA or EXA with Option B40 or higher bandwidth option

Hardware configuration

N9030A PXA signal analyzer

Description	Model-Option	Additional information
3.6, 8.4, 13.6, 26.5, 42.98, 44, 50 GHz frequency range	N9030A-503, -508, -513, -526, -543, -544, or -550	One required
Analysis bandwidth to 25, 40, 85 or 160 MHz	N9030A-B25, -B40, -B85 or -B1X	One required, based on bandwidth of WLAN signal under test
Precision frequency reference	N9030A-EA3	Recommended
Preamplifier, 3.6, 8.4, 13.6, 42.98, 44, 50 GHz	N9030A-P03, -P07, -P13, -P26, -P43, -P44, or -P50	One recommended
Microwave preselector bypass option	N9030A-MPB	Required for measurements > 3.6 GHz
Real-time spectrum analyzer capability, 85 or 160 MHz bandwidth analysis	N9030A-RT1 or RT2	One required for real-time analysis

N9020A MXA signal analyzer

Description	Model-Option	Additional information
3.6, 8.4, 13.6, 26.5 GHz frequency range	N9020A-503, -508, -513, or -526	One required
Analysis bandwidth to 25, 40, 85, 125, or 160 MHz	N9020A-B25, -B40, -B85, -B1A, B1X	One required, based on bandwidth of WLAN signal under test
Electronic attenuator, 3.6 GHz	N9020A-EA3	Recommended
Preamplifier, 3.6, 8.4, 13.6, or 26.5 GHz	N9020A-P03, -P07, -P13, -P26	One recommended
Microwave preselector bypass option	N9020A-MPB	Required for measurements > 3.6 GHz
Real-time spectrum analyzer capability, 85 or 160 MHz bandwidth analysis	N9020A-RT1 or RT2	One required for real-time analysis

N9010A EXA signal analyzer

Description	Model-Option	Additional information
3.6, 7.0, 13.6, 26.5, 32, or 44 GHz frequency range	N9010A-503, -507, -513, -526, -532, or -544	One required
Analysis bandwidth to 25 or 40 MHz	N9010A-B25 or B40	One required, based on bandwidth of WLAN signal under test
Preamplifier, 3.6, 7.0, 13.6, 26.5 GHz	N9010A-P03, -P07, -P13, -P26	One recommended
Microwave preselector bypass option	N9010A-MPB	Required for measurements > 3.6 GHz
Electronic attenuator, 3.6 GHz	N9010A-EA3	Recommended

N9000A CXA signal analyzer

Description	Model-Option	Additional information
3.0, 7.5, 13.6, or 26.5 GHz frequency range	N9000A-503, -507, -513, or -526	One required
Analysis bandwidth to 25 MHz	N9000A-B25[1]	Required
Preamplifier, 3.0, 7.5, 13.6, or 26.5 GHz	N9000A-P03, -P07, -P13, or -P26	One recommended

1. The maximum analysis bandwidth for CXA is 25 MHz, which allows the CXA to support 802.11a/b/g and 802.11n 20 MHz measurements.

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

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

Web

Product page:
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