Testing Transmitters and Receivers with Pulsed Ultra-Wideband Signals

Simplified testing of high-precision radar systems

Application Note

Overview

Ultra-wideband (UWB) technologies were originally designed for short-range connectivity at high data rates in applications such as gaming and video streaming. Today, UWB is being used in a growing range of applications such as high-precision anti-collision systems, mine detectors and asset trackers. Depending on the needs of the application, the UWB signal may be modulated with pulse or orthogonal frequency division multiplexing (OFDM) techniques.

This application brief focuses on a solution for testing of transmitters and receivers that use pulsed UWB signals. There are three major sections: the problem, the solution, and the results and benefits. The problem section covers the general and specific measurement challenges. The solution shown here is based on an actual test system designed to test transmitters and receivers in a pulsed UWB radar system. The results from this system provide significant benefits from technical and operational perspectives.

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81180A and M8190A Wideband Arbitrary Waveform Generator

Agilent Technologies

Problem

Key characteristics of UWB signals include a broad and flat power spectrum with a high peak power level, but only over a short range, and a carrier frequency of up to 11 GHz. Pulsed UWB signals require narrow pulses with bandwidth greater than 500 MHz or fractional bandwidth greater than or equal to 0.2, where fractional bandwidth is the ratio of bandwidth to center frequency. The signals are susceptible to multipath interference, and can be affected by existing wireless services. UWB transmitters have the potential to interfere with GPS, TV and radio signals.

These characteristics create challenges in testing when generating signals for receiver testing and when analyzing signals produced by the transmitter. Thorough receiver testing demands a variety of pulse shapes, bandwidths and modulations. Realistic simulation of various signal scenarios requires the generation of complex sequences of pulses. All these signals and sequences must be generated with sufficiently wide bandwidths over the required range of carrier frequencies, and with precise control over the output power.

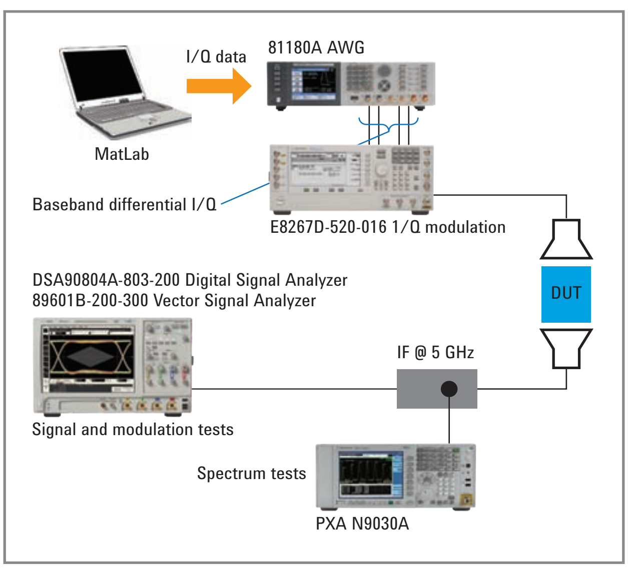

Figure 1. This system provides the signal generation and signal analysis capabilities needed for testing of receivers and transmitters that use pulse UWB signals.

When characterizing a transmitter, the key need is signal analysis with sufficient instantaneous bandwidth to measure the occupied bandwidth of a pulsed UWB signal. There is also a need to measure out-of-band characteristics (e.g., spurious emissions) and perform regulatory mask testing. Finally, error vector magnitude (EVM) is a common figure of merit for signal quality and this requires standards-based demodulation and analysis.

Solution

Agilent's application engineering organization helped the customer create a system capable of testing the transmitter and receiver portions of pulsed UWB devices. The system can generate appropriate test signals that are sent to the receiver side of the device under test (DUT) and can also measure and analyze signals produced by transmitter section.

A diagram of the system is shown in Figure 1. The upper section of the diagram contains the three elements used for signal generation: MATLAB software, an Agilent 81180A arbitrary waveform generator (AWG) and an Agilent E8267D PSG vector signal generator. The PSG/81180A combination produces 5 GHz signals modulated with I and Q information.

The lower section provides signal analysis with an Agilent N9030A PXA signal analyzer, an Agilent Infiniium 90000A DSA Series high-performance oscilloscope and the Agilent 89600B vector signal analysis (VSA) software, which runs inside the scope. This portion of the system provides two levels of analysis bandwidth: up to 140 MHz with the PXA and from 140 MHz to 13 GHz with the 90000A. The upper end can be extended to 32 GHz with an Agilent Infiniium 90000 X-Series high-performance oscilloscope.

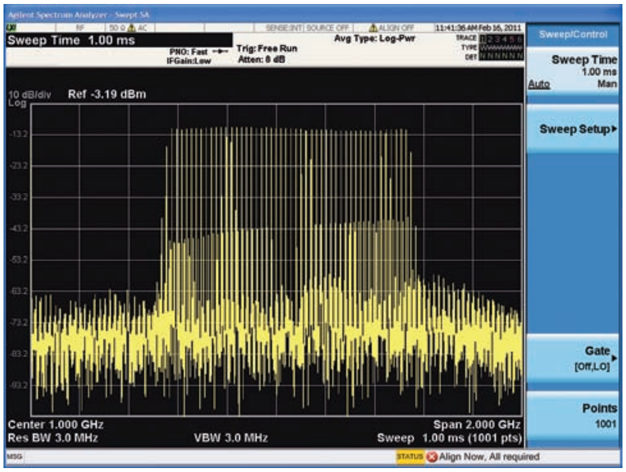

Figure 2. Working in combination, the 81180A AWG and E8267D PSG can generate pulsed UWB signals with the characteristic broad, flat power spectrum.

Signal generation for receiver testing

MATLAB is used to create a sequence of Gaussian monopulses, each having a 500 MHz bandwidth. These signals are downloaded into the memory of the 81180A AWG (Figure 2).

The 81180A is a 12-bit, 4.2 GSa/s AWG capable of producing pulses with 1 GHz bandwidth. It includes up to 64 MSa of memory that can be used very efficiently with advanced sequencing capabilities: 16,000 unique sequences, 1 million loops and a 1 K scenario table.

The 81180A can be configured with one or two channels, and two units can be synchronized to provide four channels. In this case, a two-channel 81180A is used to produce complex I/Q pairs that drive the external I and Q inputs of the PSG vector signal generator. The 81180A provides differential outputs that are well matched to the PSG inputs.

The PSG has an output range of up to 44 GHz, and this is extendable to 500 GHz with millimeter wave modules. In case even wider bandwidth or more memory is needed, the M8190A 12 GSa/s AWG offers 5 GHz analog bandwidth per channel. The 2 Gsample memory per channel allows even longer playtime. Modulation capabilities include AM, FM, ΦM and pulse as well as ASK, FSK, MSK, PSK, QAM and custom I/Q. The PSG includes an internal baseband generator with 80 MHz RF bandwidth, an AWG, and real-time I/Q capabilities. As used here, the PSG is configured with options 520 and 016, which provide 20 GHz frequency range and wideband, differential external I/Q inputs, respectively.

Signal analysis for transmitter testing

As noted above, this section of the system provides two levels of analysis bandwidth: up to 140 MHz and from 140 MHz to 13 GHz. The PXA signal analyzer provides analysis bandwidth up to 140 MHz while the Infiniium scope—configured as a dynamic signal analyzer—provides analysis bandwidth from 140 MHz to 13 GHz.

For the lower range, the PXA signal analyzer provides frequency coverage up to 50 GHz and provides a choice of analysis bandwidths: 10 MHz standard and 25, 40 or 140 MHz optional. The analyzer can be configured with more than 25 measurement applications that cover cellular communications, wireless connectivity, digital video and general purpose.

In the upper range, the Infiniium 90000A DSA Series high performance oscilloscope provides 8 GHz bandwidth, 40 GSa/s on four analog channels, and up to 1 Gpts per channel (50 Mpts/ch standard). More than 30 software applications are available, covering compliance, debugging and analysis of SATA 6G, HDMI, Ethernet, DDR and more. This system uses a DSA90804A configured with options 200, 200 MB of memory, and 803, 4 GB of additional PC memory.

The Agilent 89600B VSA software provides highresolution FFT-based spectrum measurements, timedomain tools and bit-level modulation analysis (Figure 3). It also supports more than 70 standards and modulation types. The software can run inside Agilent Infiniium scopes and Agilent X-Series signal analyzers such as the PXA. In this system, the 89600B software runs inside the 90000A scope, supporting modulation testing and analysis with up to 13 GHz analysis bandwidth. In this system the VSA software includes options 200, basic vector signal analysis, and 300, hardware connectivity. As a general recommendation, a signal analyzer such as the PXA is useful even if the required analysis exceeds 140 MHz. In such cases the signal analyzer can be used to measure and analyze the transmitter's out-of-band characteristics.

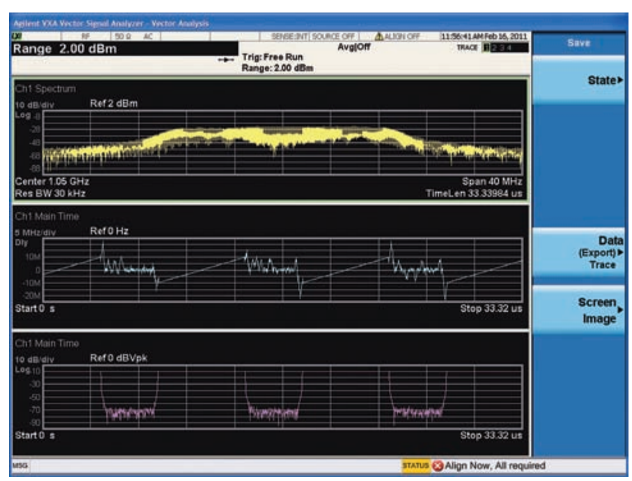

Figure 3. The 89600B VSA software enables analysis of pulsed UWB signals in the time, frequency and modulation domains.

Results and benefits

This array of commercial, off-the-shelf (COTS) equipment and software enables fine tuning of device designs and verification of device performance—in-channel and out-of-channel—with a wide range of pulse profiles. In receiver testing, one of the key benefits is the ability to reuse any simulation signals created in MATLAB in the actual testing process by downloading them to the 81180A AWG. The system also provides tremendous flexibility in the fine tuning of individual pulse shapes.

On the transmitter side, the 90000A scope provides built-in capabilities that simplify characterization of pulse-timing profiles. Either the scope or the signal analyzer can be used to verify spectrum occupancy and regulatory limits. Finally, the 89600B VSA software can be used to demodulate and analyze the modulation carried on the pulsed UWB signals.

Conclusion

The configuration presented here provides a complete solution for the testing and analysis of transmitters and receivers used in pulsed UWB radar systems. 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 solutions for other systems that use UWB and pulsed UWB signals—and to configure a system that meets your needs please contact your Agilent representative.

Related information

- Data sheet: Agilent 81180A 4.2 GSa/s Arbitrary Waveform Generator, publication 5990-5697EN
- Data sheet: Agilent M8190A 12 GSa/s Arbitrary Waveform Generator, publication 5990-7516EN
- Data sheet: Agilent E8267D PSG vector signal generator, publication 5989-0697EN
- Brochure: Agilent N9030A PXA signal analyzer, publication 5990-3951EN
- Data sheet: Agilent Infiniium 90000 X-Series high-performance oscilloscopes, publication 5989-7819EN
- Product brochure: Agilent 89600B VSA software, publication 5990-6553EN
- MATLAB information: Please visit www.mathworks.com/products/matlab and www.agilent.com/find/matlab

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