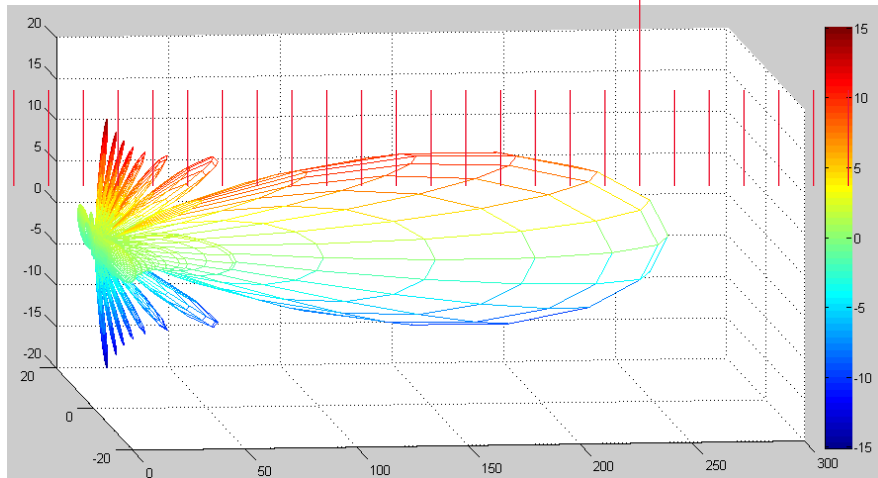


Keysight Technologies

Solutions for Using a Model-Based Platform to Quickly and Effectively Test Radar and Electronic Warfare Systems

Application Brief



Modern Radar and electronic warfare (EW) systems operate in a variety of frequency bands with multi-emitter wideband signals and complex modulation schemes. They also use advanced Digital Signal Processing (DSP) techniques to attack or avoid being attacked by enemy's EW systems. Because EW specifications are always adjusted based on the environment, today's designers require a solution for designing, verifying and testing their EW systems in an effective way.

Problem

EW systems operate in complex environments with multi-emitter input signals from radar, military and commercial communication systems, as well as different interferences, noise and clutter. EW receivers must monitor the multi-emitter signals over a wide frequency range. When clutter or interference is significant, received signals become even more complex. This complexity poses a number of challenges when designing and testing Radar and EW systems, especially when coupled with new signal generation and processing requirements, and the need to analyze different test cases.

Other challenging tasks that engineers may encounter when developing Radar and EW systems include: reducing the time and cost to develop new systems, reducing the expense of testing and validation, and getting all legacy Intellectual Property (IP) point tools to work together with RF. Validating the performance of complex Radar and EW systems earlier/continuously, instead of waiting until final integration and test, can also be difficult. Addressing these challenges is critical ensuring the success of any Radar or EW system.

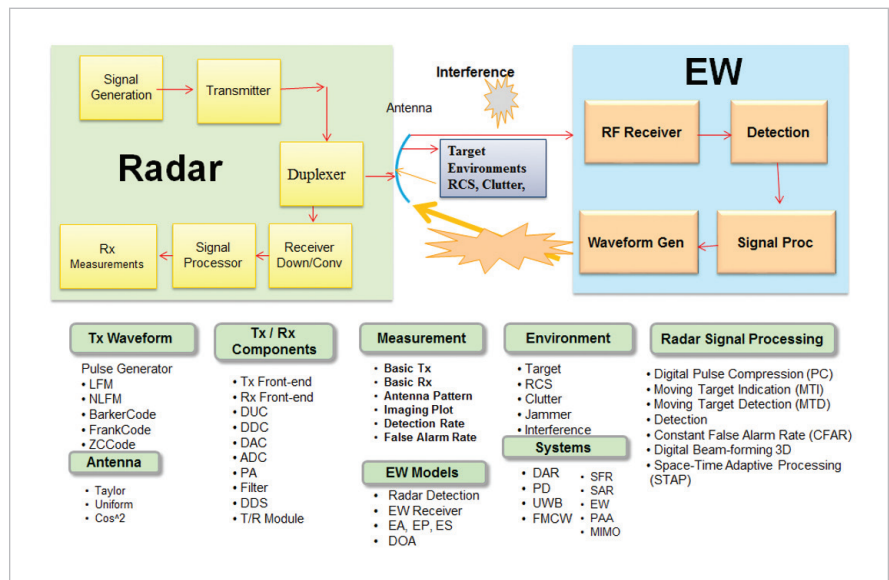
Solution

Dealing with these challenges at all stages of development requires a flexible wideband, model-based platform for designing, verifying and testing Radar and EW systems. The platform must be able to effectively model and simulate Radar and EW components and systems, and generate highly realistic scenarios for verification of transmitter and receiver performance. It must also be flexible enough to support interaction with a range of measurement instruments for hardware test and verification.

One such platform that meets this criteria is Keysight Technologies' Radar and EW simulation and test platform (Figure 1). At the core of the platform is the SystemVue Electronic System Level (ESL) design software, which enables modeling and simulation of Radar and EW systems throughout the development process using pre-created templates. Multi-emitter signals can be created using SystemVue's Signal Composer. To simplify these tasks, SystemVue features a Radar and EW library. Each functional block within a given Radar and EW system is supported by a model set within the library. For example, the Signal Generation block is supported by the Transmit (Tx) Waveform model set, which in turn supports LFM-, NLFM-, Baker-, and Frank-coded formats. When constructing a custom system, engineers simply pick one of these coding formats.

Existing DSP and algorithm models can also be imported to the library for use with library models. Custom models based on MathLang, C++, MATLAB, and HDL code, as well as subnet structures, can be created using SystemVue's easy-to-use User Interface (UI). Once created the custom models become SystemVue library models. This model flexibility enables components created by different people to be integrated together and tested at the system level for the purposes of performance evaluation and continuous validation throughout the development process.

Figure 1. Keysight's Radar and EW simulation platform models and simulates Radar and EW systems at all stages of development.



The Radar and EW simulation platform can also be used as a test platform (Figure 2). In this case, SystemVue instrument links control and integrate multiple measurements instruments into the platform, automating system-level test (Figure 3). The software surrounds the raw Radar or EW design and test equipment with the environmental, baseband and RF modeling required to close a round-trip signal processing loop in order to perform early simulation-based verification. As hardware becomes available, SystemVue continues to connect directly into the physical hardware measurement.

Figure 2. SystemVue's Radar and EW test platform can be used to test and verify hardware. In this diagram, a transmitted Radar signal with interference from SystemVue is shown being downloaded to an AWG to test EW RF receiver hardware.

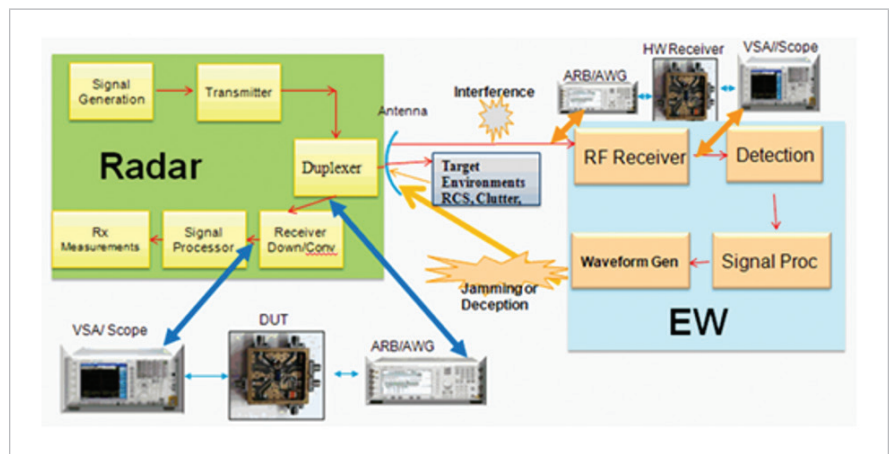
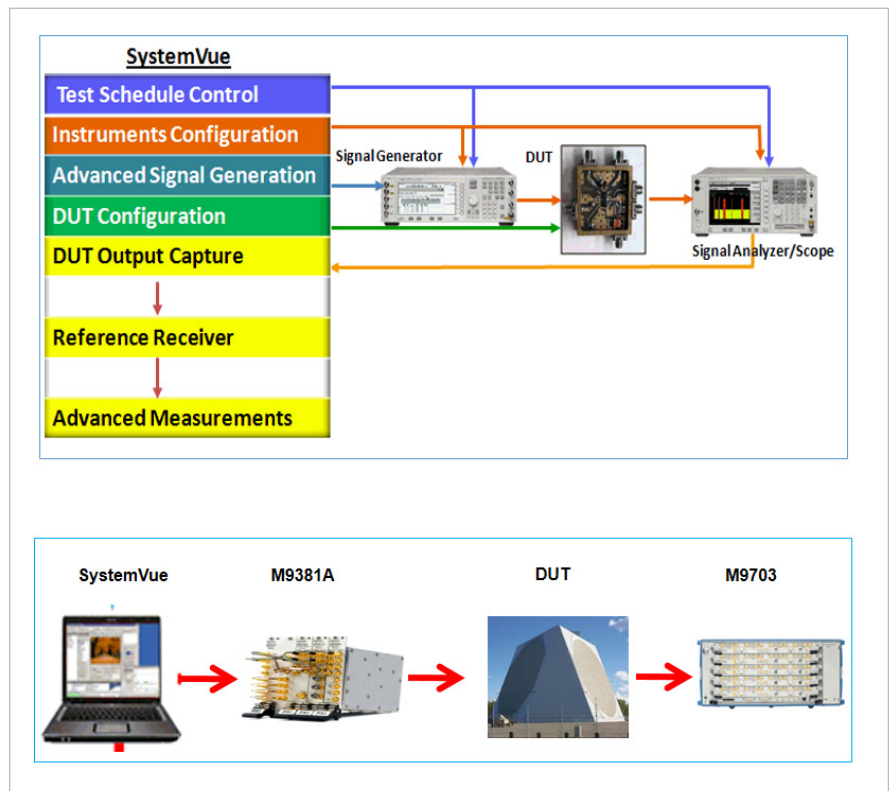


Figure 3. SystemVue integrates all test instruments together as a test system to provide complex Radar and EW test signals with environment scenarios to the Device under Test (DUT) to capture DUT outputs and then synchronized signals. It then post processes the signals to extract more information and make advanced measurements (e.g., detection rate, false alarm rate and imaging analysis). Without the integration and synchronization, each instrument would function on its own, making it impossible to perform complex tests.



During hardware testing, simulation data is downloaded to a wideband arbitrary waveform generator (AWG), such as the M9330A/M8190A. The AWG drives the I/Q inputs of a vector signal generator (e.g., the MXG, PSG or ESG) to render simulated RF test signals, including realistic threats and jamming scenarios, for testing Radar and EW receivers. Integration of a signal analyzer or wideband oscilloscope running vector signal analysis software provides measurement and analysis capabilities that are useful when developing transmitters, receivers, amplifiers, and other subsystems. For further analysis and signal processing, measured signals can be brought back to SystemVue with the help of vector signal analysis software. This combination of hardware and software enables both component testing (e.g., an RF receiver, detector, signal processor, or waveform generator) and scenario simulation for system test.

Another use for the test platform is to test whether jamming and deception signals generated by an EW system can effectively attack a Radar receiver. In this case, the signal downloading link must be moved to the radar receiver input so that the signal at the output of the Radar RF receiver can be acquired.

Addressing EW Design Challenges:

EW is defined as a military action that uses electromagnetic and directed energy to control the electromagnetic spectrum or attack an enemy. It includes Electronic Warfare Support (ES), Electronic Attack (EA) and Electronic Protection (EP). Each area of EW faces its own unique set of design challenges.

In EA applications, for example, responsive and non-responsive jammers are always used. To simplify development, SystemVue provides application templates that can be used to generate jammers. In EP, engineers must detect the Direction of Arrival (DOA) for an enemy's Radar signals. In this case, SystemVue's MUSIC and ESPRIT algorithms may be employed to estimate the DOA.

Finally, in ES, a Radar Warning Receiver (RWR) is required in one-on-one engagements to detect the radio emissions of Radar systems. Testing a RWR from an EW system requires the generation and analysis of an appropriate test signal. Many factors must be considered when modeling a RWR (e.g., frequency band, direction finding methods and emitter identification). Also, once the receiver algorithm design is done it must be verified under realistic scenarios.

SystemVue has the ability to generate complex multi-emitter waveforms efficiently with its user-friendly user interface. Also, the RWR signal can be modeled and simulated in SystemVue. As an example, a template of a type of RWR test platform that can be constructed to test an EW system receiver is shown in Figure 4. By modifying the platform's source input and reset parameters, different RWR test signals can be generated. The RWR signal can even be modified to implement the engineer's own EW algorithm, which can then be tested in the platform. In Figure 4, an emitter signal is generated in SystemVue, downloaded to the M1890A AWG and then modulated by the E8267D vector signal generator.

Figure 4. Shown here is a multi-emitter signal with different Radar and communication components generated in Keysight's SystemVue-based Radar and EW test platform.

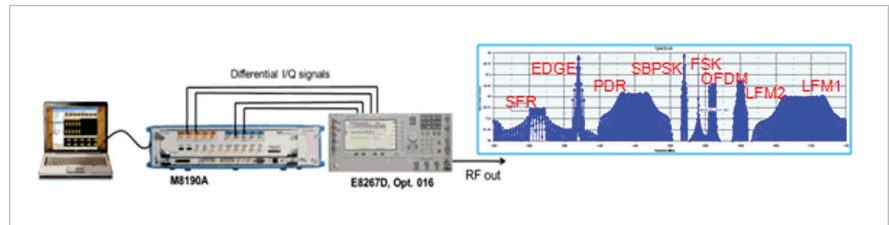
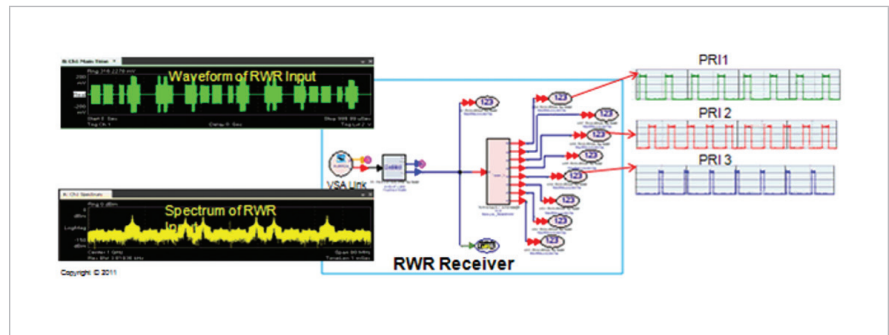


Figure 5. This RWR test platform template utilizes the Frequency Bands Recognition technique. The RWR is based on Frequency Division Signal processing with eight inputs, each of which may be set to a different frequency range.



In the example in Figure 5, a received multi-emitter signal waveform (denoted in green) arrives at the input of the RWR. The spectrum is shown in yellow. The goal is to find the components for the arrived multi-emitter signal. The main task of the RWR is to process received signals to determine components in both the time and frequency domain. Within the RWR, channelization is performed. The output of each channel is the recovered signal-of-interest, indicating that the RWR has successfully recognized LFM1, LFM2 and LFM3, the original signal components from either a Radar or communication system.

Summary of results

With modern Radar and EW systems operating in increasingly complex environments, effectively designing, verifying and testing Radar and EW systems has become all the more critical. A Radar and EW simulation and test platform based on SystemVue offers the ideal solution to this dilemma. The platform can be used for modeling and simulation of Radar and EW systems. When linked to other Keysight measurement instruments via SystemVue, the platform can also be used for test and verification of Radar and EW components and systems.

Using the platform, engineers gain access to a myriad of benefits. It provides a true design-oriented value proposition to shorten the development cycle and allows users to save time and money by minimizing field tests. Moreover, its multiple environment scenarios enable engineers to create real-world test environments for high-quality products. Such capabilities and benefits are critical to ensuring successful development of modern Radar and EW systems.

Related information

SystemVue Radar application notes

- Simulation and Verification of Pulse Doppler Radar Systems, Publication Number: 5990-5392EN
- Radar System Design and Interference Analysis Using Keysight SystemVue, Publication Number: 5990-5393EN
- Using SystemVue's Radar Library to Generate Signals for Radar Design and Verification, Publication Number: 5990-6919EN
- Solutions for Ultra-Wideband Radar System Design: Integrating Design with Ultra-Wideband Test for Flexible Radar Verification, Publication Number: 5990-8349EN
- Using Keysight SystemVue to Create Realistic Scenarios for Radar and EW Applications, Publication Number: 5990-7533EN
- Mixed-Signal Integration Challenges in Complex Radar Systems, Publication Number: 5990-8556EN

SystemVue Radar product information

- YouTube video: <http://www.youtube.com/watch?v=97Px9ByNyMI>
- Webcast: "Uncovering the Hidden Impairments in Testing Advanced RADAR Systems"
- SystemVue product info and videos:
<http://www.keysight.com/find/eesof-systemvue-info>
- SystemVue W1905 page:
<http://www.keysight.com/find/eesof-systemvue-radar-llibrary>
- Creating Multi-Emitter Signal Scenarios with COTS Software and Instrumentation: <http://www.youtube.com/watch?v=DGbjBT3Elog>
- IMS 2013 Presentation: Creating and Analyzing Multi Emitter Environment Test Signals with COTS Equipment:
<http://www.youtube.com/watch?v=NjXkeYfLfQc>



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