Keysight Technologies
Understanding the SystemVue To ADS Simulation Bridge

Application Note

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Introduction

The Keysight Technologies, Inc. SystemVue is a new system-level design environment that enables a top-down, model-based design methodology for both communication physical layer (PHY) systems and aerospace/defense systems.

This application note examines the link from SystemVue directly into an RF hardware design flow that allows mutual system-RF co-verification. At a practical level, this is achieved by adding special I/O blocks that connect dataflow simulators in both SystemVue 2010.01 and Keysight Advanced Design System (ADS) 2009 Update 1. This connection allows a complex-valued, sampled I/Q datastream from SystemVue to flow to ADS where it can be processed with the Circuit Envelope or Transient/Convolution circuit simulator and then return to SystemVue for coded receiver and demodulation (Figure 1).
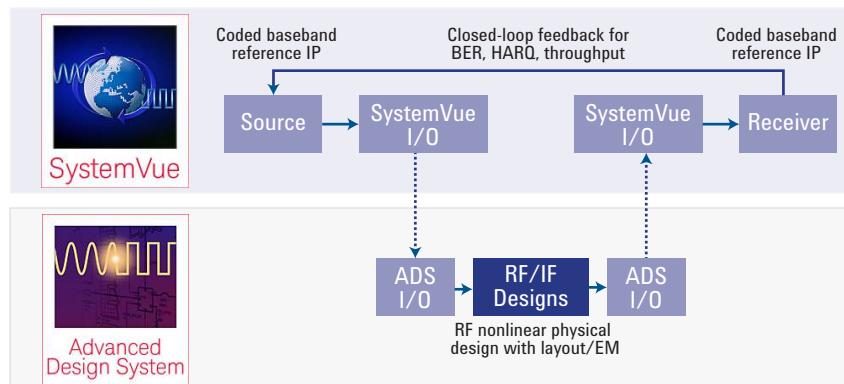

Figure 1. SystemVue can drive ADS in a live co-simulation to achieve higher system-level accuracy and enable more predictive collaboration.

Benefits for both baseband/DSP and RF designers

This completed round trip allows system-level architects and baseband algorithm developers to benefit from the increased accuracy for analog-domain components and RF "work-in-progress." Typically, these users of math, C++, and HDL language modelling do not have access to high-accuracy, envelope-domain physical models. Instead, they do their development in isolation with inferior RF equivalents.

RF circuit designers also derive a benefit from the completed round trip. Their early RF designs can be seen operating in a working system with early baseband DSP processing wrapped around them, using realistic waveforms. While ADS users are accustomed to co-verifying baseband designs with their RF circuits, in most situations, the baseband DSP has already been completed. Consequently, there is no real opportunity to change the DSP, only to verify the RF. RF design groups can now access earlier baseband investigations (in the math or C++ stages), before they are committed to implementation and while there is still time to re-partition the system design between either the baseband or RF paths—the best place to solve a problem, if one should occur.

In essence, SystemVue allows cross-domain debugging (down to the math or C++ algorithms) in order to track and solve architectural issues that were previously difficult to do across toolsets.

Indirect alternatives to live co-simulation

In this application note we will look at a live co-simulation between SystemVue and ADS. However, there are indirect alternatives to this configuration that have other advantages. They are briefly discussed here, for a more complete perspective.

SystemVue can export active baseband models and file-based I/Q waveforms to ADS, for use natively within the ADS environment. Similarly, ADS can export X-parameters* and static I/Q waveforms back to SystemVue. These exported objects are easier to use, run orders of magnitude faster in the target environment (with controllable accuracy trade-offs), and allow separate simulations to be done offline across different computers, organizations, license pools, and intellectual property domains (Figure 2).
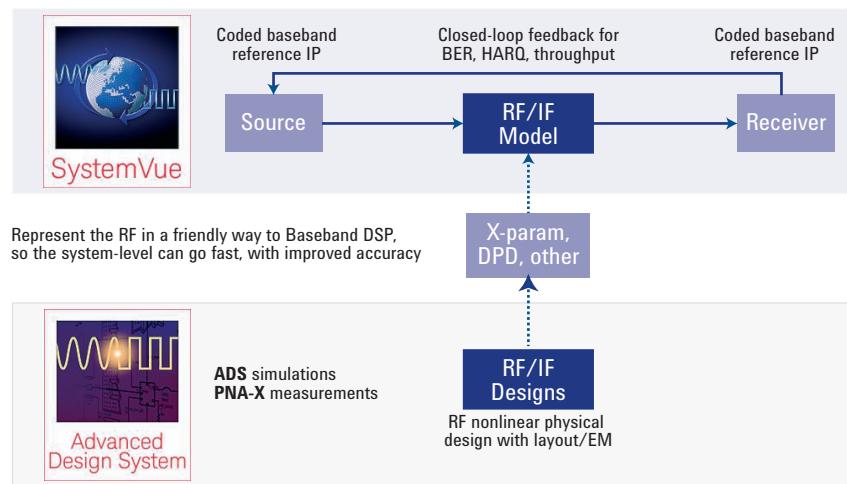

Figure 2. SystemVue and ADS can both export models to each other's environments, allowing faster, offline simulations tailored to that environment.

Live co-simulation, the subject of this application note, allows both baseband and RF design to be used directly in their native environments, with no additional translation or model extraction steps. While the resulting simulations are often slower, they enable the full functionality, libraries and accuracy of the original environments to be used. For example, the ADS Circuit Envelope simulator supports memory and dynamic biasing effects that are not typically included in behavioral models, and can also include the full 3D EM accuracy of the physical amplifier design. Another benefit is that the live simulation connection makes it convenient to cross-check and debug partially-completed designs (that is, use them "as-is"), saving considerable trouble-shooting and verification effort at later stages of integration.

SystemVue-ADS co-simulation: two cases

Two application cases are shown below. The first case shows a direct link between the SystemVue dataflow simulator, and the dataflow simulator in ADS ("ADS Ptolemy"), shown in Figure 3. This link allows for re-use of signal processing schematics and behavioral models that an ADS user may already have created. Additionally, it enables ADS users to take advantage of newer libraries and capabilities of the SystemVue platform.
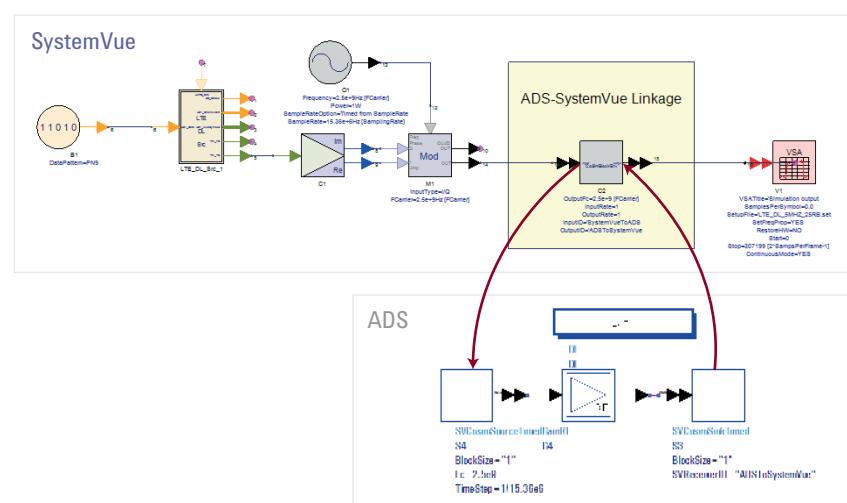

Figure 3. Shown here is the SystemVue to ADS Ptolemy co-simulation link.

The second application case goes one step further (Figure 4). It shows the same link from SystemVue to ADS Ptolemy, but here ADS Ptolemy also performs its own system-circuit co-simulation inside ADS, linking to either the Circuit Envelope or Transient/Convolution simulation engines. By connecting SystemVue to a real physical simulation, system-level designers can improve the accuracy of the RF PHY for their algorithmic studies (e.g., for digital pre-distortion). ADS users can take advantage of higher SystemVue capabilities, such as closed-loop LTE "throughput" measurements, by embedding their RF in active HARQ feedback channels.
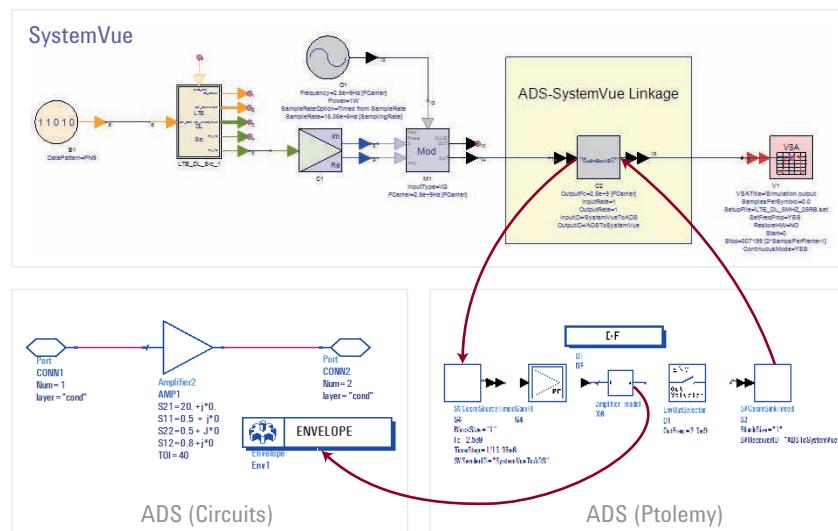

Figure 4. System designers who already own ADS Ptolemy can perform cross-domain, line-by-line debug of their C++ and math algorithms in SystemVue while connected to active RF, carrier/envelope-level memory effects in ADS. This cannot be done without the two Keysight platforms, shown above.

Configuration

The ADS-SystemVue co-simulation link discussed here requires files and examples that are not included with the commercial releases of either SystemVue 2010.01 or ADS 2009 Update 1. To download and install these files, supported customers are invited to visit the Keysight EEsof EDA Knowledge Center technical support website at (http://edocs.soco.keysight.com/x/YoFvBg).

Installation steps

— Download the archive from the Keysight EDA Knowledge Center and unpack it to a known directory.

— Exit ADS, if it is currently running. Establish environment variables for **HPEESOF_DIR** and **ADSPTOLEMY_ MODEL_PATH**, per the instructions in the "SETUP" document. When you run ADS, you should have a new DSP schematic palette called "SystemVue Cosimulation" as shown in Figure 5.

— Run SystemVue, if it is not currently running. Use the SystemVue Library Manager to enable the cosim.dll file. You should now have a new library called "Cosim Parts" in the Parts Selector window (Figure 6).
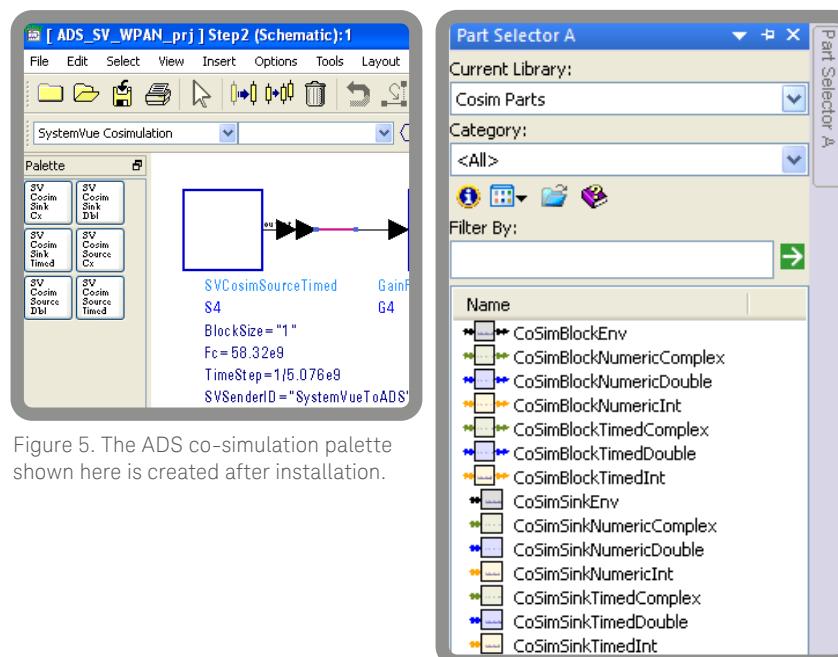

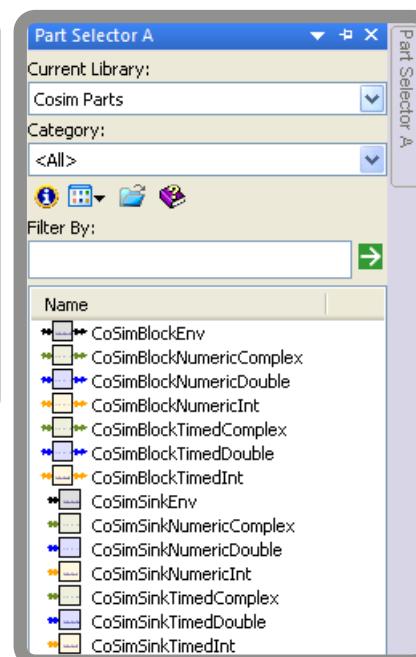Figure 5. The ADS co-simulation palette shown here is created after installation.

Figure 6. Shown here is the SystemVue co-simulation palette, after installation.

To run the examples

Start SystemVue and ADS sessions on the same machine. Both programs should be running and have all required licenses available.

– Load a pair of corresponding workspaces into both ADS and SystemVue that are set up to talk to each other.

– Run the SystemVue example first. The SystemVue simulation will "pause" as it tries to find a corresponding ADS simulation session (Figure 7).

– Next, run the ADS Ptolemy simulation. Once it connects to the SystemVue session, the SystemVue simulation status window will change to an active status. Both simulations will now run to completion (Figure 8).

– Finish visualizing the data using the dataset/plotting windows in either platform, or using the Keysight 89601 Vector Signal Analysis (VSA) software. Note that the VSA software is optional.
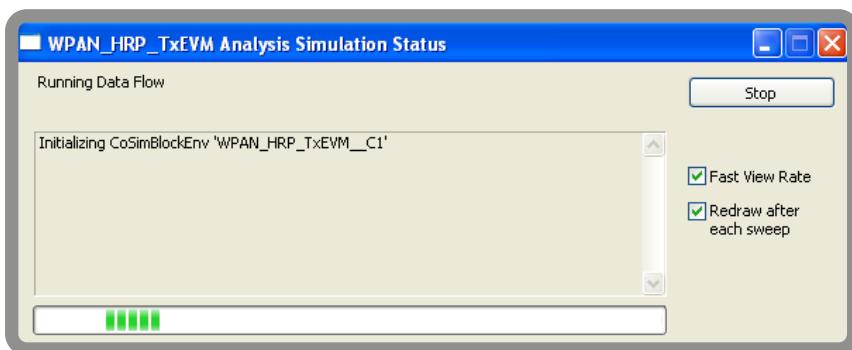

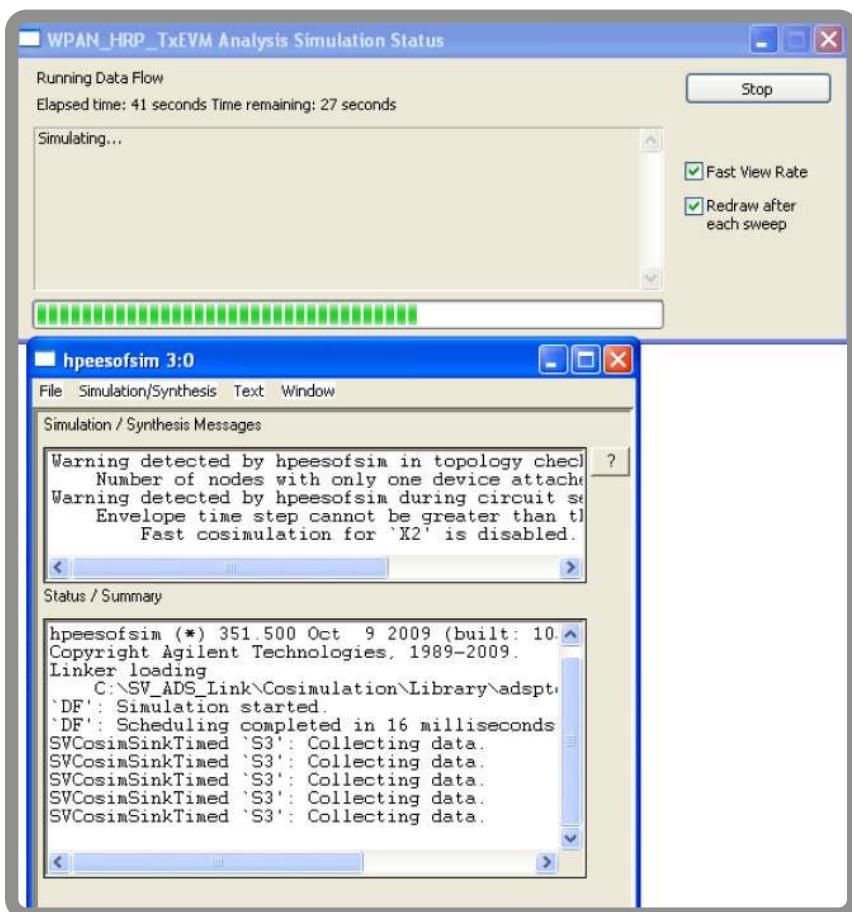Figure 7. The SystemVue simulation status window shows that that simulation is pending connection to ADS.

Figure 8. Depicted here are the SystemVue and ADS simulation status window, after connection is made.

Application Examples

Example 1

LTE power amplifier (LTE version 8.9, Dec. 2009)

The wide bandwidth, high crest factor and extreme linearity required for LTE power amplifiers (PAs) requires particular attention to the signals being applied to the system. LTE measurements are a strong function of the exact signal being used. Therefore, format-compliant signals based on the most-current revision to the 3GPP LTE standard are needed for verification. Certain standards-based measurements are also necessary, such as throughput, EVM and various spectral masks. The co-simulation linkage allows RF circuit-level design-ers to use higher-level LTE libraries in SystemVue to verify their RF designs at the system link level.

Figure 9 illustrates how the SystemVue to ADS linkage is used for verifying a PA. Figures 10 and 11 show the LTE PA operating in both linear and nonlinear regions.
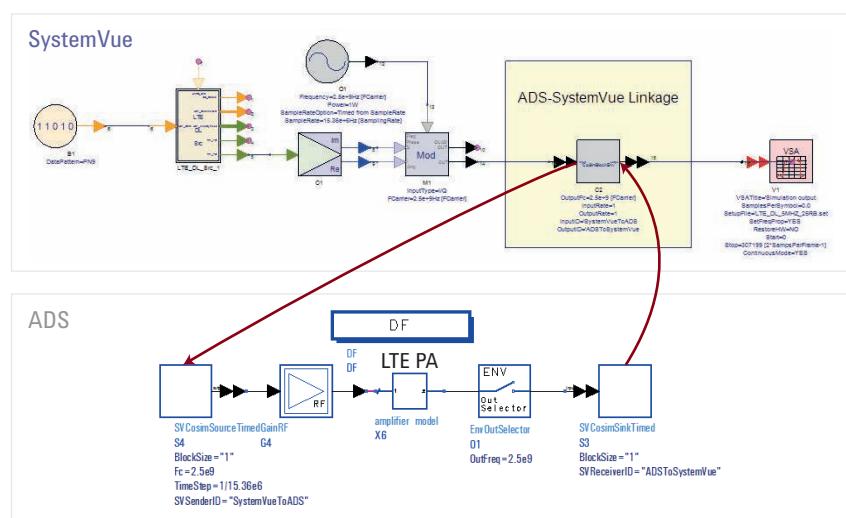

Figure 9. Verifying a PA, using format-compliant signals based on the latest update to the 3GPP LTE standard (Dec-2009, at this writing).
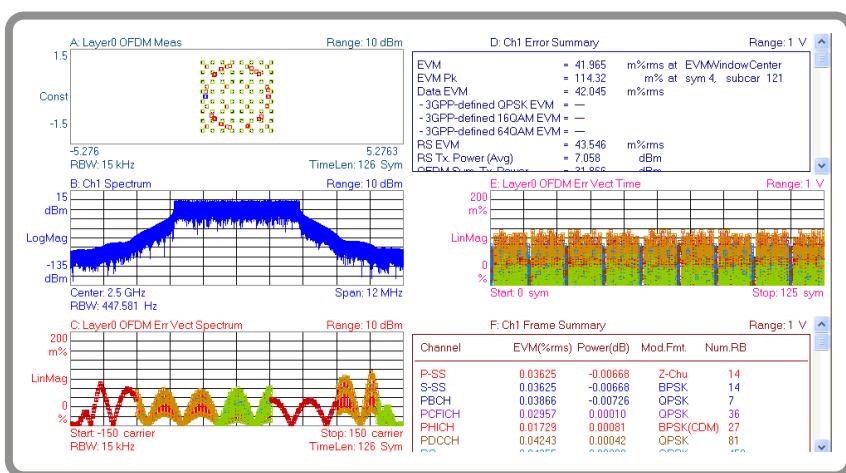

Figure 10. An LTE PA is shown working in its linear region, with a residual EVM < 0.1%, as measured by the independent 89601 VSA measurement software.
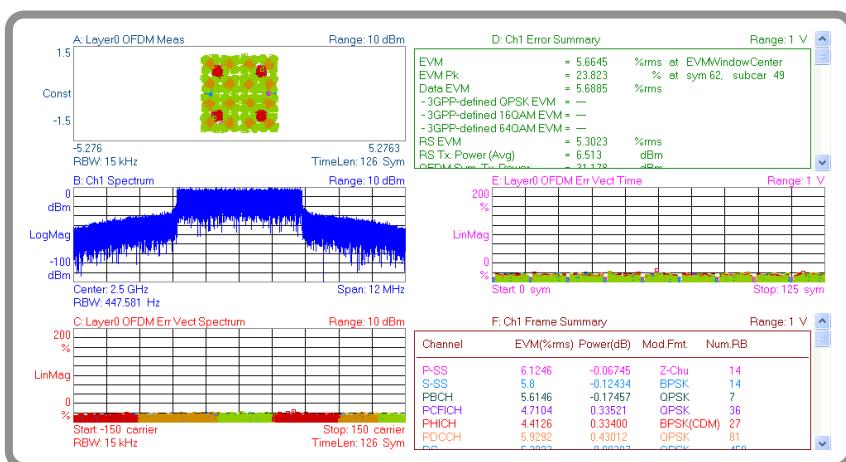

Figure 11. An LTE PA is shown working in its nonlinear region. This particular power level causes a residual EVM > 5%.

Example 2

Millimeter wave WPAN 60-GHz design

Similar to LTE, designing a 60-GHz power amplifier in ADS for one of the wireless personal area network (WPAN) standards requires an authentic signal source and measurements that are found in SystemVue, not ADS. The ADS-SystemVue configuration for this application is shown in Figure 12. Figures 12 and 13 show the 60-GHz WPAN PA operating in both its linear and nonlinear regions.
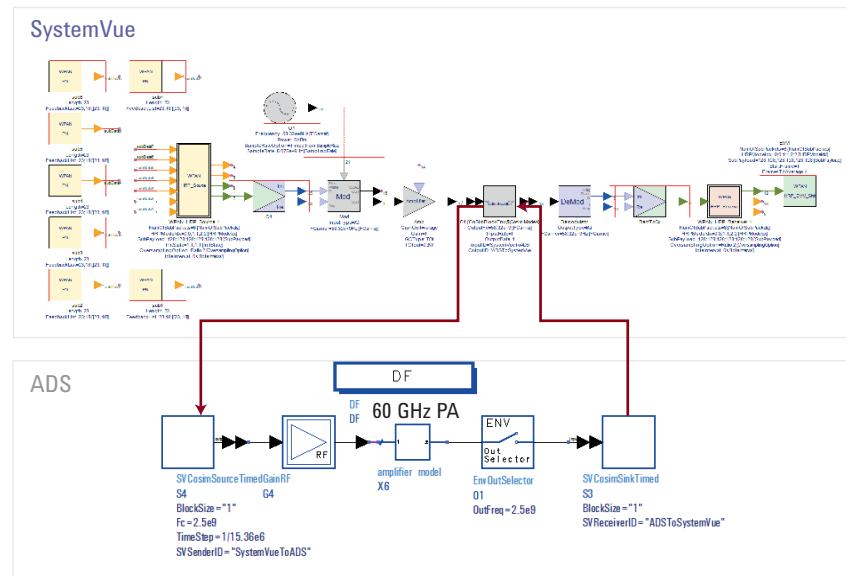

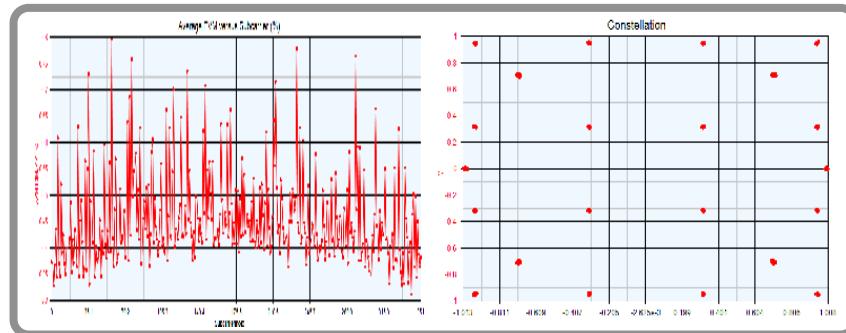Figure 12. Verifying a 60-GHz PA based on the latest WPAN standard (802.15.3c).

Figure 13. A 60-GHz WPAN PA is shown working in its linear region, with EVM < 0.8% across a large number of individual orthogonal frequency-division multiplexing (OFDM) carriers.
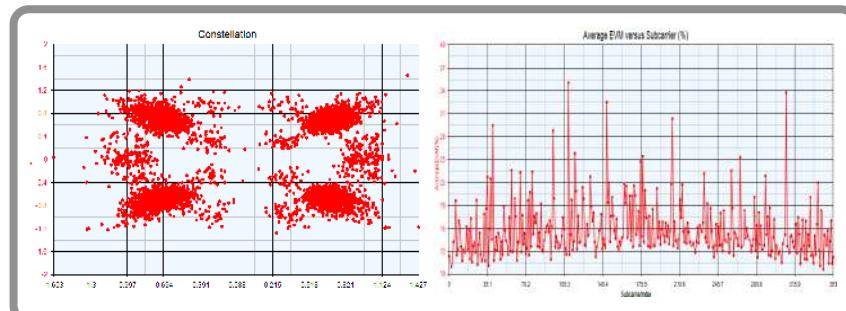

Figure 14. A 60-GHz WPAN PA working in its nonlinear region, with EVM > 20% across a large number of OFDM carriers.

Example 3

ZigBee transmit PA design

Figure 15 shows a link-level SystemVue simulation being used to create a clean 2.45-GHz transmitter signal that adheres to the ZigBee standard (802.15.4). The sampled I/Q samples are passed through the live co-simulation link to a PA being simulated in ADS. The distorted signal returns to SystemVue in the same simulation and is further passed to the Keysight 89601 VSA software for demodulation and analysis. Figures 16 and 17 show the 2.45-GHz PA operating in both linear and nonlinear regions.
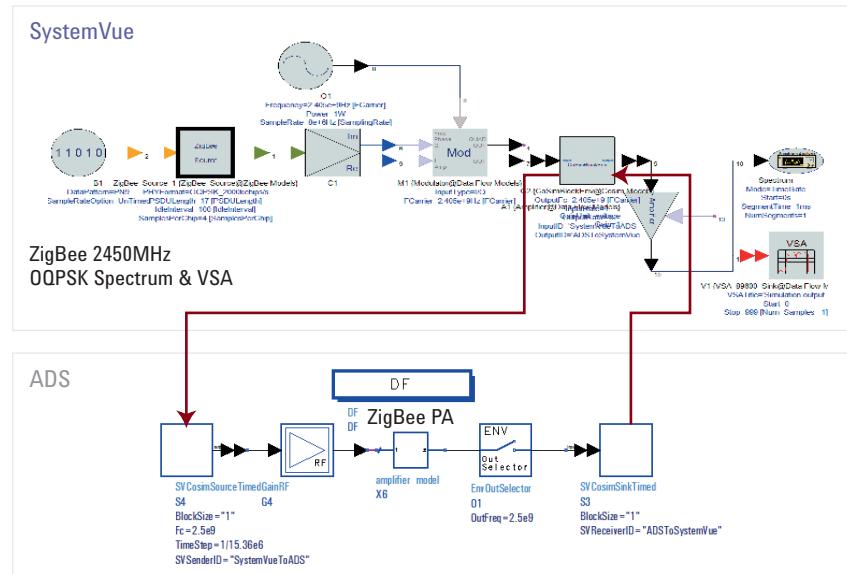

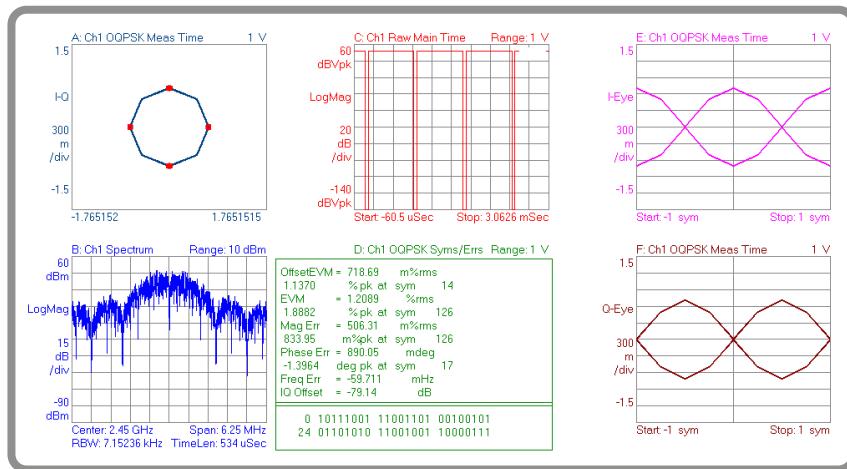Figure 15. Designing a 2.45-GHz ZigBee PA.

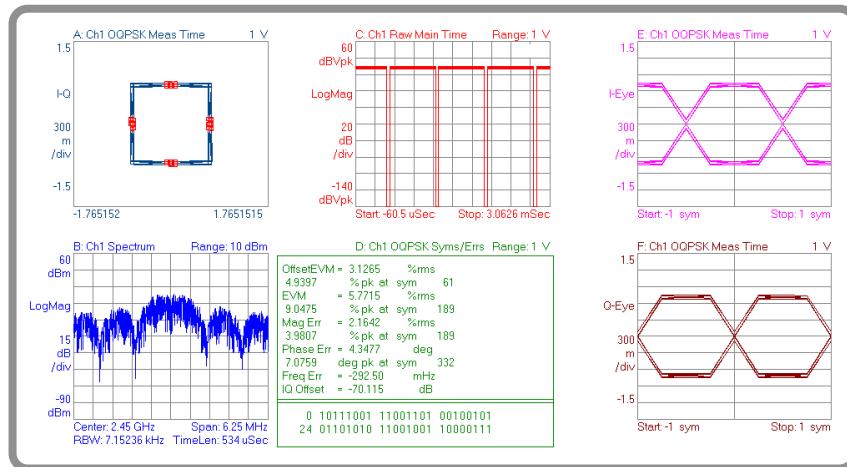Figure 16. A 2.45-GHz ZigBee transmit PA working in the linear region.

Figure 17. A 2.45-GHz ZigBee transmit PA working in the nonlinear region.

Summary

The SystemVue to ADS bi-directional link uses shared memory to transfer data effectively between the two platforms. Once the link has been configured, it is easy to use. The application examples in this application note demonstrate that the new linkage brings additional value to users of both ADS and SystemVue, helping them to perform evaluations that would otherwise be very difficult to do using only one of the platforms.

X-parameters is a registered trademark of Keysight Technologies. The X-parameter format and underlying equations are open and documented. For more information, visit www.keysight.com/find/eesof-systemvue.

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