Solutions for

Testing Very High Throughput 802.11ac Signals

Achieve Quick and Accurate Generation and Analysis of Wider Bandwidth 802.11ac Signals

Application Note

Overview

Since the introduction of the first 802.11 Wireless Local Area Network (WLAN) standard, new usage models requiring ever higher data throughputs have emerged, in turn necessitating new 802.11 variants. The 802.11n standard, for example, came about as a way to support things like data sharing amongst connected devices in the home or small office and wireless printing.

Today, the increasing popularity of bandwidth-intensive activities such as in-room gaming, high definition video streaming and content download to mobile devices, is creating demand for even better performance with greater speed. The IEEE 802.11ac WLAN standard is specifically designed to meet these needs.

As an extension of 802.11n, the Very High Throughput (VHT) 802.11ac standard specifies a minimum 500 Mbit/s single link and 1 Gbit/s overall throughput, running in the 5 GHz band. In contrast to the 20 MHz channel bandwidth of earlier standard variants, 802.11ac mandates an 80 MHz bandwidth, with optional wider bandwidths of 160 and 80+80 MHz.

While the first implementations of 802.11ac will likely have a maximum of 80 MHz bandwidth, and no more than the maximum 4x4 MIMO specified in 802.11n, follow-on implementations are expected to utilize the wider bandwidth options and up to 8 MIMO streams.

Problem

The high volumes of WLAN devices call for strict attention to manufacturing costs and the use of innovative design techniques to maximize repeatability and minimize cost-of-test. This leads to the need for exhaustive 802.11ac transmitter and receiver testing during the design and pre-production stages of development. In addition to these tests, 802.11ac designs will need to pass conformance tests and additional functional tests to verify performance and prove interoperability. Some of the new features in the 802.11ac standard result in significant new challenges in design and test; namely, the generation and analysis of the wider bandwidth signals required for 802.11ac's 80- and 160 MHz options (Table 1).

Consider the generation of 80 MHz signals, for example. Many of today's RF generators simply do not have a high enough modulation sampling rate to support the typical minimum 2x oversampling ratio that is needed for accurate signal generation. Without this capability, images can occur in the signal due to aliasing.

Signal analysis of either the generated 80- or 160 MHz signals can be just as problematic, requiring a higher demodulation bandwidth than has been required to test any other common wireless communications product.

TABLE 1. Key specifications of the IEEE VHT 802.11ac standard.

Feature	Mandatory	Optional
Channel bandwidth	20 MHz, 40 MHz, 80 MHz	160 MHz, 80+80 MHz
FFT size	64, 128, 256	512
Data subcarriers/pilots	52/4, 108/6, 234/8	468/16
Modulation types	BPSK, QPSK, 16QAM, 64QAM	256QAM
MCS supported	0 to 7	8 and 9
Spatial streams and MIMO	1	2 to 8 Tx beamforming, STBC, BPSK, QPSK, 16QAM, 64QAM Multi-user MIMO (MU-MIMO)
Operating mode/PPDU format	Very high throughput/VHT	

Solution

Efficiently testing VHT 802.11ac components, transmitters and receivers requires appropriate generation and analysis of 802.11ac's 80, 80+80 and 160 MHz signals. Realizing this goal demands that engineers use wider bandwidth instrumentation. The instrumentation must offer the level of performance necessary to ensure accurate measurements. Moreover, it must be specifically designed to handle the 802.11ac standard's complexity and able to quickly adapt to its changing requirements. That means use of flexible signal generation and analysis software that can be used with different hardware, such as arbitrary waveform generators (AWGs), RF signal generators, general-purpose signal analyzers, and oscilloscopes to quickly generate signals and then find and isolate any potential problems. Using such software allows engineers to create the wider bandwidth 802.11ac signals that can then be used to test and troubleshoot 802.11ac components, transmitters and receivers.

Prime examples of wider bandwidth solutions featuring this mix of capabilities are Agilent Technologies' SystemVue Electronic System Level (ESL) design software, N7617B Signal Studio for WLAN software, N5182B MXG X-Series vector signal generator, AWGs, 89600 VSA software, the N9030A PXA X-Series signal analyzer, and the Infiniium 90000 X-Series oscilloscope. Signal Studio is used to create 802.11ac waveforms which are downloaded to the MXG to generate RF signals with up to 160 MHz bandwidth. SystemVue is used to create 802.11ac waveforms which are downloaded to the AWG and used to modulate an RF signal generator, while the 89600 VSA, PXA signal analyzer and 90000 X-Series oscilloscope are used for signal analysis. Working together, these products provide a comprehensive design and test capability that is critical to the successful implementation of mass-market VHT WLAN products.

Enabling VHT 802.11ac Signal Generation

802.11ac waveforms can be created using the SystemVue W1917 WLAN Baseband Verification Library, which provides a working baseband reference design for both 802.11ac transmit and receive signal processing paths. An open EDA implementation allows more intimate access and control of the inside of the block diagram for baseband developers. It also allows the creation of either ideal or precisely-impaired signals of all bandwidths and modulation types.

Once the waveforms are created, SystemVue downloads the 802.11ac test vectors to a wideband AWG like Agilent's 81180A or M8190A to generate 160 MHz signals. The AWG creates analog I/Q signals that are applied to the external I/Q inputs in a vector signal generator (e.g., Agilent's N5182A MXG) for upconversion to RF frequencies. SystemVue also supports both a 160 MHz signal and a split 80+80 MHz mode to create the two 80 MHz segments in separate signal generators and then combine the RF signals.

802.11ac signals can also be created using the Signal Studio for WLAN software and MXG signal generator. Up to 4 MXGs can be used to provide MIMO test signals with 160 MHz bandwidth. Signal Studio also supports 80+80 MHz mode using two signal generators and combining of the RF signals.

Fast and Accurate Signal Analysis

Performing signal analysis on VHT 802.11ac signals requires the use of the 89600 VSA software with Option BHJ for 802.11ac modulation analysis. The software provides superior general-purpose and standards-based signal evaluation, and troubleshooting tools that engineers can use to dig into signals and gather the data they need to successfully troubleshoot physical layer signal problems. Its high-resolution spectrum analysis enables a fast basic check of a downlink signal's structure. Moreover, it supports up to four channels of MIMO and is compatible with over 30 Agilent signal analyzers, scopes and logic analyzers.

For signal analysis, the 89600 VSA software is used in combination with either the PXA signal analyzer or 90000 X-Series oscilloscope. The PXA supports up to 160 MHz demodulation bandwidth (Option B1X), and provides frequency coverage up to 50 GHz and up to 75 dB spurious-free dynamic range at the 160 MHz analysis bandwidth (Figure 1). Its key specifications include: –129 dBc/Hz phase noise (room temperature) at 10 kHz offset (1 GHz), ±0.19 dB absolute amplitude accuracy and sensitivity of –172 dBm displayed average noise level (DANL) at 2 GHz. The PXA's advanced performance provides valuable insight that helps speed the design, verification and troubleshooting of both current and future 802.11ac devices.

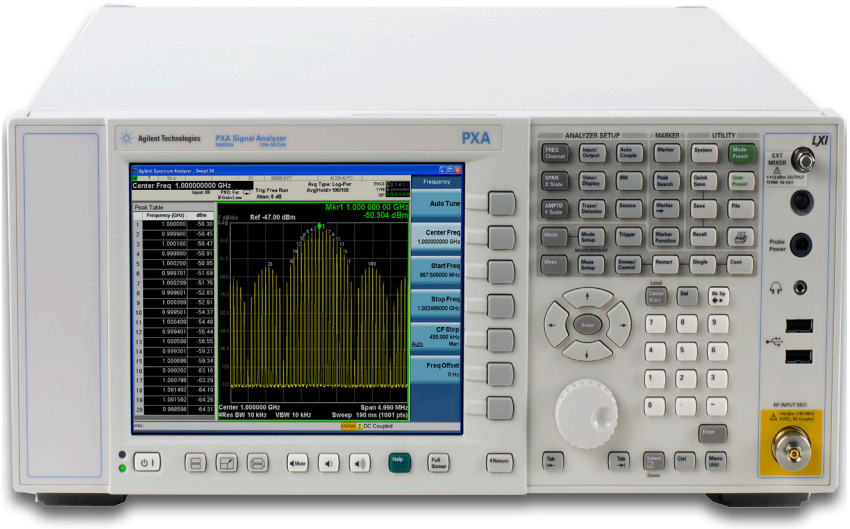

FIGURE 1. As the highest-performance X-Series analyzer, the PXA delivers exceptional performance that reduces measurement uncertainty and reveals new levels of signal detail.

When combined with the 89600 VSA software's 802.11ac modulation analysis, the PXA enables high-performance, comprehensive 802.11ac analysis. Essentially, waveforms generated by SystemVue are captured using the PXA signal analyzer. The 89600 VSA software, running on the PXA, then provides detailed analysis of 802.11ac signals. Together the instruments allow engineers to perform a range of standard-based parametric measurements such as error-vector-magnitude (EVM), ACPR and in-band or out-of-band spectrum emission mask. A highly flexible graphical user interface allows them to measure and analyze downlink signals from a number of different perspectives in the time, frequency and modulation domains.

The 90000 X-Series oscilloscope supports bandwidths beyond 1 GHz and provides time-coherent multi-channel inputs to measure RF modulated carriers, as well as deeper memory to analyze multiple frames of data for demodulation with the 89600 VSA software. Such capabilities make it well suited to perform two- and four-channel 802.11ac MIMO measurements. Its low noise (~2 mV at 50 mV/div, 32 GHz) and low jitter performance (~150 femtoseconds) ensure exceptional measurement accuracy and yield a low residual (baseline) EVM performance, which is necessary for making four-channel MIMO measurements (Figure 2). The multi-channel, phase-coherent capability of the 90000 X-Series oscilloscope enables MIMO signal analysis, as well as the ability to measure performance at various stages along a transmitter chain.

For MIMO verification, the 89600 VSA software, along with Agilent's 90000 X-Series oscilloscope is used. When used together with the oscilloscope, the instruments enable the characterization of complex, time-coherent MIMO signals with detailed and simultaneous spectrum, modulation and time waveform analysis. This provides engineers with deeper analysis insight and more accurate signal information that can be used to quickly diagnose and isolate hardware performance issues.

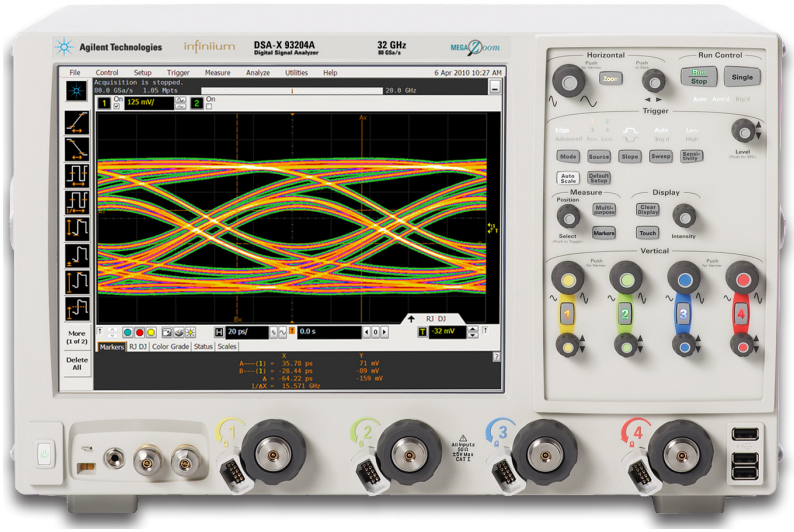

FIGURE 2. Using the 90000 X-Series oscilloscope and VSA software, it is a straightforward process to perform four-channel MIMO measurements. Four MIMO test signals are simply captured into four individual channels on the oscilloscope and then demodulated by the 89600 VSA software.

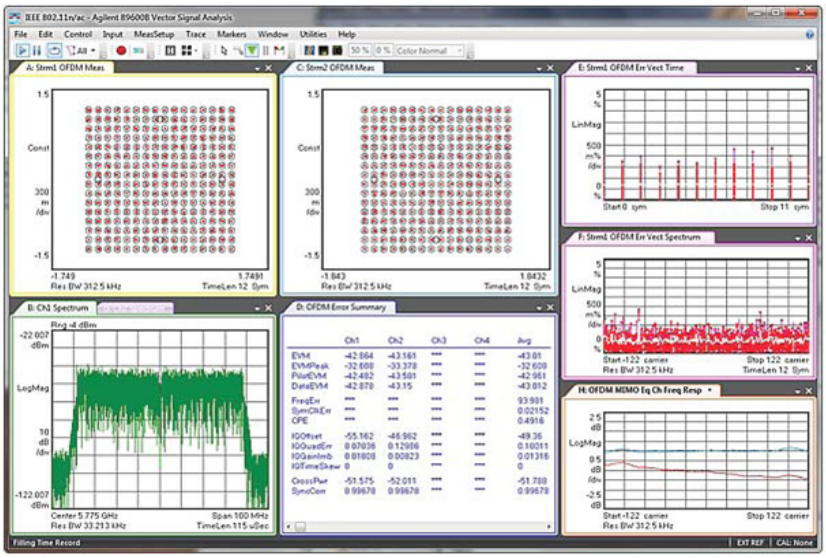

FIGURE 3. This two-channel 802.11ac measurement was made using the 89600 VSA software and a 90000 X-Series oscilloscope. The MIMO signals were created with Agilent's Signal Studio software, although SystemVue could also be used, and generated from two Agilent MXG signal generators. The displays show the constellation for both streams, as well as the EVM and IQ errors (lower middle window) and frequency response (lower right window) for both channels.

For MIMO transmitter test, the 89600 VSA is used with a 90000 X-Series oscilloscope to provide analysis of up to 4 channels, including EVM and IQ measurements for all channels, as well as cross-channel metrics such as the frequency response of each channel and the channel matrix. An example two-channel MIMO measurement is shown in Figure 3.

Summary of Results

The continuing need for more speed and bandwidth of WLAN connections, and the increasing complexity of the standards to support it, bring major challenges for the test and measurement community. A comprehensive design and test capability is critical to the successful implementation of mass-market VHT WLAN products, as is the ability to accurately and efficiently generate and analyze the VHT 802.11ac 80 and 160 MHz signals for testing components, transmitters and receivers. As wider bandwidth instrumentation equipped with 802.11ac-specific capabilities, Agilent's SystemVue software, N7617B Signal Studio WLAN software, 89600 VSA software, N5182B MXG signal generator, PXA signal analyzer, and 90000 X-Series oscilloscope are well suited to meet this challenge head on. Working together, they provide a flexible waveform and signal generation capability to help system engineers tackle next-generation WLAN testing challenges.

The Power of X

The Agilent PXA signal analyzer and Infiniium 90000 X-Series high-performance oscilloscopes are key products in Agilent's comprehensive Power of X suite of test products. These products grant engineers the power to gain greater design insight, speed manufacturing processes, solve tough measurement problems, and get to market ahead of the competition.

Offering the best combination of speed and scalability, and created and supported by renowned worldwide measurement experts, Agilent's X products are helping engineers bring innovative, higher-performing products to emerging markets around the globe.

To learn more about Agilent's suite of X products please visit: www.agilent.com/find/powerofx.

Related Applications

While this note specifically covers IEEE 802.11ac, the same products can be configured for use in many digital communications applications. Options targeted at legacy Wireless LAN, all standard 2G, 3G and 4G cellular standards, as well as general-purpose vector signal generation and analysis are available. For more information on your specific application, search www.agilent.com.

- All of 2G, 3G and 4G cellular communication
- LTE FDD and TDD
- WiMAX™ (Fixed and Mobile)
- WLAN (802.11a/b/g/n) and 802.11ac
- Custom OFDM

Related Agilent Products

The design and measurement tools highlighted in this note are best suited to the wide channel bandwidths of IEEE 802.11ac. Agilent supplies a full range of AWGs, logic analyzers, oscilloscopes, vector RF signal generators, and signal analyzers that can be used either as stand-alone products or in conjunction with SystemVue design libraries, Signal Studio waveform generation software and vector signal analysis software to provide insight into your digital communication components, assemblies and products throughout their design, manufacturing and service life.

- X-Series Oscilloscopes
- Dual Channel PXI Vector Signal Analyzer
- Wideband MIMO PXI Vector Signal Analyzer
- PXA Signal Analyzer
- EXG and MXG X-series Vector Signal Generators
- PXB Baseband Generator and Channel Emulator
- SystemVue System Design Software
- Signal Studio Waveform Generation Software

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