Addressing the Challenges of Radar and EW System Design and Test using a Model-Based Platform

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Today's designers require a solution for designing, verifying and testing their Radar and EW systems in an effective way.

Radar systems have come a long way since their introduction in the 1940's, today encompassing a broad range of applications, ranging from supermarket door openers to highly complex shipboard phased-array fire-control radars. Modern systems require higher performance to work in today's ever more complex Electronic Warfare (EW) environments, which include jamming and deception. As a result, EW systems must be properly designed to effectively attack Radar systems. Modern Radar and EW systems must also have the ability to reach out and touch the environments in which they operate, detect and characterize sources of electronic noise such as RF jamming or co-location antenna interference, and adapt the Radar's performance accordingly to compensate for that interference. Moreover, EW specifications are always adjusted based on the environment. Because of these challenges, today's designers require a solution for designing, verifying and testing their Radar and EW systems in an effective way.

Challenges

Radar and EW systems operate in increasingly complex spectral environments with multi-emitter input signals from Radar, military and commercial communication systems, as well as different interferences, noise and clutter. Even in an urban center, the airwaves may include countless wideband RF and microwave emitters—and therefore, potential interferers—such as wireless communications infrastructure, wireless networking systems and civilian Radars.

This complexity poses a number of challenges when developing Radar and EW systems, especially when coupled with new signal generation and processing requirements, and the need to analyze different test cases. For example, how does the engineer reduce the time and cost associated with developing these new systems, while also reducing the high cost of testing and validation? How do they get all legacy Intellectual Property (IP) point tools to work together with RF? And, how do they validate the performance of their complex Radar and EW systems earlier/continuously, instead of waiting until final integration and test? Addressing these challenges is critical ensuring the success of any Radar or EW system.

Introducing the Model-Based Platform

One way to quickly and effectively deal with these challenges is through use of a model-based platform. The platform relies on simulation of Radar and EW systems with cross domain architectures for signal processing and RF pieces, and visualized environments. It can also link to high-performance Commercial Off-the-shelf (COTS) instruments, connecting the real world with "simulation in the loop" to achieve greater flexibility and application awareness. Using a model-based platform to design, verify and test Radar and EW systems, designers can create

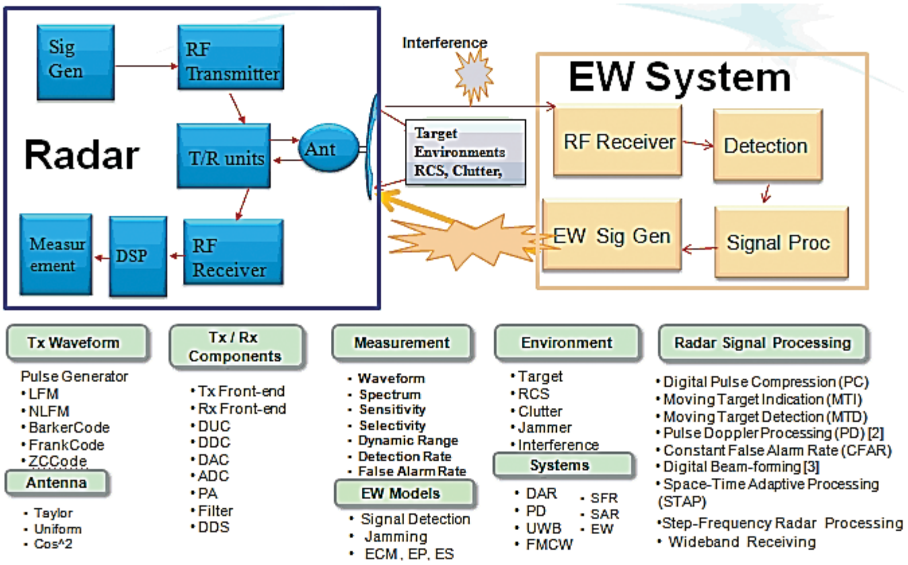

Figure 1 • A prime example of a model-based platform is Agilent's Radar and EW simulation and test platform based on SystemVue software. The simulation version of the platform, shown above, models and simulates Radar and EW systems at all stages of development.

real-world test environments for high-quality products, shorten their development cycle, and save both time and money by minimizing field tests.

The critical part of the model-based platform is an Electronic System Level (ESL) design software that models and simulates Radar and EW systems throughout the entire development process (Figure 1). With its models for Radar cross-section (RCS), user-defined antenna patterns and scanning, clutter, and interferers, designers can use the software to model a working reference design that can be used to generate test vectors. Existing DSP algorithm models can also be incorporated to construct custom systems. Custom models based on C++, MATLAB, and HDL code, as well as subnet structures, can be easily created with the software's user interface. In this manner, different components created by different people can be integrated together and tested at the system level for the purposes

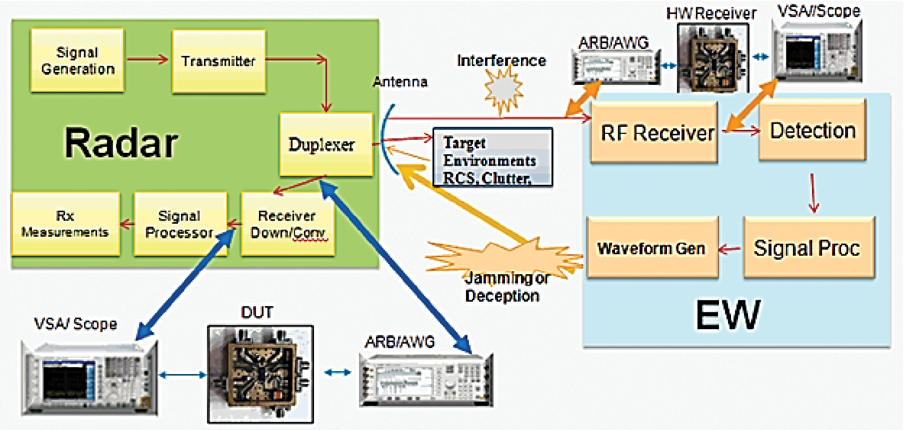

Figure 2 • Agilent's SystemVue-based Radar and EW test platform, shown above, can be used to test and verify hardware. In this diagram, a transmitted Radar signal with interference from SystemVue is shown being downloaded to an AWG to test EW RF receiver hardware.

of performance evaluation and continuous validation throughout the development process.

The simulation platform in Figure 1 can also be used as a hardware test platform (Figure 2). During hardware testing, simulation data is downloaded to Vector Signal Generators (VSGs) or wideband Arbitrary Waveform Generators (AWGs) for testing Radar and EW receivers. Integration of signal analyzers or wideband oscilloscopes running vector signal analysis software provides measurement and analysis capabilities with automated test, which are useful when developing transmitters, receivers, amplifiers, and other subsystems. For further analysis and signal processing, measured raw signals can be brought back into the ESL design software for post processing using an existing receiver capability for advanced measurements such as false alarm rate, detection rate, and imaging display. This combination of hardware and software enables automated test for both component testing (e.g., an RF receiver, detector, signal processor, or waveform generator) and testing under realistic scenarios, including jamming/deception, RCS, and clutter.

As an example, consider the test of an RF receiver in the EW system shown in Figure 2. The transmitted Radar signal plus interference from the ESL software, in this case SystemVue, is downloaded to an AWG for testing the EW RF receiver hardware. To do this, the RF output of the AWG connects to the EW receiver hardware input. The output of the hardware is then sent to an oscilloscope. Next, the signal acquired by the vector signal analysis software is sent back to SystemVue for further processing and measuring, thereby demonstrating how the Radar and EW test platform can be used to test and verify hardware. The setup in Figure 2 can be used for testing different components such as an RF receiver, detector, signal processor, or waveform generator.

The test platform can even be used to test whether the generated Jamming and Deception signals generated by the EW system can effectively attack the Radar receiver. For this purpose, the signal downloading link is moved to the Radar receiver input and the signal at the output of the HW Radar RF receiver acquired. The RF receiver hardware can then be tested.

EW System Solutions

While both Radar and EW systems pose problems for designers during development, EW systems can be especially problematic. EW technologies include Electronic Attack (EA), Electronic Protection (EP) and Electronic Warfare Support (ES)—each posing its own unique set of challenges that can be effectively addressed with a model-based platform.

EA Application Challenges: EA applications employ jammers (e.g., responsive and non-responsive jammers

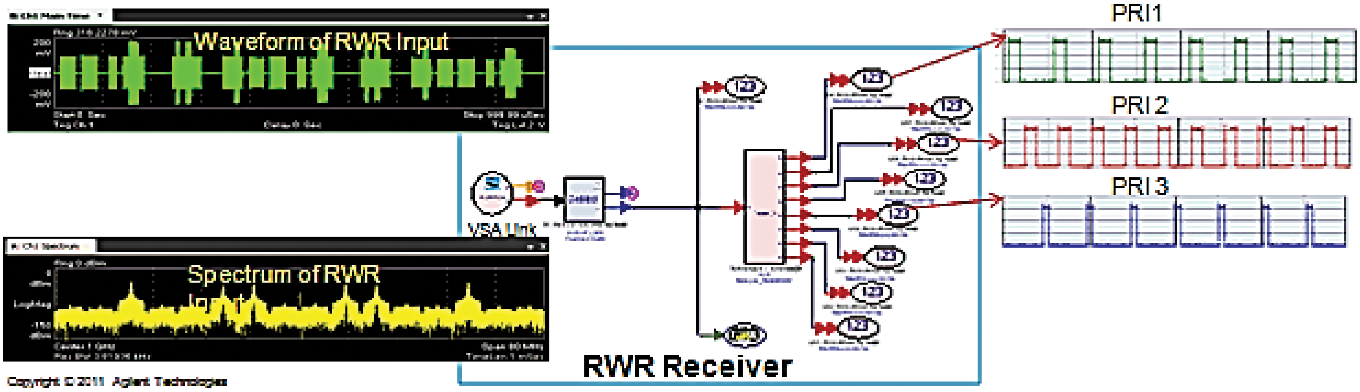

Figure 3 • This RWR test platform template utilizes the Frequency Bands Recognition technique. The RWR is based on Frequency Division Signal processing with eight inputs, each of which may be set to a different frequency range.

with masking, and coherent jammers with either marking or deception) to attack enemy's Radar. To effectively attack Radars, the jamming and deception need to be designed carefully under EW environments. Regular design tools do not provide the capability to design jamming or deception to match the EW environment. Furthermore, designers often utilize the Digital Radio Frequency Memory (DRFM) technique for EW systems. Consequently, when testing EW systems for EA applications, designers must generate jammers and when applicable, design and validate a DRFM algorithm.

Solution: Jammers can be easily generated using application templates available in the ESL software. The software also provides the functionality needed to design and validate an EA system based on DRFM under realistic environment scenarios. Existing advanced measurements enable designers to verify whether the designed jamming or deception can attack Radar effectively.

EP Application Challenge: In EP applications, designers must detect the direction of arrival (DOA) for an enemy's Radar signals under complex environment. Special algorithms are required to estimate the DOA.

Solution: The ESL software's DOA algorithms, such as MUSIC and ESPRIT, may be employed to estimate DOA. The ESL also provides a complex environment setup for EP algorithm design.

ES Application Challenges: In ES applications, a Radar Warning Receiver (RWR) is required in one-on-one engagements to detect the radio emissions of Radar systems. To test a RWR in an EW system, designers must first generate an appropriate test signal, taking many factors into consideration (e.g., frequency band, direction finding methods, pulse interleaving and resolution, and emitter identification). Also, once the receiver algorithm design is done it must be verified under realistic scenarios.

Solutions: The ESL software 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 the ESL software. 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 3. 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 the ESL software, downloaded to an AWG and then modulated by a vector signal generator.

In the example in Figure 3, 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.

Conclusion

Modern Radar and EW systems operate in increasingly cluttered and complex environments, making their design, verification and test extremely challenging. The model-based platform offers designers an ideal way to ease this burden. It can be used to model and simulate Radar and EW systems and, with integrated measurement instruments, can also act as a test system for hardware test and verification of Radar and EW components and systems. Using this platform, designers are able to shorten their development cycle, save time and

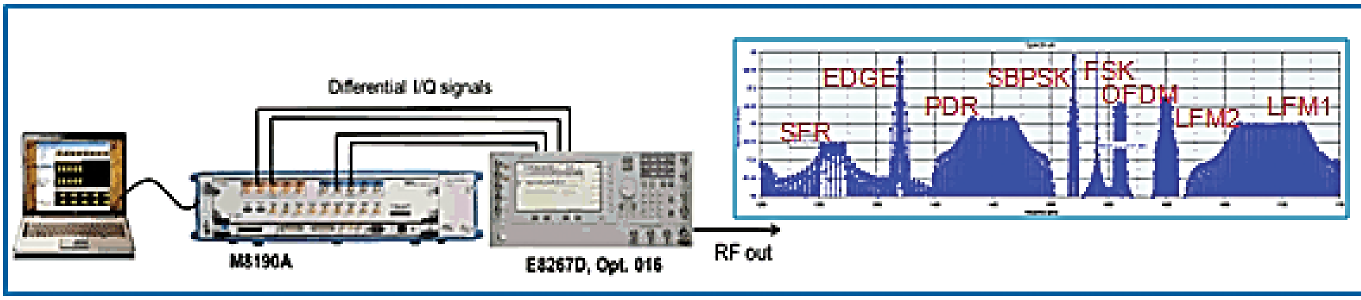

Figure 4 • Shown here is a multi-emitter signal with different Radar and communication components generated in Agilent's SystemVue-Based Radar and EW test platform.

money by minimizing field tests, and create the real-world test environments needed to produce the highest-quality products. Such capabilities and benefits are critical to ensuring successful development of modern Radar and EW systems.

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Dingqing Lu has been with Agilent Technologies/ Hewlett Packard Company since 1989 and is a scientist with Agilent EEsof EDA, working on modeling, simulation, testing and implementation of Military and Satellite Communications and Radar EW systems. From 1981 to 1986 he was with University of Sichuan as Lecturer and Assistant Professor. He was a Research Associate in the Department of Electrical Engineering at University of California (UCLA) from 1986 to 1989. He is IEEE senior member and has published 20 papers on IEEE Transactions, Journals and Conference Proceedings. He also holds a US Patent on a fast DSP search algorithm. His research interests include system modeling, simulation and measurement techniques.

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