NI AWR Design Environment V13

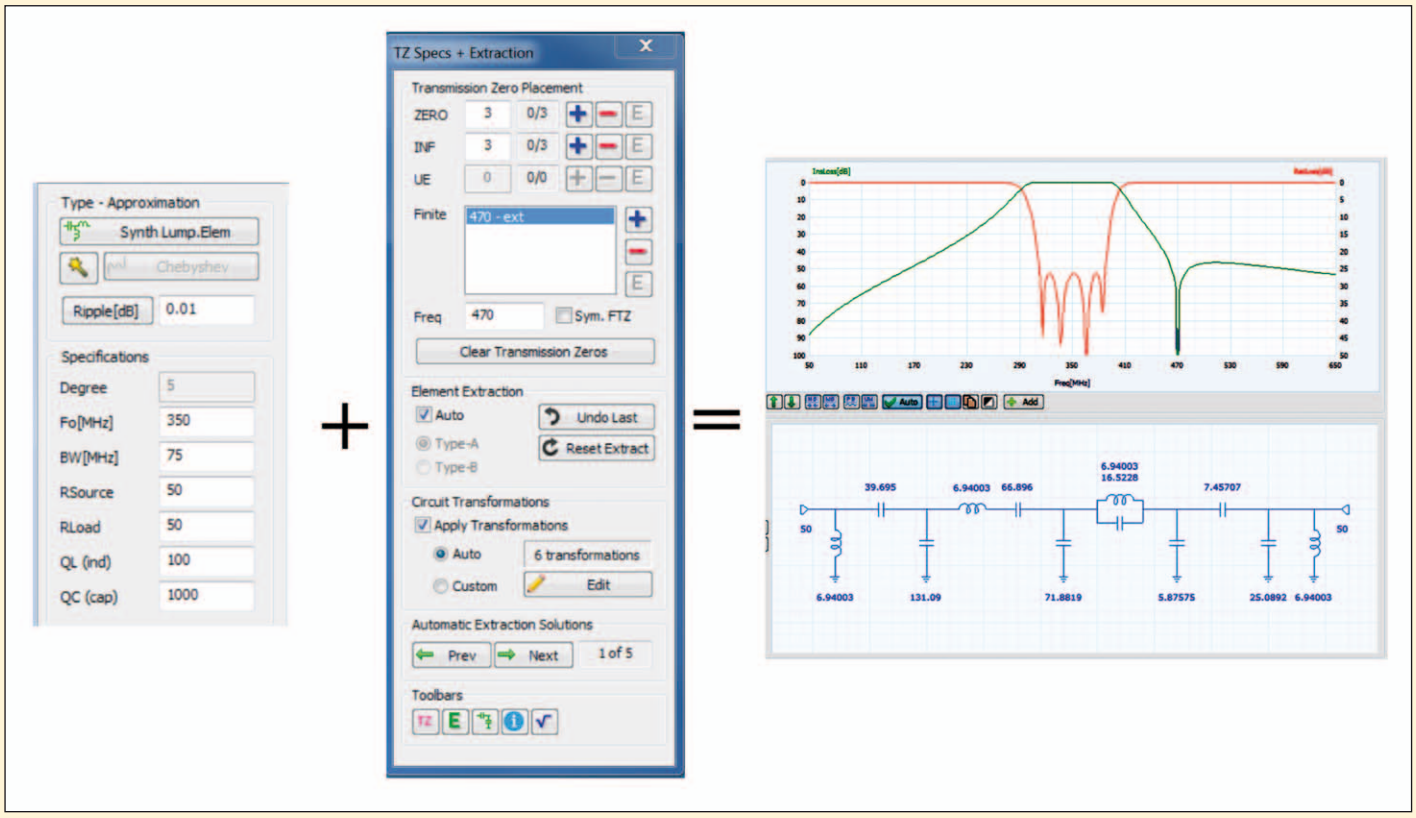

Fig. 1: New capabilities in iFilter allow users to manually place and distribute transmission zeroes at any desired frequency.

Next-generation wireless devices, LTE-A/5G infrastructure, and aerospace/defense electronic systems are creating new challenges for the way engineers design and develop RF/microwave products. These challenges, stemming from high performance goals for bandwidth, linearity, and efficiency, are complicated by system and market requirements for smaller, lighter, and less costly devices. In addition to engineering challenges, business concerns include escalating development costs, limited engineering resources, and time-to-market pressures.

To fulfill product requirements, new semiconductor and printed circuit board (PCB) materials, as well as module technologies, are being developed to achieve unprecedented integration and functionality within an increasingly smaller form factor. To successfully implement these technologies, engineers require design automation tools that can accurately predict electrical performance as it relates to physical design, accurately account for excitations from complex waveforms used in communication and radar systems, and offer seamless flow-to-manufacturing processes.

NI AWR Design Environment addresses these requirements with an integrated, open platform offering system, circuit, and EM co-simulation that captures the behavior of RF front-end components such as antennas, amplifiers, filters, mixers, and related signal-controlling passive and active devices. To keep pace with these advances in communication electronics, the software is continually evolving to meet RF/microwave market design challenges.

V13, the latest release of NI AWR Design Environment, improves engineering productivity with faster, more powerful circuit/system/EM simulation technologies, robust model libraries, and greater design flow automation. Additionally, actual product development of microwave monolithic integrated circuits (MMICs), RFICs, RF PCBs, and multi-technology modules is accelerated with the release of V13 through new synthesis capabilities, enhanced design flow automation, and interoperability with third-party software, as well as additional customer support solutions.

Key Aspects of V13

NI AWR Design Environment V13 specifically addresses design challenges associated with highly-integrated RF/microwave devices commonly found in communications and radar systems. Emphasis in the V13 release is placed on several facets of the software's end-user use model. The design environment now offers enhancements to the user interface (UI) and new additions to design flow automation, inclusive of syn-

National Instruments
Ni.com/awr
Customer Driven

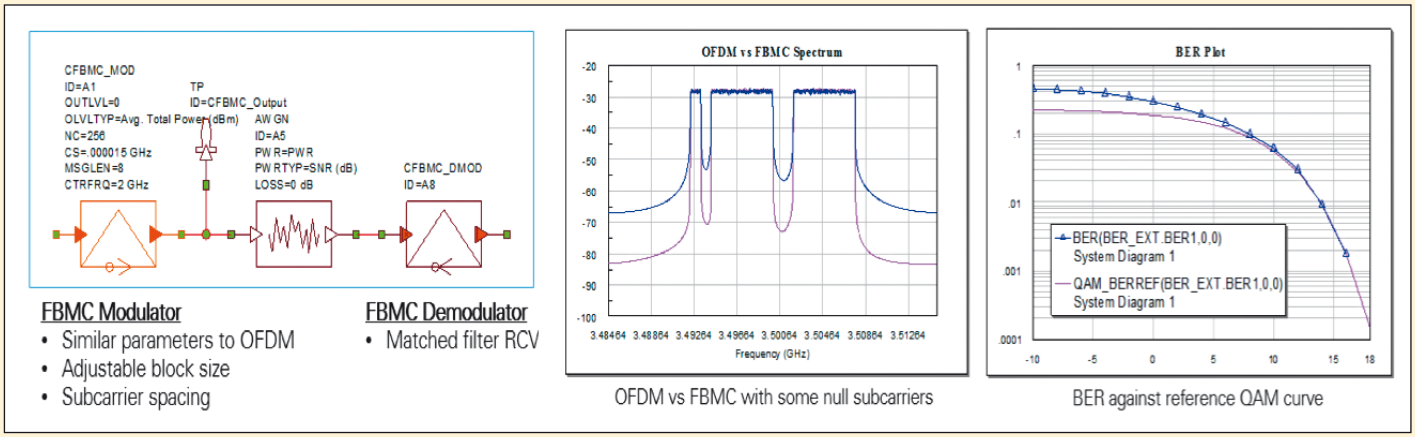

Fig. 2: 5G FBMC signal generator and BER performance. Users can determine the type of circular pulse shaping used in the FBMC signal

thesis, import/export of file format standards, and links to third-party tools. Improvements have been made to the harmonic balance (HB) and system-level simulation engines, as well as the planar and arbitrary 3D EM solvers. Physical design has been enhanced with a powerful new PCB import wizard for streamlining design flows across various vendor tools in addition to new, advanced layout editing commands. Lastly, user support has been expanded to bring new insight to the software in terms of interactive guided help and knowledge base content.

V13 New and Enhanced Features at a Glance

Design Environment and Automation

- Advanced multi-technology project support
- New optimization methods
- Transmission zeros added in iFilter
- OpenAccess schematic import/export
- Graph marker improvements
- Marching waveforms for HB/transient analysis
- Additional synthesis wizards (such as passives and mixers)

Circuit/System Simulation and Models/Libraries

- Transient and TAHB improvements
- Expanded circuit envelope simulation
- Passive model enhancements
- Spectre netlist co-simulation
- New 5G candidate waveforms library
- New system load pull (ACPR, EVM) and nested source/load pull
- Enhanced LTE-A, radar, and phased-array model libraries

EM Simulation and Modeling

- Simulation speed and solver improvements (meshing, ports, and matrix solve)
- Improved AFS algorithms
- Enhanced EM ports
- Analyst surface roughness model
- New 3D editor commands
- Enhanced bi-directional links to HFSS, CST, and Sonnet

Physical Design and Layout

- PCB layout import (ODB++, IPC2851)
- Expanded shape preprocessor modifier
- Enhanced layout editing

User Support

- New guided help (GH) interactive documentation
- Enhanced online knowledge base (KB)

Design Environment and Automation

NI AWR Design Environment V13 adds several new key capabilities for design entry (both schematic and layout), parametrized circuit, system and EM subcircuits, design synthesis, simulation and optimization controls, and measurement graphs. These improvements serve to better facilitate designs incorporating multi-technology (mixed-technology) projects, commonly used to simulate multi-chip modules (MCMs) that incorporate diverse MMIC and RFIC devices on a single laminate package/module.

Additionally, process design kit (PDK) specific improvements make it easier to install new PDKs and work with multiple layout process files (LPFs). Custom toolbars can now also be distributed in PDKs to support highly customized design flows for leading front-end module manufacturers.

OpenAccess

Advances in hierarchical design management, complemented with a new OpenAccess import/export wizard (supporting, for example, the import/export of RFIC schematics and project symbols from Cadence Virtuoso) and Spectre netlist simulation, provide for the ready and easy design and analysis of small-scale RFICs commonly used in MCMs. Improvements in EM integration, discussed in more detail below, provide direct simulation of embedded passive components, critical interconnects, and entire IC or laminate structures.

Optimization/Synthesis

V13 offers new functionality to accelerate design starts with the addition of synthesis wizards for designing transformers, power dividers, hybrids, mixers, and multipliers based on a given set of user input specifications.

Module Design

Multi-technology module design incorporates different IC (PDK) and PCB processes and, at times, different design tools. To deliver smaller devices with optimum performance, it is common for front-end module manufacturers to integrate gallium arsenide (GaAs), gallium nitride (GaN), silicon germanium (SiGe), or RF complementary metal oxide (CMOS) PAs, CMOS or silicon-on-insulator (SOI) switches, and acoustic filters on a single laminate package.

V13 Highlights:

- AXIEM/Analyst EM analysis speed and capacity improvements
- Spectre netlist conversion and APLAC co-simulation for RFICs
- Multiple technology enablements
- Multiple PDKs/LPFs
- Ongoing PDK releases
- Hierarchical EM simulation
- EM Socket bidirectional flows for third-party tools

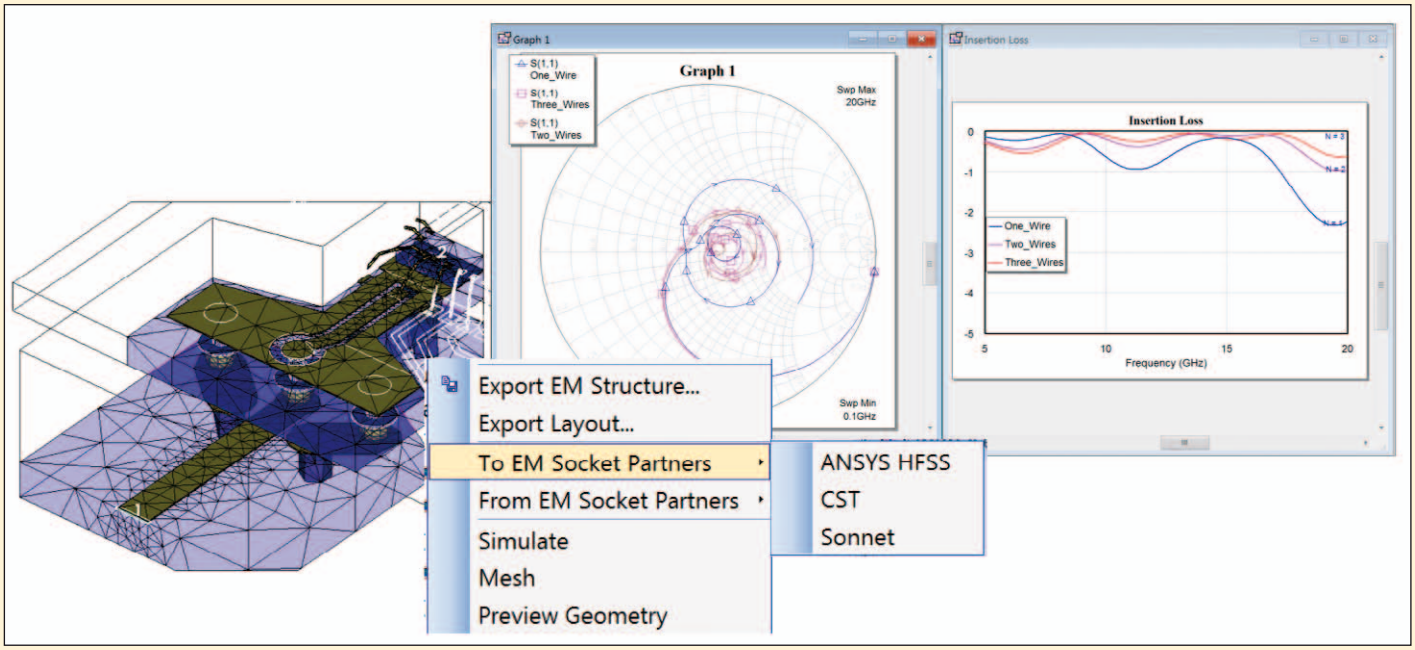

Fig. 3: Third-party EM Simulators can be selected as the EM simulator

Design optimization has been improved with the introduction of genetic algorithm methods (advanced genetic and particle swarm), leveraged from the evolutionary algorithms employed within AntSyn antenna design and synthesis software (awrcorp.com/antsyn). These optimizers use recombination and selection to rapidly and robustly explore a large number of points randomly distributed over the design space. This results in a more efficient and faster approach to investigating design possibilities and identifying optimum solutions.

Filter Synthesis

iFilter, an integrated filter synthesis module (Fig. 1), seamlessly runs as a wizard within NI AWR Design Environment, enabling designers to keep filter designs and their evolution a part of the entire, managed circuit design project. iFilter's intuitive user interface quickly has users designing filters, connecting them directly to circuitry, and making tradeoffs that positively impact their design.

iFilter offers both automatic and manual flows. The automatic flow enables extraction of transmission zeros (TZ) such as DC, INF, and finite, as well as application of transformations from 80+ models. In the manual flow, the user manually places and distributes the transmission zeros. For a standard bandpass filter implementation, zeros can be weighted on the low side or the high side of the passband, allowing for extra emphasis on filter rejection for the selected side. In addition, transmission zeros can be added manually at any desired frequency. The user extracts transmission zeros in a preferred order and applies specific transformations to yield a better design. The completed filter can be implemented in Microwave Office circuit design software with a single click for further refinement and optimization.

Measurement Graphs

Even before a simulation is complete, the new marching waveforms feature in V13 begins plotting "real-time" measurement data on defined measurement graphs, giving designers an early preview of simulation results and the opportunity to adjust a design or simulation parameter if there are any issues with the design response or simulation setup.

To help users assess measurement data, two new marker types, auto-search markers and offset markers, are now available. Auto-search markers automatically search for a user-specified feature such as trace maximum and shift along the x-axis to stay aligned with the feature as the trace is updated due to tuning, optimization or other performance goals. Offset markers maintain a specified x or y offset from another marker on the trace. In addition, rich-text notes can now be attached to markers to help document graphs and share insights with fellow designers.

Circuit and System Simulation and Libraries

APLAC, the high-frequency circuit simulation technology seamlessly integrated into NI AWR Design Environment Microwave Office and Analog Office, has been developed to minimize memory requirements

5G/LTE-A Communications

5G candidate waveform modulators are available as a 5G waveforms library in V13. Along with the support for carrier aggregation of contiguous and non-contiguous spectrum, V13 allows higher data capacity through wideband (40 MHz) aggregation. The added 5G functionality includes signal generation and demodulation to allow for full system simulation and measurements such as BER, ACPR, and EVM.

V13 Highlights
- New 5G waveforms library (OFDM variations, GFDM, FBMC)
- Channel models: METIS 2020
- New multi-beam examples
- Addresses physical-layer (PHY) level design for 5G mmWave bands
- MIMO and multiple-in-multiple-out (MIMO) PHY link level simulations
- Transceiver design and analysis
- Tradeoffs in RF link architecture and component selection
- Carrier aggregation for DL/UL
- BER/block-error rate (BLER) measurements

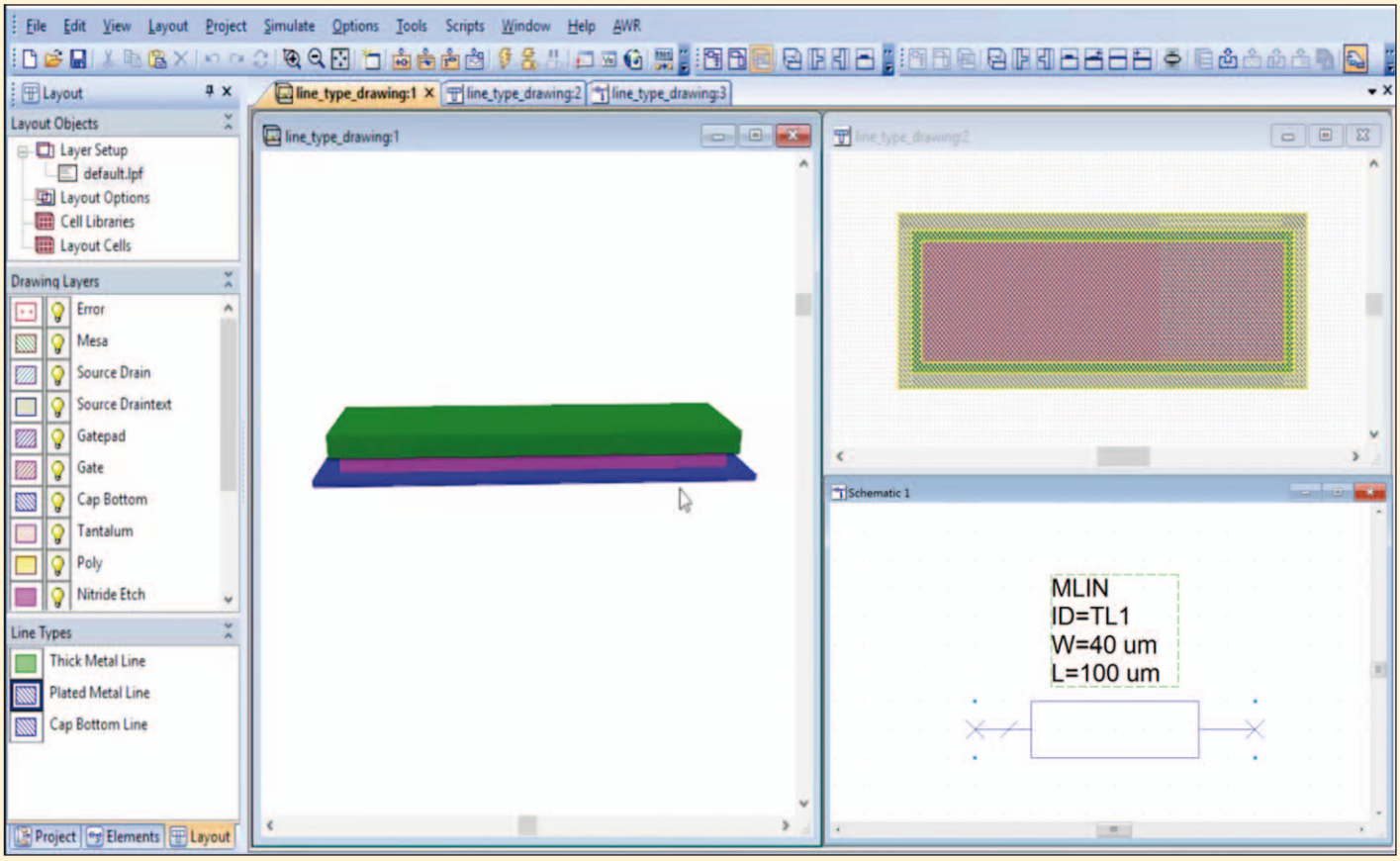

Fig. 4: Visual System Simulator can fully analyze complete phased array systems

and simulation run times while maintaining accuracy.

To address nonlinear devices for communication systems, APLAC now includes circuit envelope, capable of addressing circuits excited by non-periodic signal sources such as modulated RF signals. The associated measurements provide the time-varying voltage or current of a particular carrier and the associated spectrum surrounding that carrier. With the added capability of simulating modulated waveforms with circuit envelope, new sources have been added to describe modulated waveforms, such as the ability to specify the IQ data of a modulated signal.

The speed and robustness of the APLAC transient (time-domain) simulation engine is enhanced with a new core algorithm and improved time-step algorithm. Other developments include new error control and a transient preset option that can be set to Accurate, Moderate, or Fast. The transient-assisted HB (TAHB) option, used for digital divider circuits and accurate nonlinear phase-noise measurements of analog and RF applications, can be leveraged in V13 for oscillator analysis by setting the TAHB options to Disabled, Convergence Aid, or Initial Guess.

With time-domain simulations such as transient and circuit envelope, it is necessary to extract a time-domain model for passive devices, S-parameters, and transmission lines. Improvements to the time-domain model in V13 include a better speed-to-accuracy ratio in the extraction of S-parameter data, more robust handling of poor quality data, and more robust passivity enforcement.

For power amplifier (PA) designers, this latest version of Visual System Simulator (VSS) software supports system-level load pull to generate contours for communication performance metrics such as adjacent channel power ratio (ACPR) and error vector magnitude (EVM).

For amplifier designs, Microwave Office V13 now supports nested source/load pull contours, enabling designers to directly observe changing source and load contours as a function of source and load impedance terminations. This unique capability allows designers to provide a new terminating impedance to either the source or load and directly observe the change to the contours at the other port without having to re-simulate the circuit, thereby eliminating the time-consuming iterative approach to source/load matching.

System design for communication applications is further enabled with new capabilities introduced in V13 of VSS. The software now provides LTE-Advanced (LTE-A) support for carrier aggregation of intraband and interband component carriers and 5G candidate modulated waveforms such as filter-bank multicarrier (FBMC) (Fig. 2), generalized frequency-division multiplexing (GFDM), and filtered orthogonal frequency-division multiplexing (F-OFDM). These technologies take advantage of faster processing speeds to offer higher data rates and are therefore being considered to replace OFDM download (DL) and single-carrier frequency-division multiple access (SC-FDMA) upload (UL).

For sharing and re-using results in subsequent simulations, a new outpthe type of ut file measurement feature in VSS writes a compatible nonlinear behavioral model text file that includes information on fundamental input, fundamental output, intermodulation (IM3) products (for two-tone simulations), harmonics (for one-tone simulations), S11, S22, characteristic input and output impedances, and noise figure (NF). In addition, signal heritage information obtained from the RF Inspector (RFI) technology within VSS can be exported to an .xml file.

Radar and Phased Array

VSS's phased-array block UI enables easy setup for different array configurations and "first cut" analysis of array gain patterns.

V13 Highlights

- Multiple and variable pulse repetition frequency radar sources
- Antenna/phased-array blocks support signal direction
- RF links characterization for array elements – Gain, P1dB, NF, sensitivity (S)
- Enhanced modeling of element patterns, including mutual coupling
- Support for automotive radar, 802.11p (car-to-car)

EM Simulation and Modeling

The AXIEM and Analyst electromagnetic (EM) simulators within NI AWR Design Environment use Maxwell's equations to compute the electrical behavior of a structure from its physical geometry. AXIEM provides responses for 3D planar structures such as transmission lines, spiral inductors, and metal-insulator-metal (MIM) capacitors, whereas Analyst addresses 3D objects such as wire bonds, ball grids, finite substrates, and 3D horn antennas. Improvements to AXIEM and Analyst in V13 focus on solver speed and accuracy, as well as features that support greater automation and design flow integration with Microwave Office.

AXIEM V13 simulations using the iterative matrix solver are now faster due to the simultaneous solution of multiple ports (right-hand sides), benefiting structures with large port counts the most. The AXIEM advanced frequency sweep (AFS) algorithm automatically selects a set of frequency points to simulate, then uses these simulated points to interpolate the S-parameter response for the entire band. In V13, AFS is now faster and more accurate, and generally converges on a solution with fewer frequency points.

Like AXIEM, Analyst V13 offers up to a 50 percent reduction in simulation run times. Major meshing upgrades improve robustness and speed and there is now easier access to the "Ports Only" solve to access port fields, propagation constants, and port impedances. Analyst is now able to model the effects of surface roughness when a roughness parameter is specified, improving the accuracy of transmission line simulations, where surface roughness impacts electrical behavior, such as insertion loss.

In addition, Analyzer now offers approximate open and spherically perfectly-matched layer (PML) boundary conditions, which can result in faster simulations for antenna far-field calculations, because the spherical extrusion typically adds fewer elements to the mesh than it would in the rectangular case. Analyst V13 also introduces new 3 D editor functionality and improvements targeting drawing (sketcher) functions and solid object controls, materials and attributes organization in the browser tree, autocomplete for parameter and variable expression, and variable grouping and sorting, to highlight a select few.

Third - Party EM Tools

The AWR Connected program enables the automated flow of layout data from NI AWR Design Environment into partner simulators. Supported partners include ANSYS HFSS, Sonnet, and CST. In V13, AWR Connected for third-party EM simulators is now more robust and fully bi-directional. After the layout is created in the Microwave Office layout editor, third-party EM tools can be selected as the EM simulator and the resulting dataset is automatically imported back into Microwave Office to tune, optimize, perform yield analysis, and verify results.

Physical Design and Layout

At RF and microwave frequencies, electrical performance is directly influenced by physical design. Therefore, great care must be taken to ensure that a component's physical attributes are fully incorporated into the simulation model and that the physical details used in simulation are fully and accurately replicated by the manufacturing process. V13 offers new and improved features that impact design layout and interoperability between NI AWR Design Environment and third-party IC and PCB electronic design automation tools.

PCB Data Files

The PCB import wizard in V13 makes importing large amounts of complex board data easier and more efficient. V13 now supports the import of IPC-2581 (A and B) and ODB++ (V7 and V8) files that are produced by most enterprise board tools, including Cadence Allegro, Mentor Graphics, Zuken, and more. Importing these files produces a schematic layout representing the board geometry along with a STACKUP element defining the board cross-section. This new capability is intended for importing PCB designs and preparing them for EM simulation with AXIEM and/or Analyst.

Once layout geometries are either imported or drawn directly into the design environment layout editor, several new capabilities help designers set up the entire structure or portions of the design for characterization through EM simulation. General shape modifiers – sometimes known as defeaturing - transform the layout for faster, more robust EM simulation to study product data. The shape preprocessor modifier uses a set of rules to specify the types of editing operations to perform on the shapes of each layer and on shapes between layers. The modifier extends the advantages of EM geometry simplification rules to schematic layout and provides a clean and flexible method for applying layer-based shape editing operations in layout.

A new line types pane has been added to the layout manager, offering a fast method for simultaneously drawing line-type shapes with all the layers and layer offsets associated with specific MMIC/PCB process technologies commonly used in multi-metal STACKUPS as defined in the line-type definition in the LPF. The layout editor offers several new edit layout commands, including a two-point move and copy with reference command, an expanded rotate submenu supporting rotate, rotate right, and rotate left commands, and auto-repeat.

Conclusion

NI AWR Design Environment V13 provides new, innovative solutions in design automation and simulation technology for the advancement of high-frequency electronic products serving the communication and aerospace/defense industries. As component requirements for these applications drive advances in semiconductor, PCB, and MCM integration, NI AWR software offers powerful enhancements in design flow automation and greater speed and accuracy for its circuit/system/EM simulation technologies, enabling device manufacturers and system integrators to meet challenging performance metrics, size, cost, and time-to-market goals.

For more detail on NI AWR Design Environment V13 visit

awrcorp.com/whatsnew

which provides documentation covering the hundred plus enhancements/additions to this latest release. ◄