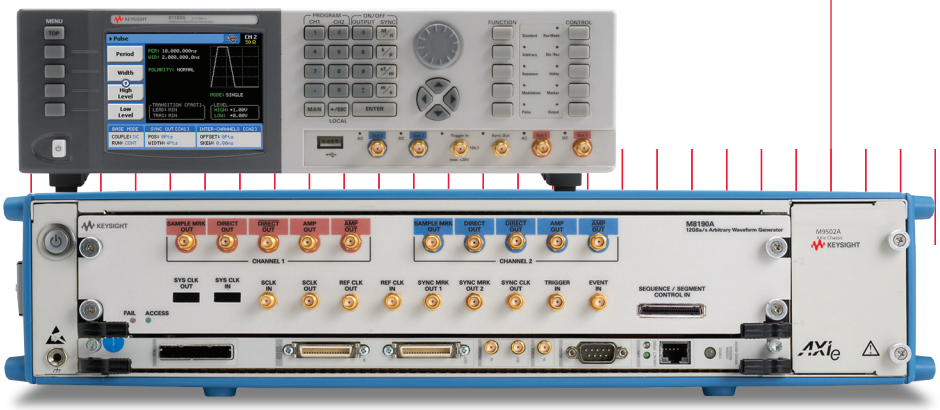
Keysight Technologies, Inc.

Creating a Complete and Flexible Solution for WiGig Testing

Wideband modulation in 60 GHz communication

Application Note



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81180A and M8190A Wideband Arbitrary Waveform Generator

KEYSIGHT TECHNOLOGIES

A combination of instrumentation and software enables receiver and transmitter testing.

Overview

Wireless Gigabit (WiGig) is an up-and-coming technology expected to enable wireless connectivity of up to 7 Gb/s in data, display and audio applications. The organization sponsoring this technology is the Wireless Gigabit Alliance. Its board of directors comprises AMD, Atheros, Broadcom, Cisco, Dell, Intel, Marvell, MediaTek, Microsoft, NEC, Nokia, NVIDIA, Panasonic, Samsung, Toshiba, and Wilocity. Keysight Technologies, Inc. serves as a contributing member of the alliance.

The industry standard relevant to WiGig is IEEE 802.11ad. Draft 1.0 of the specification was published in January 2011. Per the draft standard, signals will occupy the unlicensed 60-GHz frequency band and all 802.11 ad-compliant devices will provide backward compatibility with the 802.11 standard. As a result, tri-band devices will operate at 2.4, 5.0 and 60 GHz.

Many companies have launched product development projects based on this standard and developers now face challenges in both system-level design and verification testing. This application note outlines the problems associated with designing and verifying WiGig devices and presents a viable test configuration for conducting thorough WiGig device test.

Problem

When developing new WiGig products, testing must address the transmitter and receiver portions of each device. In a tri-band device, signals have three key attributes: they operate at 2.4 GHz, 5.0 GHz and 60 GHz; are modulated with various modulation schemes; and have bandwidths in either the under-20 MHz range (802.11a/g/n and 802.11b/g) or up to 2.0 GHz (802.11ad). At various points within the radio block diagram, the signals may be baseband, intermediate frequency (IF) or radio frequency (RF).

As a general problem statement, the IEEE 802.11ad draft standard includes specific measurements with expected values for transmitters and receivers. Examples include receiver minimum sensitivity and transmit error vector magnitude (EVM) as shown in Figure 1.

In addition to testing to the draft specification, design teams may want to verify the overall performance of a new WiGig device. They will want to look at important measurements such as match, gain or loss through frequency converters, and nonlinear tests such as a 1dB gain compression measurement (P1dB) under various operating conditions.

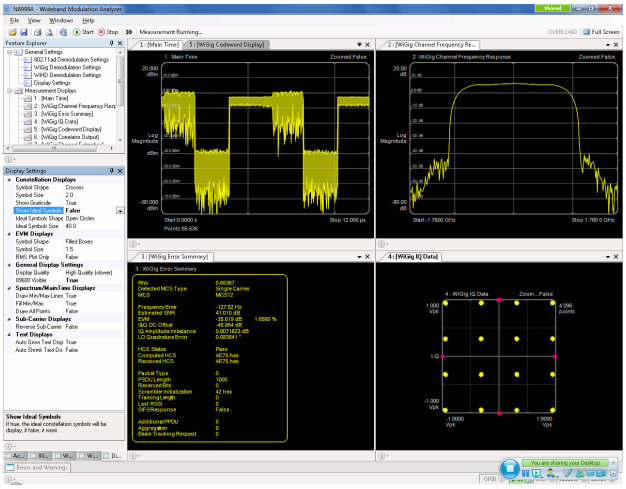

Figure 1. WiGig I/Q signal without pre-distortion generated by M8190A.

Solution

Thorough testing of WiGig transmitters and receivers at baseband, IF and RF requires three essential elements: arbitrary waveform creation, frequency conversion and signal, modulation and spectrum analysis. Keysight Technologies has developed a flexible and configurable test setup that covers all of these requirements (Figure 2).

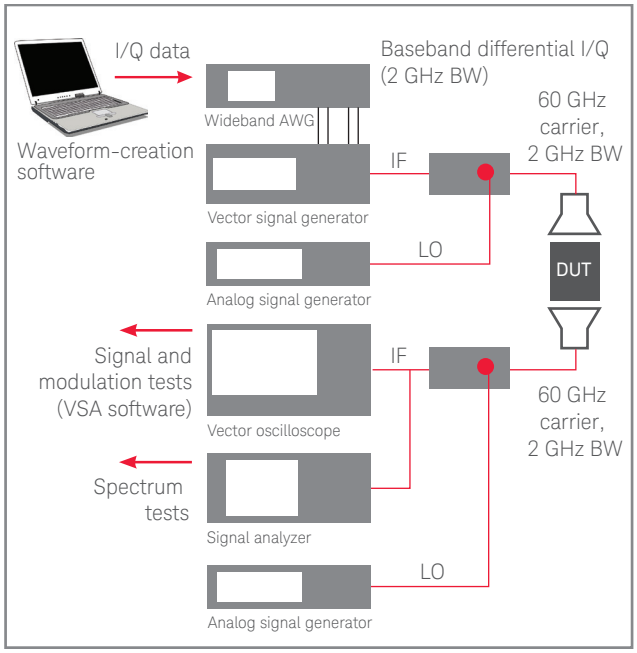

Figure 2. Thorough testing of WiGig transmitters and receivers requires a mix of capabilities: waveform creation, signal generation, frequency conversion, signal analysis, modulation analysis, and spectrum analysis.

Signal simulation: Baseband elements on the transmitter side

Starting at the top of Figure 2, waveform creation at baseband frequencies is accomplished with specialized software and an arbitrary waveform generator (AWG). Keysight offers the 81180A 4.2 GSa/s or the M8190A 12 GSa/s AWG to create highly accurate simulations of standard-compliant simulations of standard compliant signals that can be applied to transmitters and receivers.

Key features of the 81180A include: 12-bit resolution, up to 64 MSa memory, advanced sequencing capabilities, and differential I/Q output. The 81180A is available with one or two output channels. Two units can be linked together to provide four synchronized outputs. Each output channel has up to 1-GHz modulation bandwidth, up to 2-GHz I/Q modulation bandwidth and up to 1.5-GHz carrier frequency. The 2 GHz modulation bandwidth of the 81180A is a perfect fit to the modulation input of the Performance Signal Generator E8267D.

The M8190A ensures even higher accuracy and repeatability with 14-bit resolution up to 8 GSa/s sampling rate and up to 80dBc SFDR. The 14 bit vertical resolution allows generating a high dynamic range. The instrument allows switching between 14 bit resolution up to 8 GSa/s and 12 bit resolution up to 12 GSa/s. The M8190A is a modular instrument packaged in the AXIe form factor, whereby the 81180A is a box form factor.

Characterization of device performance versus the standard also requires generation of impaired or corrected signals that mimic real-world issues such as fading, distortion, I/Q skew, and carrier-to-noise problems. One way to accomplish this is with waveform-creation software that can download waveforms into AWG memory such as Keysight's SystemVue and Wideband Waveform Creator software, or MATLAB from The MathWorks.

Signal simulation: IF and RF elements on the transmitter side

Moving down Figure 2, note that IF-band frequency conversion is accomplished with an upconverter. This configuration uses the Keysight E8267D PSG vector signal generator with optional wideband external I/Q inputs (Option 016). As shown, the AWG is used to directly drive the signal generator's internal I/Q modulator. The 81180A or the M8190A provides I/Q modulation bandwidth of up to 2 GHz.

A custom-designed upconverter provides frequency conversion to the RF range. An instrument such as the Keysight N5183A MXG microwave analog signal generator provides a stable LO signal for the upconverter.

Signal analysis: IF and RF elements on the receiver side

In the lower half of Figure 2, the custom-designed downconverter provides frequency translation to the IF band. In this configuration, a Keysight Infiniium 90000 X-Series high-performance oscilloscope with up to 32-GHz analog bandwidth and a Keysight X-Series signal analyzer with frequency coverage up to 26.5 GHz provide signal, modulation and spectrum analysis capabilities.

This configuration also includes the Keysight 89600B vector signal analysis (VSA) software, which runs on either a PC or inside PC-based Keysight instruments like the 90000 X-Series scopes and PXA signal analyzers. The VSA software supports a wealth of signal formats, provides advanced demodulation capabilities and performs measurements of EVM and other important signal characteristics.

MATLAB is another important part of the receiver-side solution. Here, it provides a powerful environment for measurement automation and data analysis. For example, it can be used to create and apply custom measurements, filters, processing, and equalization—capabilities that are especially useful when standards are not finalized. MATLAB can also be used to create 2D and 3D data plots derived from measured data.

For additional RF characterization from 10 MHz to 67 GHz, the Keysight N5247A PNA-X microwave network analyzer provides single-connection measurements of active devices such as amplifiers, mixers and frequency converters. To simplify the test configuration, built-in elements include a second signal source, a combiner and internal signal-routing switches. Through the use of advanced calibration techniques, the PNA-X provides highly accurate measurements in any environment. Example measurements include S-parameters, gain compression, two-tone measurements, and noise-figure measurements on converters and two-port devices.

Summary

The configuration presented here provides a complete solution for testing and analysis of WiGig transmitters and receivers during their development. This combination of flexible software elements and high-performance instrumentation is scalable and reconfigurable to address other technologies, as well as future projects. For more information about possible WiGig/802.11ad solutions—and to configure a system that meets your needs—please contact your Keysight representative.

Related information

- Data sheet: *81180A 4.2 GSa/s Arbitrary Waveform Generator*, publication 5990-5697EN
- Data sheet: *M8190A 12 GSa/s Arbitrary Waveform Generator*, publication 5990-7515EN
- Data sheet: *E8267D PSG Vector Signal Generator*, publication 5989-0697EN
- Data sheet: *N5183A MXG Microwave Analog Signal Generator*, publication 5989-7572EN
- Data sheet: *Infiniium 90000 X-Series High-performance Oscilloscopes*, publication 5989-7819EN
- Brochure: *PXA Signal Analyzer*, publication 5990-3951EN
- Brochure: *MXA Signal Analyzer*, publication 5989-5047EN
- Product brochure: *89600B VSA Software*, publication 5990-6553EN
- MATLAB information: Please visit **www.mathworks.com/products/matlab**
- Product brochure: *PNA-X-Series Microwave Network Analyzers*, publication 5990-4592EN

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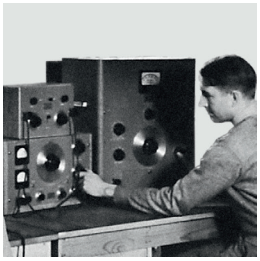

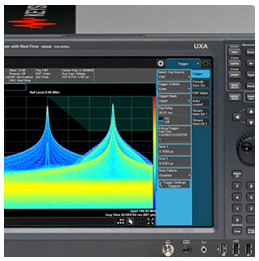

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