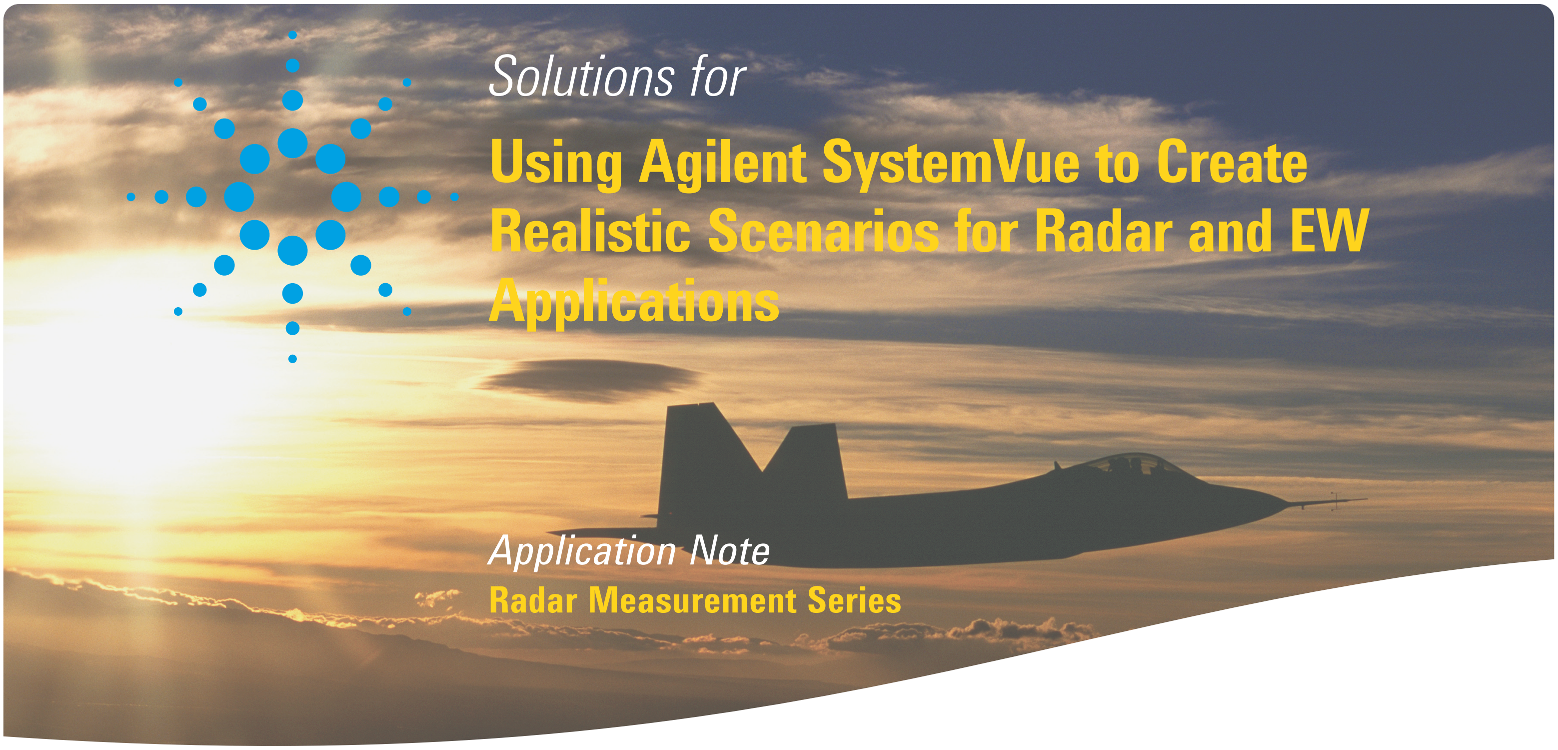
Solutions for

Using Agilent SystemVue to Create Realistic Scenarios for Radar and EW Applications



Application Note

Radar Measurement Series

Overview

When deployed, radar and electronic warfare (EW) systems face an unpredictable environment filled with known and unknown signals that may include target returns, clutter, jamming, interference, and electromagnetic noise. During design and development, it has typically been difficult and costly to simulate realistic scenarios that thoroughly exercise system performance before deployment.

Today, a combination of commercial, off-the-shelf software and instrumentation from Agilent is making it easier to create realistic signal scenarios such as multi-target returns in a complex electromagnetic environment. The software is Agilent SystemVue and its Radar Model Library (W1905). The key instruments are arbitrary waveform generators (AWGs) and vector signal generators.

Here's how it works, complex baseband signals or sequences are created in SystemVue and downloaded into the memory of Agilent AWGs such as the MXG, PSG and ESG, which can produce modulated carrier signals at up to 6 GHz with modulation bandwidth of up to 100 MHz. SystemVue can also download signals to wideband AWGs such as the Agilent M8190A, 81180A, M8241A and M9330A. The wideband AWG drives the wideband I/Q inputs of a vector signal generator such as the Agilent E8267D PSG to produce wideband or ultra-wideband (UWB) scenarios. The result is a modulated carrier signal at up to 44 GHz with up to 6 GHz of modulation bandwidth.

This combination of hardware and software provides a platform that can be used for both component testing and scenario simulation for system test. The addition of a signal analyzer or wideband oscilloscope running the Agilent 89600 vector signal analysis (VSA) software provides measurement and analysis capabilities that are useful in the development of transmitters, receivers, amplifiers, and other subsystems.

Problem

The latest generations of radar and EW systems operate in a variety of frequency bands and use wideband or UWB signals that carry highly complex modulation schemes. These systems also use advanced digital signal processing (DSP) techniques to mask or disguise their operation and thereby avoid jamming.

Within the operating environment, the range of complexities may include multiple targets, ground clutter, sea clutter, jamming, interference, wireless communication signals, and other forms of electromagnetic noise. When attempting to accurately simulate this complex environment, an additional challenge is the need for multidimensional signal processing capable of handling beamforming, space-time adaptive processing and more. Depending on the type of radar or EW system, the test platform must be capable of producing a variety of signals: pulse Doppler, wideband, UWB, and beyond.

There are also organizational hurdles. For example, the development of such complex systems typically requires the involvement of multiple people working in teams that may be physically or geographically separated. System integration can be especially difficult without a consistent, shared set of tools for simulation and testing.

Solutions and Results

Leveraging SystemVue, the Radar Model Library and a variety of Agilent instruments, Agilent's application engineering organization has developed two solutions: a radar target generator and a test platform for radar and EW testing. This combination of software and hardware capabilities makes it possible to create dynamic and realistic scenarios for both component testing and scenario simulation for system test.

Using SystemVue

The SystemVue environment can be used for modeling, simulation, verification, and testing during the design and implementation of radar and EW systems. The software also has the flexibility to incorporate models created using other tools such as C++, MATLAB and HDL.

Specific to radar development, SystemVue provides four key capabilities: the generation of custom waveforms; support for advanced measurements; control of hardware and software instruments; and emulation of "golden" transmitters, detectors or receivers.

For either a radar target generator or a system-test platform, the desired radar system is constructed within SystemVue. To simulate multiple types of systems, the software enables you to specify individual components within the block diagram:

- Signal sources: LFM, NLFM, Barker/Frank coded, UWB, frequency modulation continuous wave (FMCW), pulse
- Transmitter and receiver modules: DAC, ADC, digital upconverter (DUC), digital downconverter (DDC), direct digital synthesis (DDS), low-noise amplifier (LNA), digital elements
- Antennas: models, arrays, propagation
- RF/IF modules: transmitters, receivers, filters, power amps, oscillators, frequency synthesizers
- Radar environment: target, radar cross section (RCS), clutter (1-D and 2-D), jammers, interference, sea clutter
- Signal processing techniques: digital pulse compression, MTI, MTD, CFAR, digital beamforming, STAP, Kalman filtering, SAR
- Measurements: waveform, spectrum, sensitivity, selectivity, dynamic range, detection rate, false alarm rate, range equation

Focusing on the radar environment, the target modeling parameters include RCS, Doppler effects, delay and attenuation. The RCS models can include fluctuating types, include five types of swirling (0, I, II, III and IV).

SystemVue also includes built-in links to enable the downloading of simulated waveforms to Agilent AWGs, which can play back the simulated waveforms for the testing of transmitters and receivers.

Radar target generator and results

The major attributes of a radar target generator include RF details such as carrier frequency and modulation bandwidth as well as scenario parameters: number of target returns, duration of target returns, range, speed, azimuth, RCS, types of clutter, jamming, interference, and more. Within SystemVue these are entered as details in the system model described in the preceding section.

The solution developed by Agilent application engineers is shown in Figure 1. Starting on the left side, the first three elements are used to generate the signals necessary for transmitter and receiver testing. The signal analyzer is used to verify the test signals.

Figure 1. Figure 1. System configuration for radar target generator

The starting point is the simulation design within SystemVue, as shown in Figure 2. At the upper left the transmitter waveform generator ("Tx Waveforms") produces a baseband waveform, which is then modulated. Next, three target signals are created, combined with each other, combined with clutter signals, and output to the antenna model. The resulting signal can be analyzed within SystemVue and, when the scenario is finalized, downloaded to an AWG.

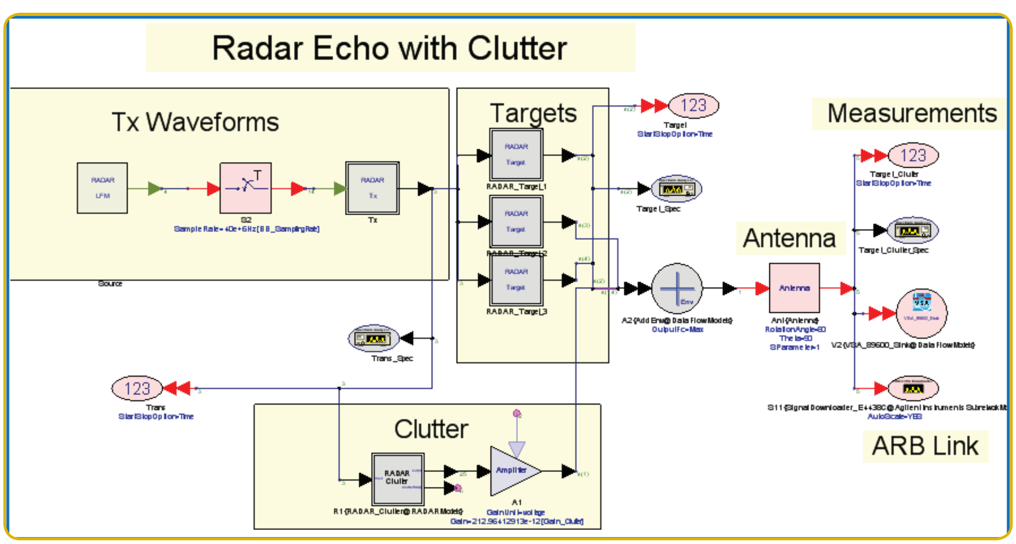


Figure 2. Example screen from SystemVue showing design of radar target generator

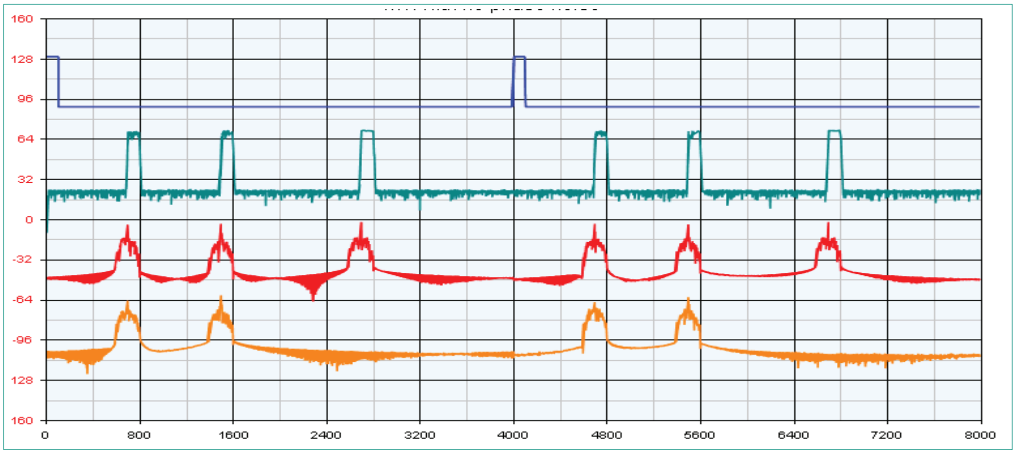


Figure 3. Simulation results for transmission signal (blue), three received target returns (green), received returns with clutter (red), and the return signal after MTI processing (orange)

Figure 3 shows the results from a three-target simulation with individual range values of 500 m, 1,500 m and 2,500 m and velocity values of 100 m/s, 200 m/s and 0 m/s. As shown, moving target indication (MTI) processing removed the stationary (0 m/s) target from the orange trace.

Figure 4 shows the simulation signal created in SystemVue and subsequently downloaded to an Agilent E4438C ESG vector signal generator with AWG capability. The four traces provide different views of the RF test signal, which is emulating radar returns from three targets.

Figure 4. Generated radar test signals: received spectrum (yellow); and radar target returns with clutter, displayed as amplitude (green), real part (blue) and imaginary part (red)

UWB radar test platform and results

The major elements of the UWB system are shown in Figure 5. This forms a component test system in which different UWB signals are generated in SystemVue, downloaded to a wideband AWG, upconverted by the vector signal generator, and applied to the hardware component as a stimulus. The real-time oscilloscope provides waveform analysis on its own and supports signal analysis with the 89600B VSA software running on the PC.

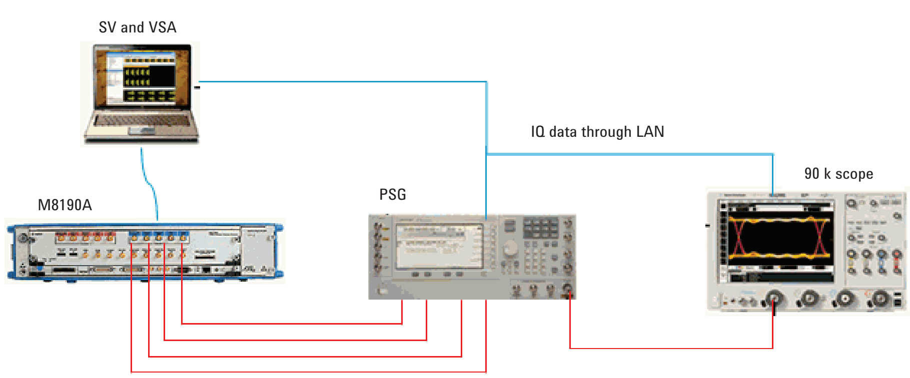


Figure 5. System configuration for UWB radar test platform

This system was used to create the LFM UWB radar signal shown in Figure 6. The signal was created in SystemVue and downloaded to an Agilent M8190A AWG, which drove the I/Q modulation inputs of the vector signal generator. The resulting signal has a 1 GHz bandwidth and 1 μs pulse repetition interval (PRI).

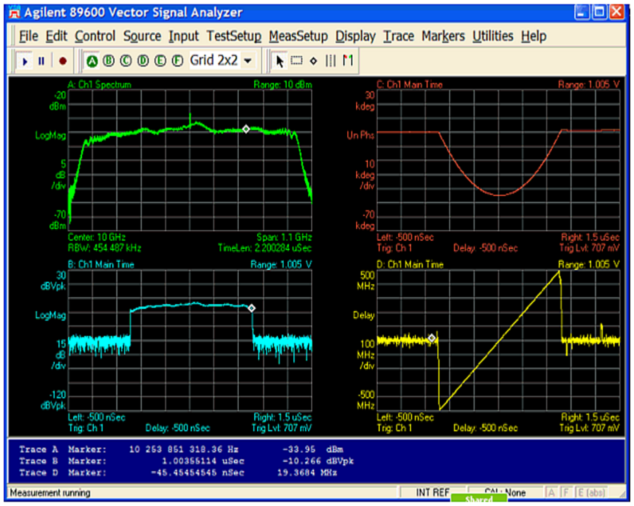


Figure 6. Spectrum, time waveform, phase and group delay measurements of an LFM UWB radar signal

The same configuration can be used to create pulsed UWB transmission signals, as shown in Figure 7. The example signal has a 250 MHz bandwidth and 1 μs PRI, as measured with an Agilent M9392A PXI VSA.

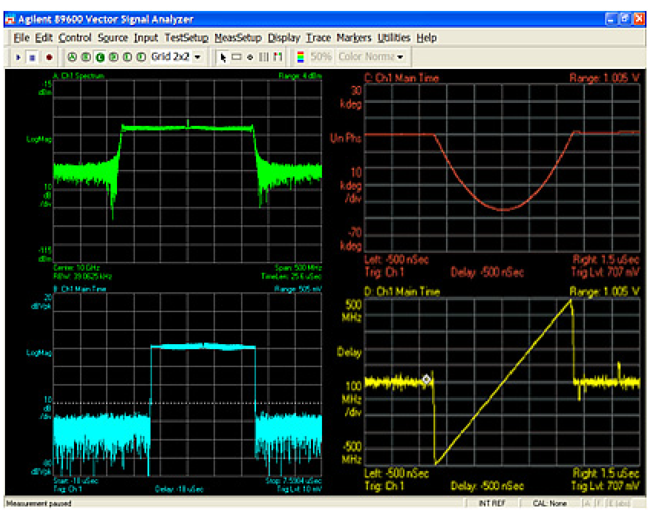


Figure 7. Spectrum, time waveform, phase and group delay measurements of a pulsed UWB radar signal

Conclusion

In the real-world, a radar system will face a complex signal environment: multiple targets, ground clutter, sea clutter, jamming, interference, wireless communication signals, and other forms of electromagnetic noise. As shown here, the combination of SystemVue and its Radar Model Library provides a powerful simulation core for the creation of complex and realistic radar scenarios with up to three target returns. A system that includes SystemVue and an Agilent AWG is a versatile solution for the testing of radar transmitters, receivers, subsystems, and components. This approach can be used to address a wide range of present and future radar systems: pulse Doppler, digital array, wideband, UWB, FMCW, SAR, and others.

Related Information

- Brochure: Agilent SystemVue ESL design software, publication number 5990-4731EN
- Brochure: Agilent SystemVue W1905 Radar Model Library, publication 5990-6347EN
- Data sheet: Agilent M8190A 12 GSa/s arbitrary waveform generator, publication 5990-7516EN
- Data sheet: Agilent 81180A 4.2 GSa/s arbitrary waveform generator, publication 5990-5697EN
- Data sheet: Agilent E8267D PSG vector signal generator, publication 5989-0697EN
- Brochure: Agilent 89600B vector signal analysis software, publication number 5990-6553EN
- MATLAB information: Please visit www.mathworks.com products/matlab and www.agilent.com/find/matlab

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