Vol.19.1

AWR Design Magazine

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ni.com/awr

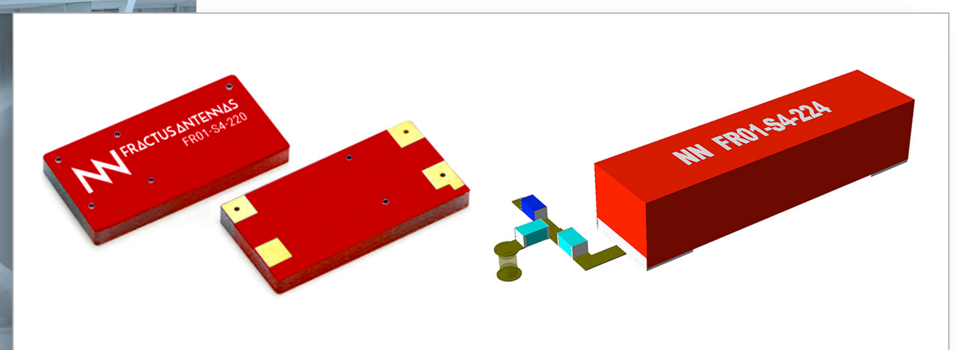
NATIONAL INSTRUMENTS™

Partnership Perspective

Fractus Antennas Library Now Available Within NI AWR Software

We announced during Q1 2019 that NI AWR Design Environment software now includes an extensible markup language (XML) library for compact, surface-mount antenna components from Fractus Antennas (NN) that accelerates the development of wireless devices for Sigfox, LoRa, narrowband internet of things (NB-IoT), LTE-M, Bluetooth, and other IoT and 5G/LTE networks.

What's twice as exciting about this is that the inclusion of this new antenna library furthers NI AWR software support for integration of RF front-end modules with single- or multi-band antenna configurations for wireless connectivity. Antenna components can be quickly and easily accessed by customers from within the elements browser of the software, making antenna integration with the wireless device design process easy and complete.



With access to these antenna parts, RF designers can rapidly address component integration on a PCB substrate through direct simulation of the Fractus Antennas part of choice, along with front-end components such as power amplifiers, low-noise amplifiers, and filters, as well as any required impedance matching. Furthermore, front-end component-to-antenna matching can also be developed using the recently released Network Synthesis Wizard that complements Microwave Office circuit design software to ensure maximum power transfer between RF driving circuitry and the antenna.

This is just the first of many cooperative efforts under way between us and Fractus Antennas. Be sure to [subscribe to our e-newsletter] to stay informed of this and more.

Best regards,

Sherry Hess
Vice President of Marketing
AWR Group, NI

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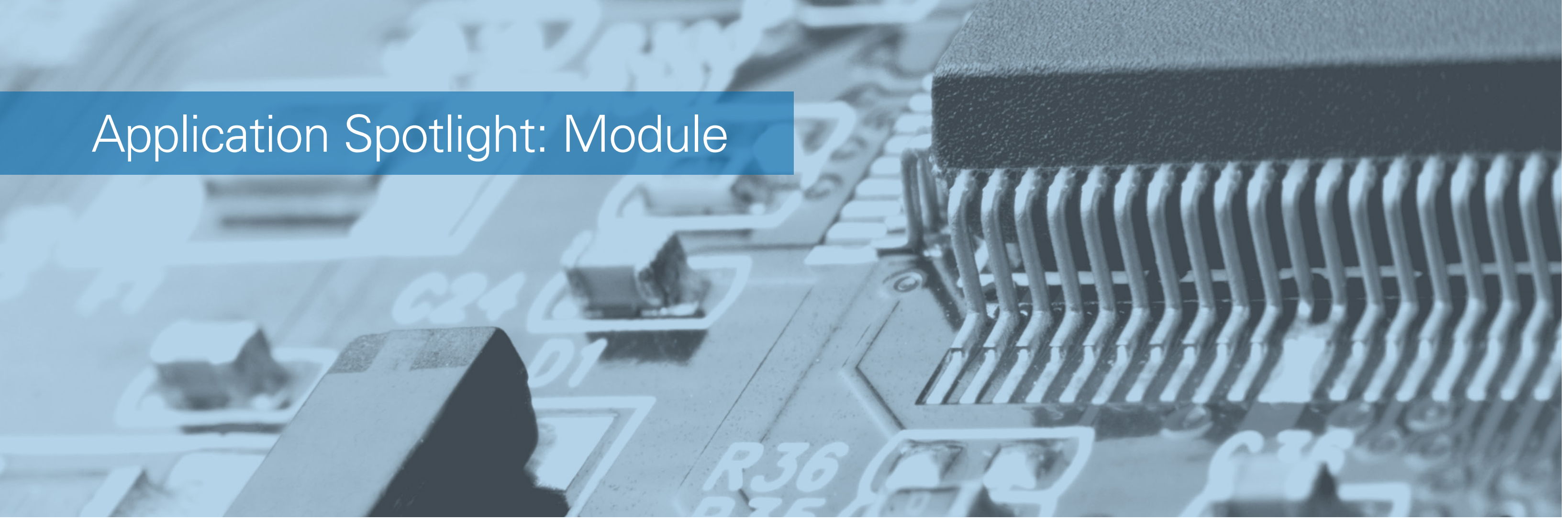


Application Spotlight: Module

Modeling the Many Facets of Wireless Module Designs

RF modules offer a large amount of functionality in a small space, but they can be an engineering challenge for development teams. This article explores the fundamental design challenges faced when creating and producing high-frequency modules for a range of wireless system applications, and how NI AWR software provides an effective work flow supporting the design and integration of these modules in the shortest time possible.

Integrating Functionality – Systems/Subsystems Approach

Creating new, multi-die heterogeneous modules and corresponding system boards involves multiple engineering teams with different perspectives. System simulation tools that operate in conjunction with physical realization tools support top-down/bottom-up analysis that enables these different engineering teams to obtain design requirements from a single master plan and compile individual results into an evolving simulation model of the entire module. The system architecture defines the arrangement of the individual radio blocks and their performance requirements, while system simulation based on behavioral models supports first-pass component specification from RF-budget measurements that include gain, power level, IP3, noise figure, and more.

Integrating Heterogeneous Technologies

The integration of one or more ICs onto multi-level substrates is a challenging task at higher frequencies where electrical characterization must be performed using EM simulation of structures implemented via layout-focused design tools, as shown in Figure 1. In this design phase, the focus is on electrical modeling of the floor plan while addressing the physical I/O requirements of the IC, integrating the package substrate constraints and variables, and considering the multiple PCB platforms (form factors) with which the module is intended to work.

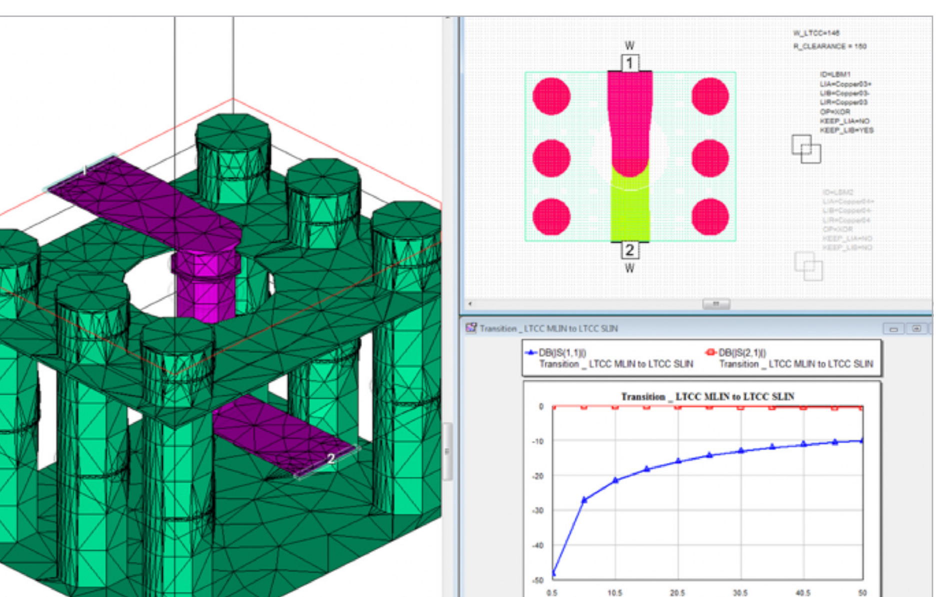


Figure 1: EM simulation is often required to electrically characterize passive components and interconnects such as transitions between layers of multi-layer substrates.

Interconnect Technology – EM Simulation and Modeling

Optimizing the performance of the transition is a common design requirement for module designs (Figure 2) with different IC and PCB process technologies. A superior design flow manages multiple, heterogeneous technologies within a single hierarchical project.

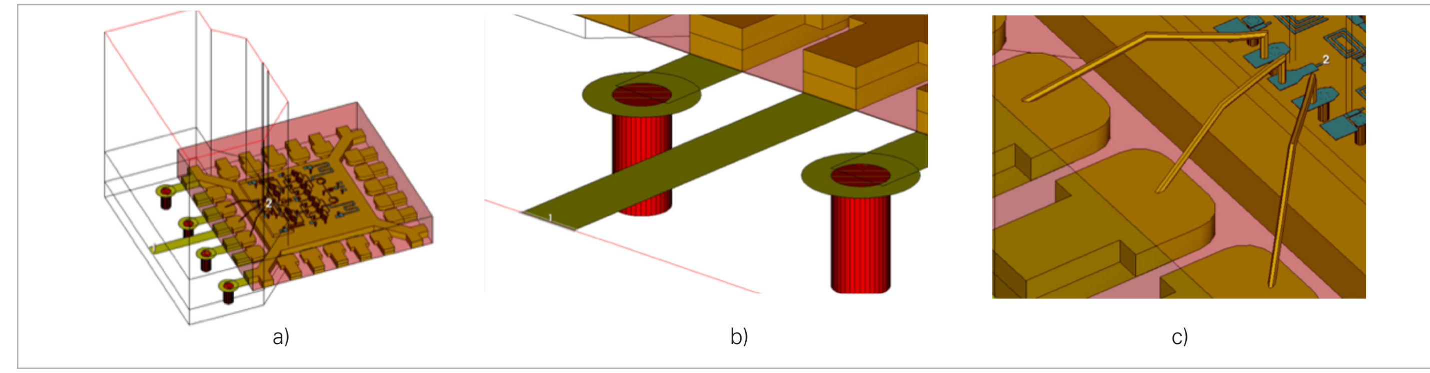


Figure 2: a) A MMIC in a QFN package on a Duroid board. The launch, Port 1, goes onto the flat package and then to the MMIC via bond wires at Port 2. b) Grounding vias from the board PDK. c) A closeup of the bond.

In this chip-package-board design flow, the layout is automatically "flattened" before being sent to the EM simulator, meaning the hierarchy of the layout is removed and the layout consists of the various dielectric layers and shapes of all the subcells merged into one layout. The design can therefore solve multi-technology layouts in place using the Analyst simulator or through the EM Socket™ technology to other 3D simulators without worrying about hierarchy and how layout cells are handled.

From the described module design flow, Microwave Office software enables users to quickly take advantage of features such as multiple PDKs and libraries for different physical technologies, the ability to drive multiple simulators from one set of layout rules, layer stackup definitions, and shape simplification rules, the use of 3D cells in a 2D layout to support both layouts in one environment, and control of EM simulation results from different simulators using data sets.

Synthesis and Embedded Antennas

Modules targeting 5G and IoT devices may need to offer embedded antenna solutions optimized for performance, cost, and size. Furthermore, multiple-in-multiple-out (MIMO) technology using multiple antennas on a single device will provide greater throughput and performance reliability. The AntSyn™ antenna synthesis module enables designers to synthesize compact MIMO antennas automatically from user requirements (Figure 3), enabling them to meet size, cost, and performance requirements. For example.

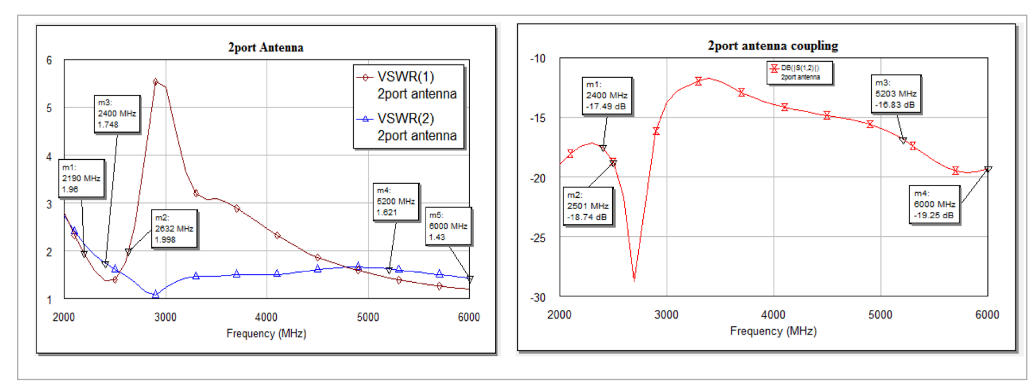


Figure 3: AntSyn results for two-port and three-port MIMO antennas

Conclusion

The rapid evolution of wireless connectivity has driven continual consumer thirst for more data throughput and reduced time to market. To meet market demand, companies will require multi-disciplinary engineering teams working together using a well-organized design flow that supports advanced design management, model libraries, integrated circuit, system, and EM co-simulation, and interoperability with CAD layout and multi-physics point tools. Fortunately, the design software and supporting test/measurement solutions needed to support advanced module development are available and continue to evolve in step with the products they help bring to life.

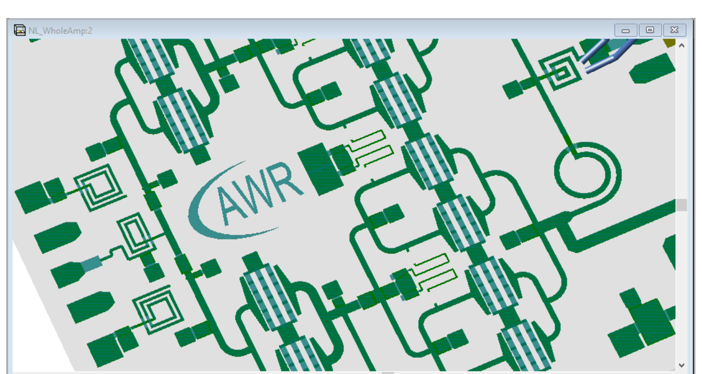
Software Spotlight

NI AWR Software V14.02 Now Released

An update to the NI AWR Design Environment platform V14 has been released and is now available to download for current customers and evaluators.

The NI AWR Design Environment platform provides RF/microwave engineers with integrated high-frequency circuit, system, and EM simulation technologies and design automation to develop physically-realizable electronics ready for manufacturing. The platform helps designers manage complex integrated-circuit (IC), package, and printed-circuit board (PCB) modeling, simulation, and verification, addressing all aspects of circuit behavior to achieve optimal performance and reliable results for first-pass success.

To learn more about NI AWR software V14 and specific details of the many improvements in V14.02, visit awrcorp.com/whats-new.



Highlights

User Interface

- The application programming interface (API) has been enhanced with numerous upgrades to access design editor information and control.

Layout

- Shape preprocessor (SPP) unique geometry simplification rules reshape circles and arcs with either an increase or decrease to the number of definition points.
- Visualization of the layout rendering for large designs has been improved for performance, along with numerous other layout improvements.

Simulators

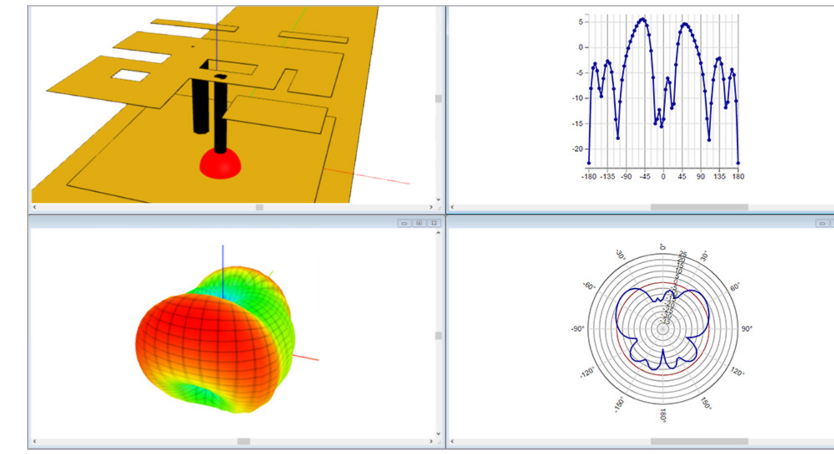
- Analyst™ EM simulator solver enhancements, including the use of wave port characteristic impedance method.
- APLAC harmonic-balance engine adds new functionalities to improve performance, including swept element parameters as a function of frequency.
- AXIEM EM simulator accuracy improved with enhancements to its Green's function/moment matrix, resulting in improved convergence.

Wizards

- The printed-circuit board (PCB) import wizard, the phased-array generator wizard, and the network synthesis wizard have been further enhanced in response to customer feedback.

AntSyn 3.1 Now Available

A new release of AntSyn software is now available for use by current customers and evaluators. This automated antenna design, synthesis, and optimization tool enables designers to input their requirements and produce antenna designs as outputs. The growing demand for wireless connectivity requires antenna solutions that are optimized for system performance, cost, and size. IoT accounts, like Striiv, have found this innovative EM-based synthesis tool valuable for designing antenna solutions for their products.



AntSyn 3.1 Highlights

User Interface

- Additional antennas added to the library bringing the total number of templates to 537
- New antenna types for series-fed patch arrays, as well as new waveguide-fed, dual-ridge, transverse electromagnetic (TEM) and multifunction horn antennas
- Ability to specify waveguide feeds, enabling the use of dozens of different commercially-available waveguides to feed many types of horns
- Timing information to guide users on expected simulation times for certain classes of antennas and the ability to sort/queue by expected time run
- Advance library search feature to narrow the number of displayed antennas according to user-specified attributes and/or descriptions

Application Spotlight: Antenna

Unique Design Method for a 3D Mesh Antenna

Advancing communications and sensor technologies for 5G, IoT, and radar-enabled smart vehicle applications requires more capable antennas and RF front-end components, pushing engineers to create novel designs based on evolving techniques and materials, advanced device integration, and greater exploration of the design space with unique topologies and architectures. The most recent capabilities in NI AWR software enable a unique antenna designs based on synthesis and simulation technologies.

Antenna Synthesis Example

To demonstrate the power of these emerging technologies, a 3D-mesh antenna was designed using AntSyn™ antenna design, synthesis, and optimization software, which utilizes genetic algorithms and simulates on Amazon's computing cloud.

A 3D-mesh antenna is in the class of evolved antennas consisting of a rod-shaped conductor (straight or 90-degree bending), intersected in a way that is synthesized by a computer-aided design (CAD) program, which can then be imported into a 3D electromagnetic (EM) analysis program such as the Analyst™ finite-element method (FEM) simulator for additional EM verification and tuning.

Synthesis results in a number of candidate antenna designs, each with an assigned quality rating that reflects how well the design met the antenna requirements. Users can review the results in AntSyn software and then export any of the model geometries to an EM simulator of choice for further analysis. The AntSyn software-generated structure and the resulting radiation pattern are shown in Figure 1.

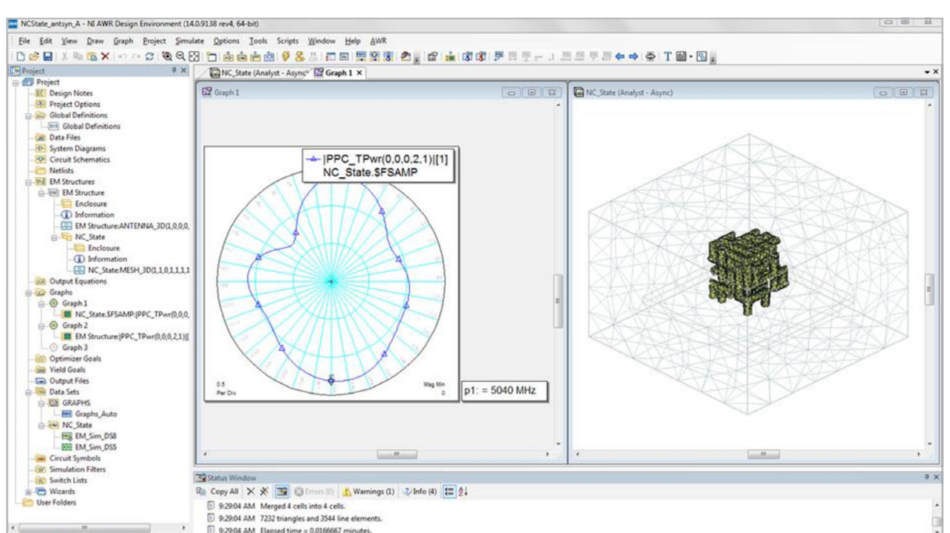


Figure 1: Synthesized antenna is imported into Analyst software for further EM analysis.

Fabrication

The 3D-mesh antenna, due to its highly complex structure, can be costly and difficult to build using the traditional machining method, however, it can be easily realized with 3D printing. The fabrication process for the 3D-mesh antenna is shown in Figure 2.

The AntSyn software model with minor modifications on the feeding port can be directly used for 3D printing. The input port of the antenna in the simulation model in Figure 2a was disconnected from the ground structures in order to manually add a coaxial connector port designed based on a standard SMA bulkhead mount connector. The model was 3D printed using a digital light processing (DLP) 3D printer and acrylate-based resin material. The resolution setting was 50 μm×50 μm×50 μm. A 45-degree orientation of the model was chosen, as shown in Figure 2b, allowing the number of external support structures to be minimized. The 3D printed antenna part was metalized (Figure 2c) by using a method developed by the authors, which is an electroless plating process adapted for 3D printing material coating the surface with ~100 nm thickness of silver. The metal layer thickness was increased to ~30 μm by using electrolytic copper plating.

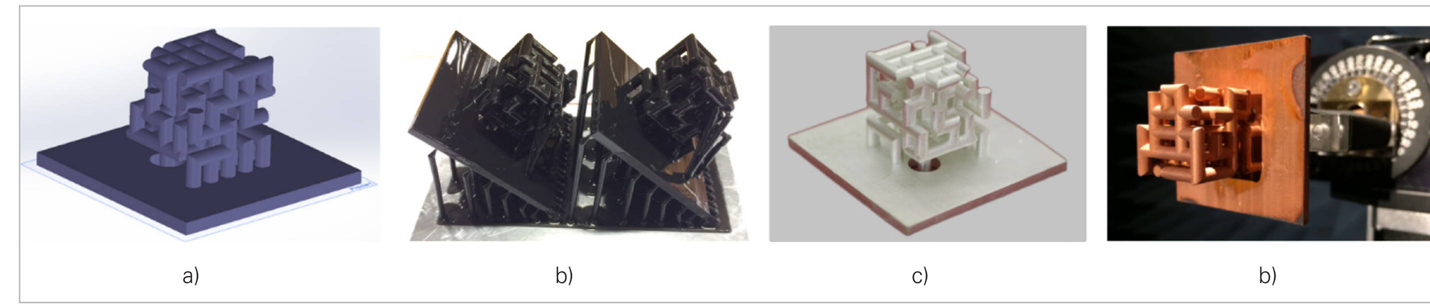


Figure 2: 3D mesh antenna prototyping: a) CAD model, b) 3D printed antenna, c) silver-coated antenna, d) plated antenna under test (image courtesy of J. Shen and D. S. Ricketts).

Test

The fabricated antenna was then mounted on a rotary station in the anechoic chamber for the pattern testing (Figure 2d). The S-parameters, gain, and radiation pattern of the 3D-mesh antenna were measured and compared to the EM simulation result, as shown in Figure 3.

The measured return loss shows the wideband matching from 4.6-5.4 GHz. The measured gain is around near 5 GHz. The measured patterns at E- and H-plane are consistent with the simulation result at 5 GHz. The discrepancy between the simulation and measurement could be raised by the dimension errors during the 3D printing process or the effect of coaxial feeding, which was not included in the simulation.

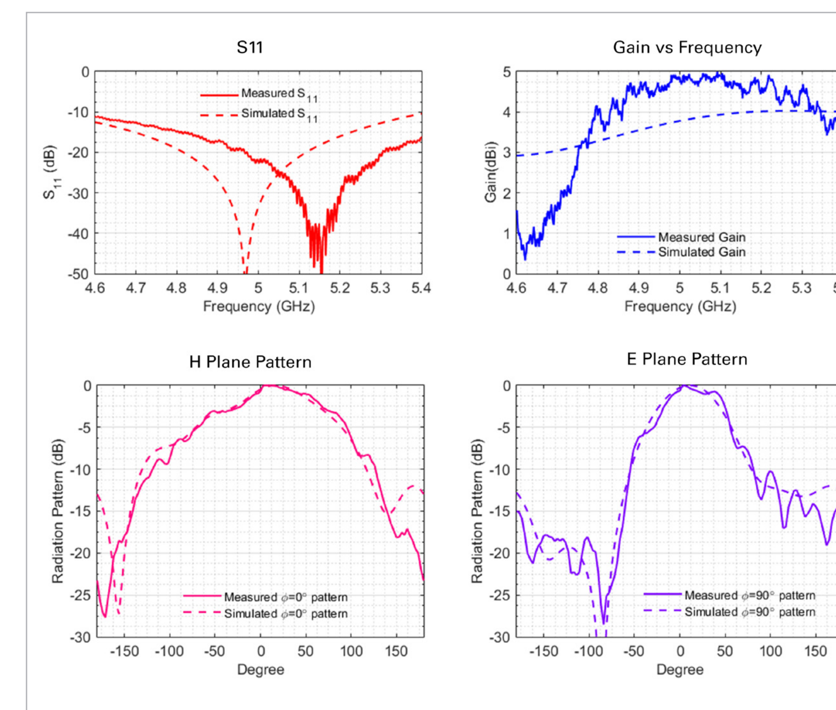


Figure 3: Comparison of measurement and Analyst result of the 3D mesh antenna (image courtesy of J. Shen and D. S. Ricketts).

Conclusion

A unique antenna design based on the new synthesis and simulation technologies within NI AWR software has been presented, which produces a high-performance, novel antenna through greater exploration of the design space than would be possible through older, traditional approaches. The simulated design provided the physical information required to create actual hardware through 3D printing. The resulting measured versus simulated radiation data showed excellent agreement, further validating this approach for future antenna development.

Note: Special thanks to Dr. David Ricketts and Junyu Shen, North Carolina State University, for their contributions to this example.

Academic Spotlight

Saratov State University: Professor Designs UHF Antenna Amplifier

Challenge

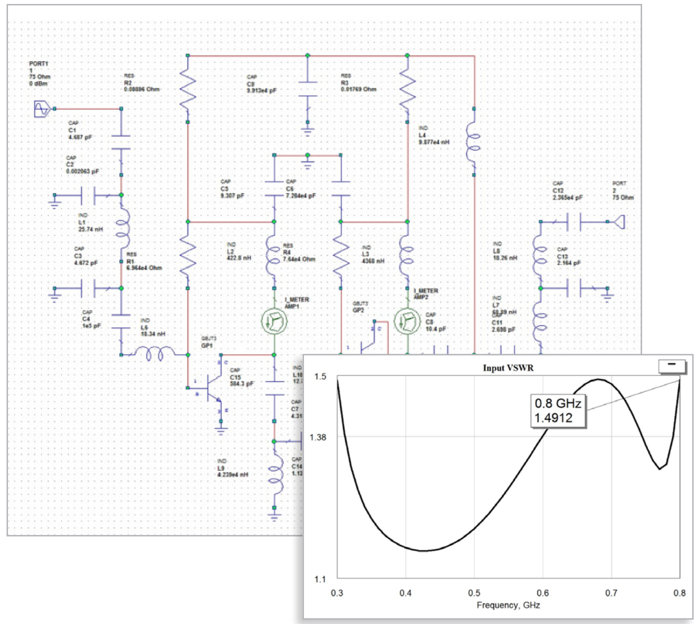
Saratov professor Alexander Khvalin co-authored with student and now RF engineer Alexey Voroblev a paper describing the development of a design method using an ultra-high frequency (UHF) antenna RF power amplifier (PA) based on structural and parametrical optimization.

Solution

The designer used the NI AWR Design Environment platform to model the amplifier in the 0.3-0.8 GHz frequency range because of its ease of use and the ability to use EM documents and schematics in one project.

Conclusion

The comprehensive documentation, technical support, and ability to consult with specialists, as well as the extensive element library and vast list of example projects in NI AWR software were key in the success of this senior thesis project.



Proposed amplifier model circuit schematic (bottom) and output VSWR versus frequency (top) .

> *"NI AWR software is a powerful EDA tool capable of simulating a complete functional device inclusive of microstrip layout. The intuitive user interface and efficient optimization engine were key to the success of this project."*
>
> *Alexander Khvalin and Alexey Vorovbiev, Saratov*

Moscow Technical University: Students Design Microwave Filters

Challenge

Moscow Technical University of Communication and Informatics (MTUCI) undergraduate student I. N. Kirilov and graduate student/Assistant Professor O.V. Arinin investigated a new type of filter structure and simulated a highly selective microstrip microwave filter on that basis.

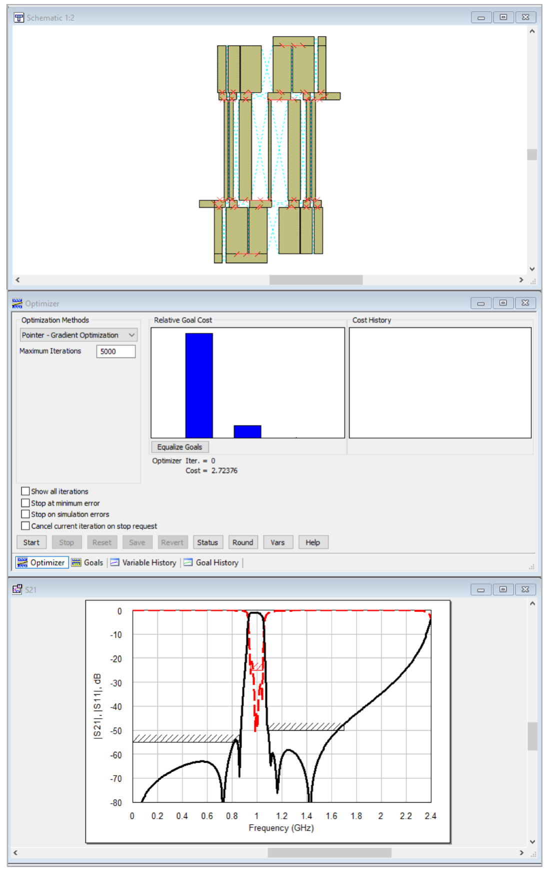
Solution

The students chose NI AWR Design Environment software for the initial analysis of the structure for this highly efficient filter. The software made it possible to quickly and accurately analyze the capabilities of this structure and achieve an increased frequency selectivity compared to traditional comb structures with additional EM couplings between non-adjacent resonators.

Conclusion

NI AWR Design Environment software was chosen for this project because the simple and intuitive user interface enabled them to easily learn how to work with modern software for developing communication systems and it offers a full set of tools for the design of both individual circuits and full communication systems.

> *"The ease of use of the NI AWR Design Environment platform enables my students to quickly get the rst results and makes it an ideal tool for skill learning and development."*
>
> *Oleg Arinin, MTUCI*



Structure of the six-resonator MSF with galvanic connection.

Resource Spotlight: AWR.TV

Recent additions to AWR.TV include:

PA Design

- Analysis of Power Amplifiers for 5G and MIMO Applications
- GaN on Si Process for Microwave and mmWave PAs
- Load Pull, Load Lines, Maximum Efficiency, and 3D Graphs
- How to: Network Synthesis Wizard

Filter Design

- Python Script-Controlled Filter Synthesis
- EM Planar Filter Frequency Response Optimization

Antenna Design

- Dual-band WiFi MIMO
- Design and Simulation of a Planar Inverted-F Antenna

Radar Design

- ADAS Automotive Radar System

Resource Spotlight: Resource Library

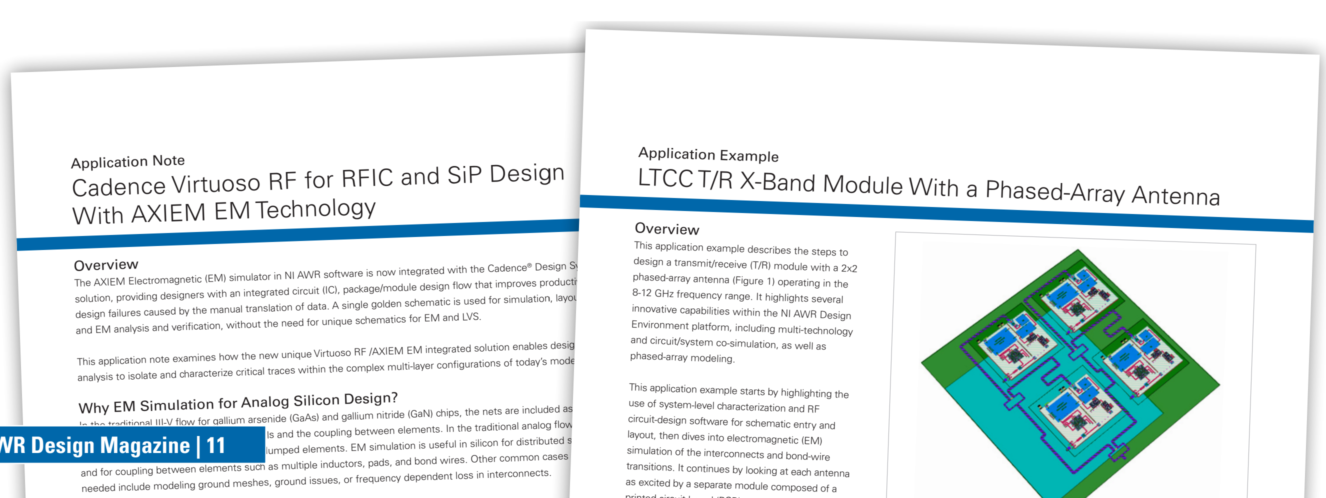
Recent additions to the Resource Library include:

White Papers

- Software Solutions for RF Module Development
- Design and Physical Realization of Phased-Array Antennas for MIMO and Beam-Steering Applications
- RFIC PA Development for Communication and Radar Systems: Basic Operations and Metrics
- Primer: Load-Pull Primer for Optimizing PA Performance

Application Notes

- AXIEM EM Simulator Within Cadence Virtuoso RF for RFIC/SiP Design
- LTCC T/R X-Band Module With a Phased-Array Antenna
- Network Synthesis Wizard Automates Interactive Matching-Circuit Design
- EM Verification of Complex Board Structures Streamlined With PCB Import Wizard



Application Note

Cadence Virtuoso RF for RFIC and SiP Design With AXIEM EM Technology

Overview

The AXIEM Electromagnetic (EM) simulator in NI AWR software is now integrated with the Cadence® Design S... solution, providing designers with an integrated circuit (IC), package/module design flow that improves producti... design failures caused by the manual translation of data. A single golden schematic is used for simulation, layou... and EM analysis and verification, without the need for unique schematics for EM and LVS.

This application note examines how the new unique Virtuoso RF /AXIEM EM integrated solution enables desig... analysis to isolate and characterize critical traces within the complex multi-layer configurations of today's mode...

Why EM Simulation for Analog Silicon Design?

...and gallium nitride (GaN) chips, the nets are included as ...ls and the coupling between elements. In the traditional analog flow ...lumped elements. EM simulation is useful in silicon for distributed s... and for coupling between elements such as multiple inductors, pads, and bond wires. Other common cases needed include modeling ground meshes, ground issues, or frequency dependent loss in interconnects.

Application Example

LTCC T/R X-Band Module With a Phased-Array Antenna

Overview

This application example describes the steps to design a transmit/receive (T/R) module with a 2x2 phased-array antenna (Figure 1) operating in the 8-12 GHz frequency range. It highlights several innovative capabilities within the NI AWR Design Environment platform, including multi-technology and circuit/system co-simulation, as well as phased-array modeling.

This application example starts by highlighting the use of system-level characterization and RF circuit-design software for schematic entry and layout, then dives into electromagnetic (EM) simulation of the interconnects and bond-wire transitions. It continues by looking at each antenna as excited by a separate module composed of a ...

Resource Spotlight: E-Learning

Recent additions to the E-Learning portal include:

Several new e-learning modules are now available for NI AWR Design Environment users and evaluators. A multi-part RF printed circuit board (PCB) layout import wizard, which runs approximately one hour, informs how to use the PCB layout import wizard for successful EM verification within Microwave Office circuit design software. It covers verification flows and layout file formats supported, and showcases a Zuken PCB design example through material, port, and mesh setup, as well as simulation.

The Planar EM In Depth module, part of the NI AWR software Planar Electromagnetic (EM) E-Learning Series, offers in-depth instruction on using the EM environment in Microwave Office circuit design software and covers the STACKUP, material setup, setting polygon properties, setting boundary conditions, and setting the grid.

RF PCB Import Wizard

- Discussion of Flows
- Layout File Formats
- Design Import Example
- EM Setup Example
- Meshing Best Practices
- Point Ports

Planar EM in Depth I

- EM within Microwave Office
- Process Creator
- LPF Examined
- Drawing Layers
- LPF (ASCII)

Planar EM in Depth II

- The STACKUP
- Material Setup
- Polygon Properties
- Boundary Conditions
- Grid Settings

Planar EM in Depth III

- Creating an EM Layout
- Drawing Polygons
- Navigating Layout
- Controlling the Layout Browser

Meet the Trainer

Dr. John Dunn is a senior engineer/ EM technologist at AWR Group, NI and spearheads our training programs. Before entering the commercial electronics industry, Dr. Dunn was a professor of electrical engineering at the University of Colorado, Boulder, for 15 years. He earned his M.S. and Ph.D. degrees in applied physics from Harvard University, Cambridge, MA, and his B.A. in physics from Carleton College, Northfield, MN.