

AWR Design Magazine ^{Vol.19.2}



Application Spotlight:
LTCC Design

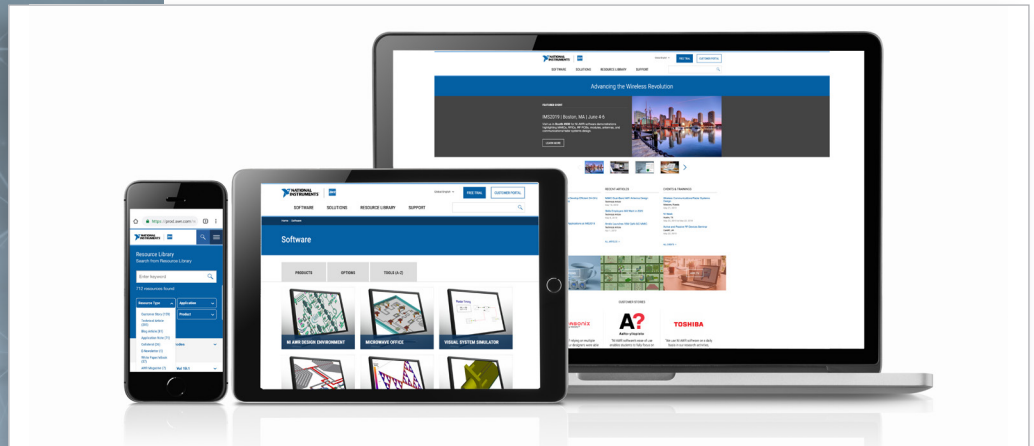
Software Spotlight:
Latest Release V14.03

Application Spotlight:
EM Inside Cadence

Success Stories:
Customer and
Academic

A Reimagined Website Enhances the User Experience

A completely reimagined ni.com/awr website is now live, which enhances the user experience and continues our commitment to supporting RF/microwave design productivity for our customers by making content easier to access from any device. The new site features a streamlined, modern design with a responsive interface that matches the look and feel of parent company National Instruments (ni.com) yet provides the NI AWR software community of users, whether viewing from a cellphone, laptop, or desktop, with a dedicated portal from which to learn more about our products and the solutions they deliver.



Highlights of the new site include:

- Improved functionality and an enhanced, more responsive user experience for both desktop and mobile devices
- Reimagined product, solution, and support menus offering fast and easy access to the content users seek
- Rich graphics that help viewers easily visualize the software and its many applications
- Expanded resource library including additional industry content as well newsletters and the popular AWR Design Magazine
- New cross-promotion feature providing fast and easy access to related content on article and customer stories pages
- New and updated datasheet and product collateral

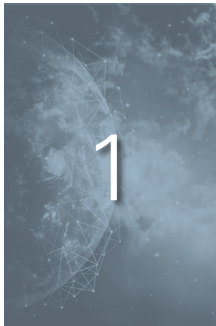
If you haven't explored our redesigned site yet, please take some time to experience it at ni.com/awr and share your thoughts/comments with us about what you like and perhaps ways to improve it further. You can send your impressions to us at awr.marketing@ni.com.

Best regards,

Sherry Hess
Vice President of Marketing
AWR Group, NI

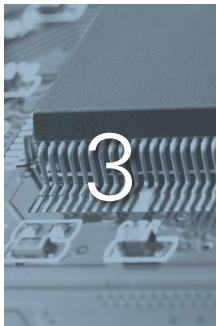


Table of Contents



Viewpoint: ni.com/awr

A reimagined website enhances the user experience



Application Spotlight: LTCC Design

10 steps for designing a transmit/receive (T/R) module with a 2x2 phased-array antenna



Software Spotlight: NI AWR Software

Key enhancements to the V14.03 release



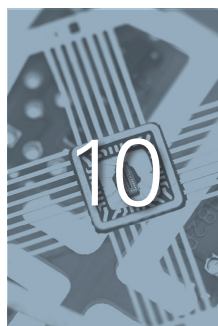
Application Spotlight: EM Inside Cadence

AXIEM EM simulator within Cadence Virtuoso RF for RFIC/SiP Design



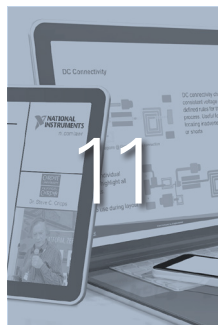
Academic Spotlight: University of Bath

An antenna array for locating GPS interference



Academic Spotlight: University of L'Aquila

An active filter design methodology



Resource Spotlight: AWR.TV & Resource Library

The latest YouTube videos and technical resources



Resource Spotlight: E-Learning Portal

Recent online training modules



Customer Spotlight: CommScope

Inverted-F antenna for LTE



Customer Spotlight: Lexiwave

24-GHz radar antenna array

LTCC Transmit/Receive X-Band Module

Overview

NI AWR Design Environment software provides several innovative capabilities for designing phased-array antennas, including multi-technology and circuit/system co-simulation, as well as phased-array modeling. This application example presents 10 steps for designing a transmit/receive (T/R) module with a 2x2 phased-array antenna (Figure 1) operating in the 8-12 GHz frequency range.

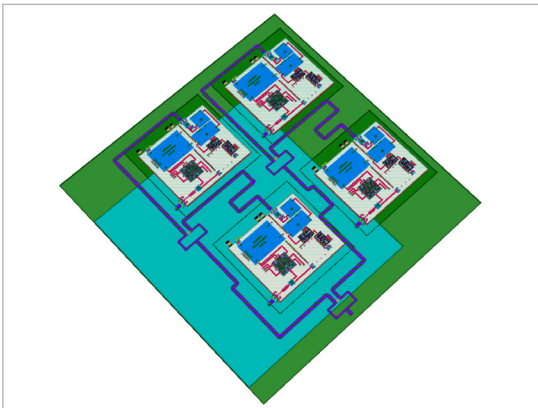


Figure 1: T/R module with 2x2 phased-array antenna.

It 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 printed-circuit board (PCB) as the mother board, low temperature co-fired ceramic (LTCC) technology for embedded passive components and as a platform for the microwave monolithic integrated circuit (MMIC) and dies, a

MMIC for the power amplifier (PA), a PA driver, a phase shifter, an attenuator, vendor or internally-designed components, transitions such as bond wires, microstrips, and striplines (MLIN/SLIN) (Figure 2), and an antenna.

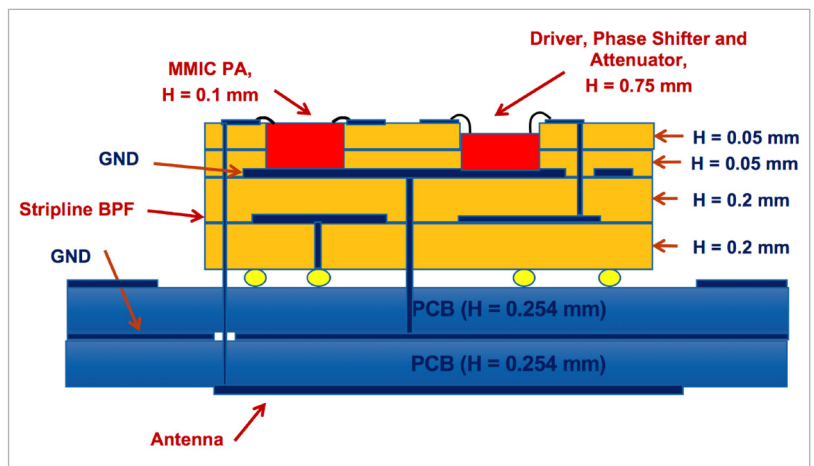


Figure 2: Simplified STACKUP for the module.

Several NI AWR software tools are highlighted throughout the design flow, including Visual System Simulator™ (VSS) software for system-level characterization, Microwave Office circuit design software for schematic entry and layout, AXIEM and Analyst™ simulators for EM simulation of the interconnects and transitions (bond wires), and AntSyn™ antenna synthesis and optimization software for the phased-array antenna design, as well as several specialized synthesis wizards.

The multi-technology capability in the NI AWR Design Environment platform enables the use of different technologies, including gallium arsenide (GaAs) chips, LTCC modules, and Duroid boards, seamlessly at the circuit, layout, and EM simulation levels, all within the same project. NI AWR software co-simulation provides the ability to work at both the circuit level and system level in a single environment. The software's specialized synthesis tools are useful for designing the filters and components. EM simulation is easily used where needed without leaving the Microwave Office environment.

Step 1: Designing the System

Figure 3 is the system design diagram for this example, which uses the VSS Tx/Rx-mode test bench. At the system level, hierarchy was used to inject signals on the left (Tx continuous wave [CW] test) and on the right (Rx CW test), which could be switched with VSS components (middle). The T/R module was used as a subcircuit within the system design.

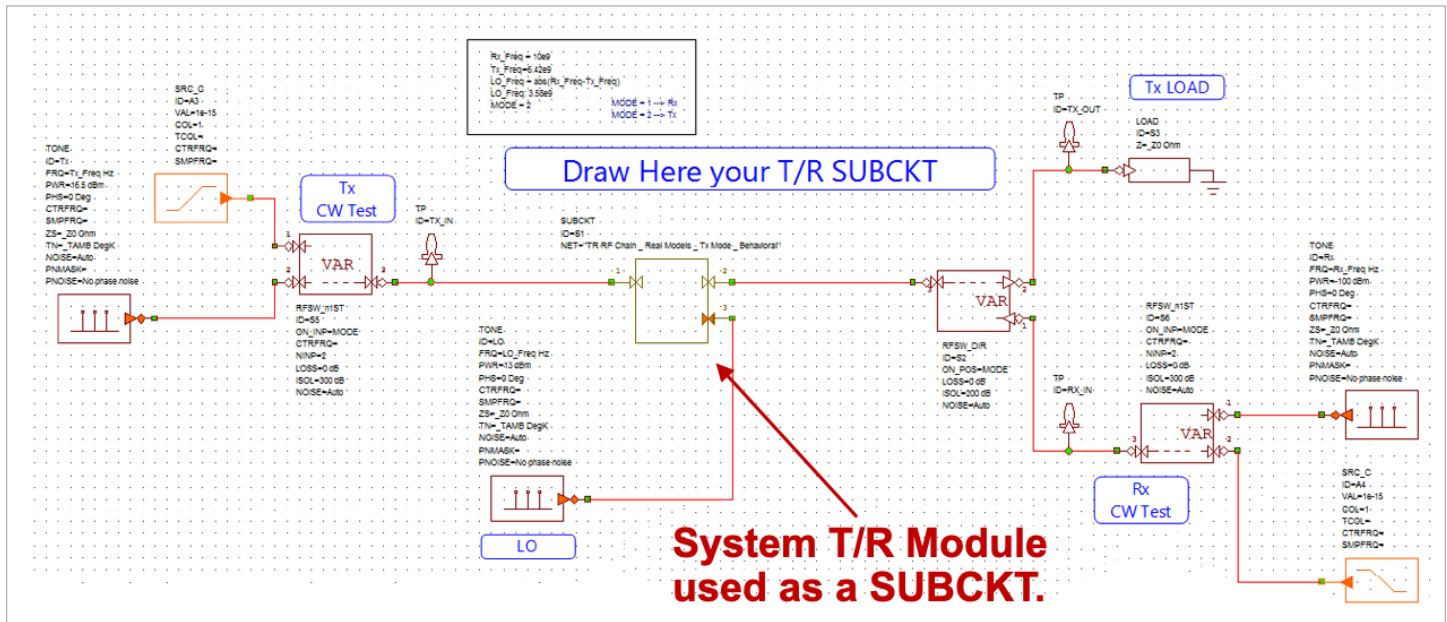


Figure 3: System design diagram, including T/R module subcircuit.

Step 2: Creating the PCB/LTCC

Next, the PCB and LTCC were designed. The PCB contains two dielectric layers, on top of which sits an LTCC, including a MMIC PA. The process creator technology in NI AWR Design Environment software generated the STACKUP and intelligent net (iNet™) technology was used for generating the layout files, cells, and other substrate blocks.

Step 3: Designing the Antenna

The next stage was to design the antennas. The 2x2 array was designed using the AntSyn EM-based antenna synthesis tool. The goals of the antenna design and classes of antennas to explore were specified and then the AntSyn tool found the optimal antenna automatically based on the chosen parameters (Figure 4).

Step 4: Importing the MMIC

NI AWR software multi-technology allows designers to include several PDK technologies such as PCBs, LTCCs MMICs, and RFICs in the same project. The MMIC was imported with all the MMIC process definitions, including global definitions, low-pass filter (LPF), schematic, layout, linear and nonlinear models, and more.

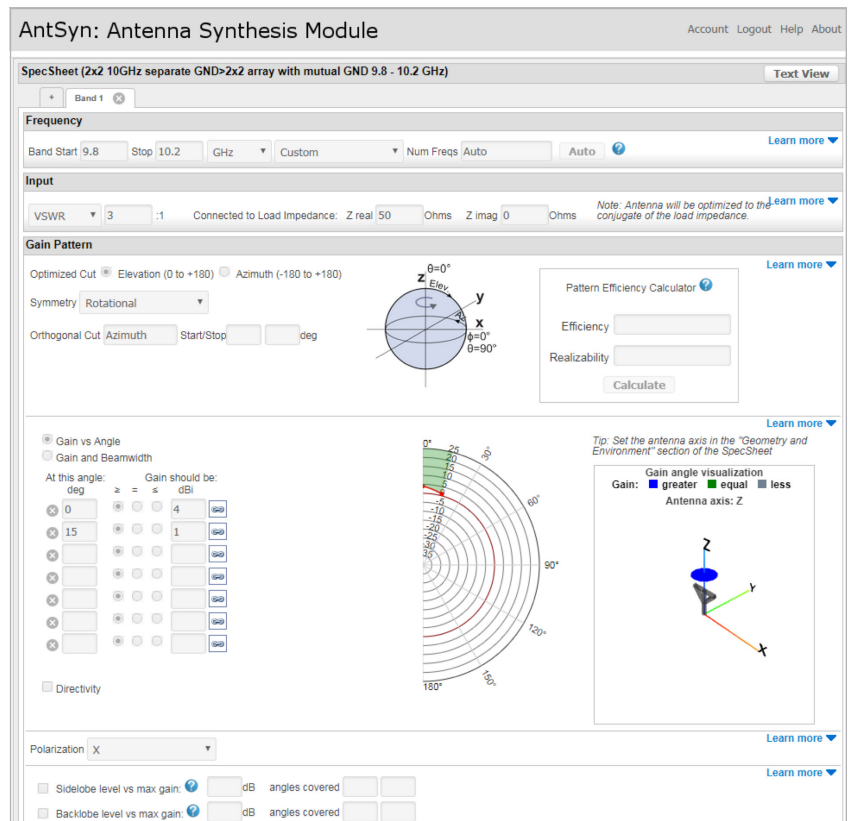


Figure 4: The AntSyn antenna synthesis tool interface.

Step 5: Designing and Simulating the Signal Path

Next, Analyst software was used to design and simulate the signal path, had transitions from the MMIC PDK to the LTCC PDK using dual bond wires. The distance between the bond wires and their length was optimized and the transitions were optimized up to 50 GHz.

Step 6: Completing the Circuit

With the designs finished, everything was then combined into a single schematic, which included the stripline BPF, the vendor models, the imported MMIC PA, and all of the transition models.

Step 7: Importing the LNA

As with the MMIC PA, the LNA model was imported from another project and bond wires and bias lines are added.

Step 8: Completing the Module

The T/R module in this example used a time-division duplex (TDD) approach. A vendor switch model was added (S3P and layout). Figure 5 shows the schematic model, layout model, and the transitions.

Step 9: Optimizing the Antenna Match

The matching of the antenna was then performed, which was a bidirectional matching from the antenna into the PA itself. Once the EM models were parameterized, the antenna matching circuit could be optimized.

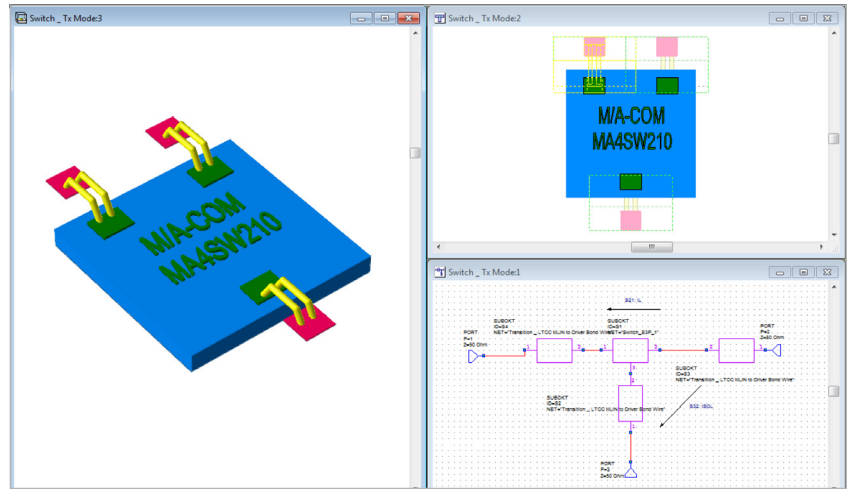


Figure 5: The schematic model, layout model, and transitions.

Step 10: Verifying System-Level Performance

The final step was to verify the performance of the module at the system level using real signals. The model was imported into VSS software and modulated signals such as quadrature phase-shift keying (QPSK), quadrature amplitude modulation (QAM), wireless local area network (WLAN) 802.11, LTE, 5G, and others, were injected into the module for testing. Figure 6 shows the error-vector magnitude (EVM) (top left), the spectrum (top middle), the modulation (top right), the spectrum (lower left), and the spectrum of the single tone (lower right). The lower middle is the entire design.

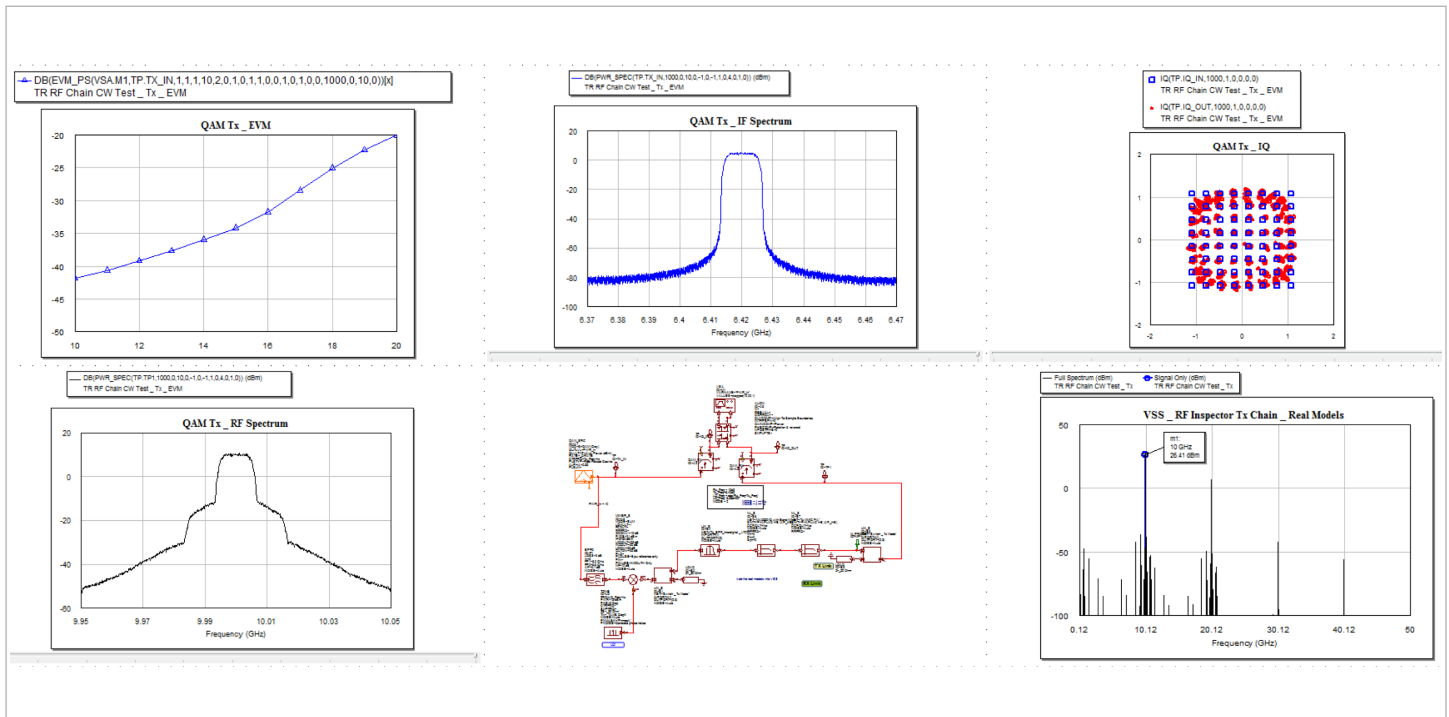


Figure 10: Performance system simulations of the module.

Software Spotlight



NI AWR Design Environment: Latest Release

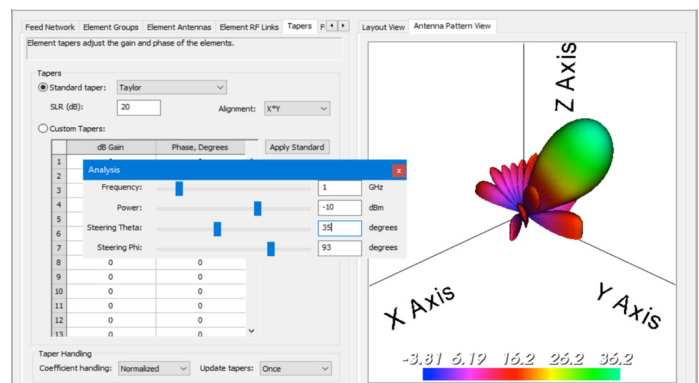
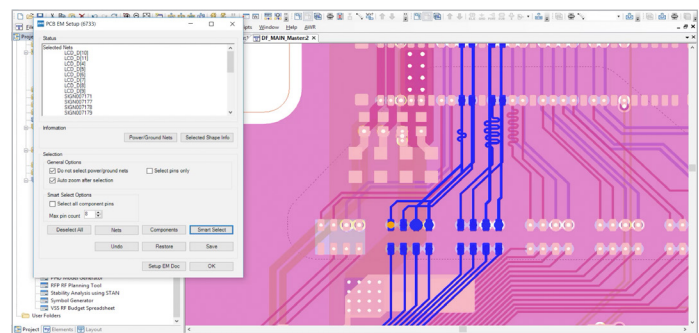
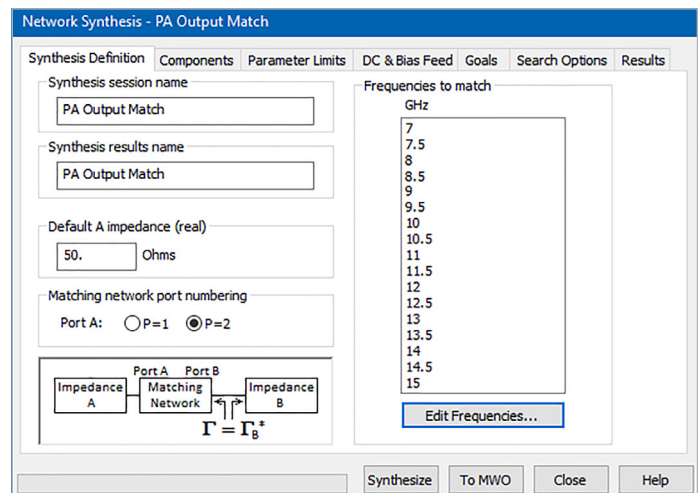
The V14.03 release of NI AWR Design Environment software is now available for current customers and evaluators to download on ni.com/awr. Enhancements to the software application programming interface (API), PCB import wizard, load-pull technology, and more are included in this update. Visit the dedicated V14 landing page at awr.com/whatsnew to learn more.

NI AWR software users are reminded that the V14 release of NI AWR Design Environment software continued our commitment to delivering software solutions that empower RF/microwave designers with a superior user experience, enabling them to focus on developing products that meet stringent performance and time-to-market requirements.

New technologies released in V14 included:

- Network synthesis wizard for expediting design starts by empowering engineers with the ability to interactively develop networks optimized for noise, power, or matching networks between amplifier stages or between different components, such as an amplifier and antenna
- PCB import wizard for smart editing and interactively isolating critical board sections/nets and multi-layer interconnects from imported data, generating simulation-ready EM structures
- Phased-array generator wizard for configuring phased-array antenna systems and generating a schematic-based circuit/system/antenna network of the optimized array and feed network

To learn more about the breadth of capabilities in NI AWR software, reach out to your [local sales representative](#).



Application Spotlight: EM Inside Cadence

AXIEM EM Simulator Within Cadence Virtuoso RF for RFIC/SiP Design

Overview

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

Using the AXIEM Simulator With Cadence Virtuoso RF

The AXIEM EM simulator within Microwave Office circuit design software is a best-in-class planar, open boundary 3D planar engine that solves for currents on horizontal metal traces and vertical vias. Prior to the Virtuoso RF integration of the AXIEM EM solver, users of both tools relied upon manual integration, namely exporting and importing the layout between the Virtuoso environment and the AXIEM simulator within the Microwave Office environment.

Integrated AXIEM Solver/Cadence Virtuoso RF Flow

The integrated AXIEM EM solver within the Cadence IC/ System-in-Package (SiP) flow for layout of silicon ICs provides design optimization and layout verification within a single schematic.

Traditionally, layout and schematic are loosely coupled in Cadence software. The golden schematic couples much more tightly with the layout, reducing error and saving time. Figure 1 shows the golden schematic on the left and the AXIEM spiral layout in Virtuoso RF. The model assistant is docked on the right side of the layout window.

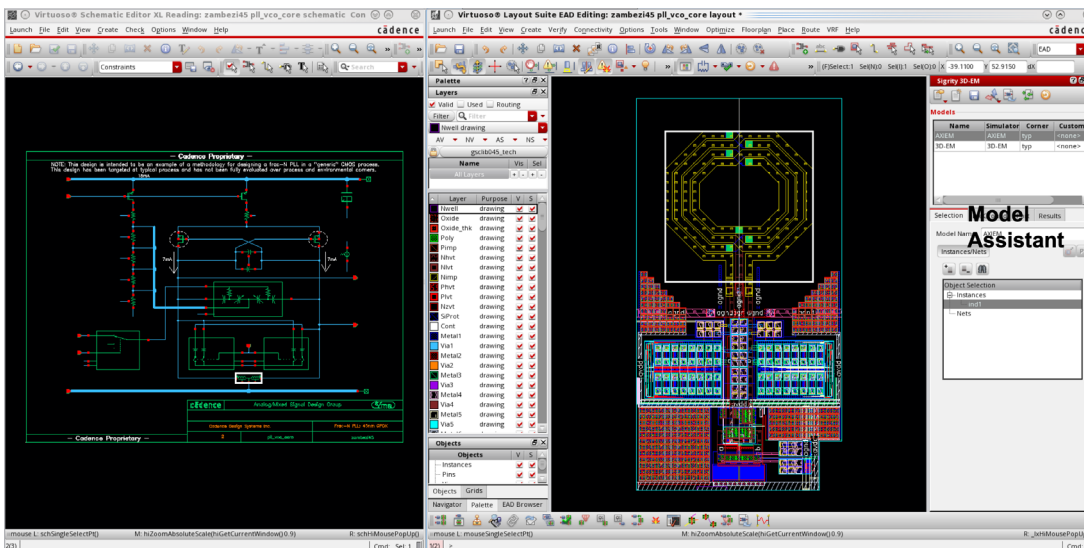


Figure 1: AXIEM model in Virtuoso RF.

The white box drawn around the spiral is the limit of the layout that is extracted to AXIEM software, in this case the spiral and feed lines. Ports are automatically attached to the feed lines once the layout is placed in the AXIEM simulator. There is no need for the designer to add ports; they are added wherever the feed lines hit the simulation boundary in the Virtuoso layout. The box on the far right is the model assistant. It enables the designer to set the AXIEM simulator nets and various control options.

The Process Setup in Virtuoso RF

For it to work properly, AXIEM software requires that the STACKUP properties, material properties, and various simulation settings be configured. These settings reside in the Virtuoso modeling assistant.

Figure 2 shows the process design kit (PDK) setup in the model assistant with several representative menus, for example, dielectric and via properties are shown in the middle picture, where the silicon material properties and layer thicknesses are listed.

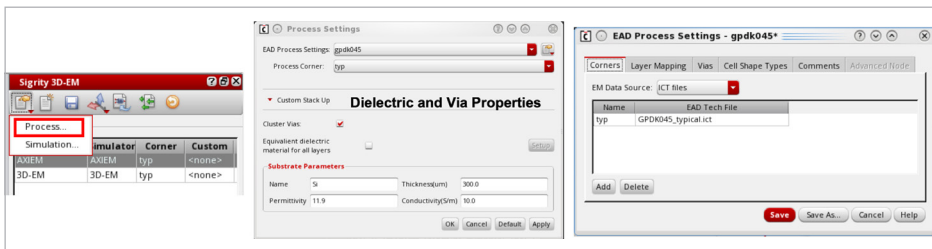


Figure 2: PDK setup in the Virtuoso model assistant.

There are some preview and diagnostic capabilities built into the AXIEM integration. Figure 3 illustrates how the mesh can quickly be previewed in the AXIEM model to understand the density that will be used and the accuracy level.¹ Note that in this example the mesh density is relatively sparse. There is a nice 3D view of the mesh on the surface of the inductor. Thick metal with side walls is being used to capture the coupling. The meshing density can be adjusted in the AXIEM setup menus if desired.

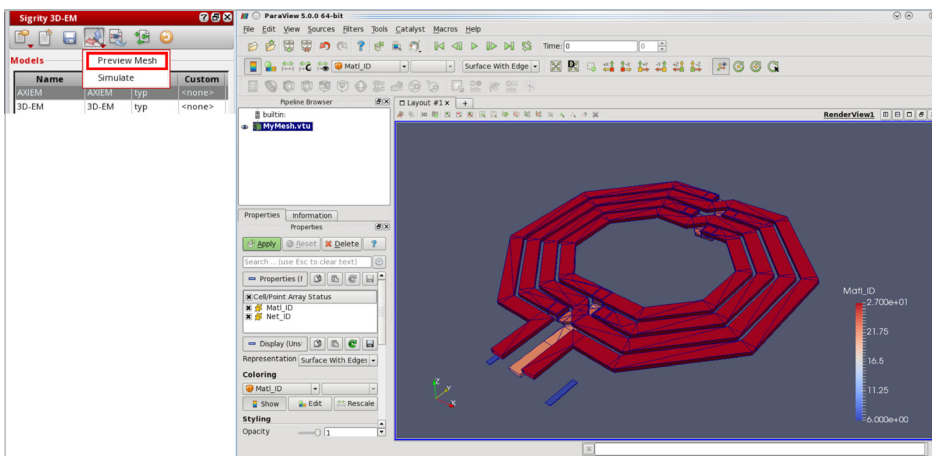


Figure 3: Mesh preview in the AXIEM simulator.

The goal of the Virtuoso RF/AXIEM EM solver flow is to enable the designer to stay within Virtuoso RF environment and yet gain access to S-parameters with full-wave accuracy. After the S-parameters are generated, the model in the golden schematic is replaced with the S-parameter results. The extracted view is then created, and the model in the schematic is replaced with the S-parameters.

Conclusion

As frequencies of operation push upward, EM simulators are becoming more and more critical for RFIC designers. Distributed effects, such as inductors, become important, as do frequency-dependent effects such as resistance. Grounding issues become critical and must be accounted for in simulations. Structures such as meshed ground planes and rings need to be EM simulated to ensure they are modeled correctly. Coupling effects between various components, which are not included in models, become an issue and must be EM simulated.

The AXIEM EM solver/Cadence Virtuoso RF design flow seamlessly integrates the process of accounting for EM effects within a circuit design project by enabling a single environment for simulation, LVS, and EM analysis and verification, without the need for unique schematics for EM and LVS. This new flow reduces the chance of error and cuts design time and verification cycles.



Antenna Array for Locating GPS Interference

Challenge

Elizabeth Lloyd, student at the University of Bath, was challenged in her doctoral research project to design a low-cost antenna array suited to the location of RF emitters that cause GPS interference.

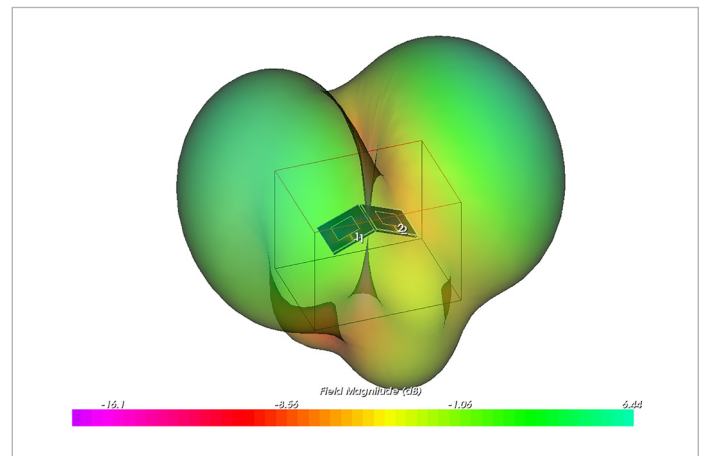
Solution

Lloyd chose Microwave Office circuit design software, which provided both the AXIEM planar and Analyst 3D FEM EM solvers needed for her innovative array composed of two planar antennas and a third 3D antenna.

With the Analyst 3D viewer, she was able to easily see the entire antenna pattern, which revealed problems that never would have been noticed using just a 2D view. This allowed her to focus on the designs that showed promise, reducing the amount of testing required.

Conclusion

NI AWR software was chosen because the University of Bath's electrical engineering students have free access to the software and all the tutorials, as well as outstanding accessible training and support.

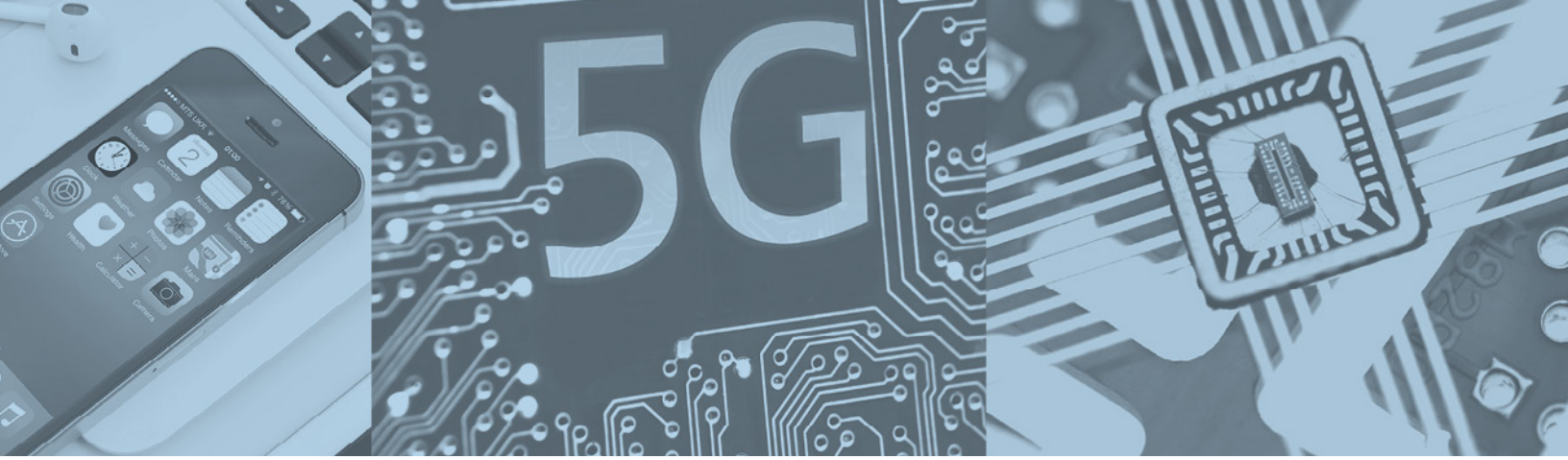


3D layout of antennas in Analyst showing the radiation pattern.



"For my 3D antenna design, it was easy to see the entire antenna pattern with the Analyst 3D EM software viewer, which revealed problems that never would have been noticed using just a 2D view."

Elizabeth M. Lloyd, University of Bath



Active Filter Design Methodology

Challenge

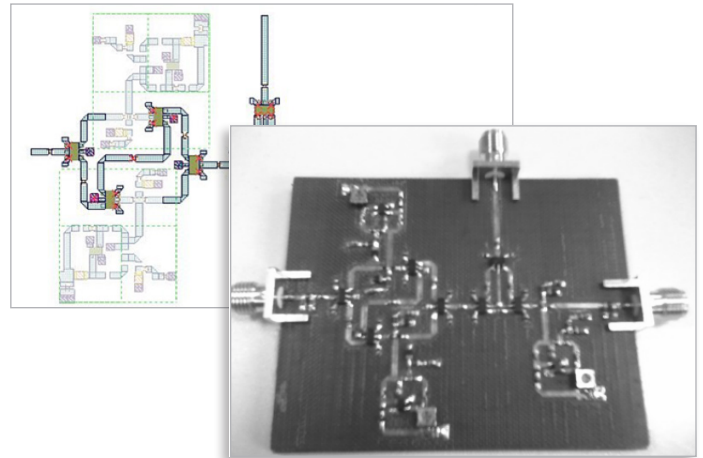
Dr. Leonardo Pantoli, researcher at the University of L'Aquila, was challenged to develop a methodology for designing high-quality active filters with tunable center frequency, low loss, high-dynamic range, and low-power consumption, all within a small footprint.

Solution

As an example, a high-order tunable filter was chosen to provide a feasibility demonstration of the proposed approach whereby each cell was composed of a shunt L-C cell and two series capacitances. Low-loss switches were added between the cells, enabling individual tuning and characterization, as well as the cascading of the three cells for full filter action.

Conclusion

The AXIEM simulator provided up to 50 percent reduction in EM simulation time without compromising the accuracy. Most importantly, NI AWR software converged on a good solution and was the only design solution able to solve the problem.



Microwave Office layout of the filter design and photo of the hybrid filter prototype.



"The optimization algorithms in NI AWR software provided a unique methodology for my active filter designs. I found it to be the only available software that was able to quickly converge on the correct solution and solve the design problem."

Dr. Leonardo Pantoli, University of L'Aquila

[AWR.TV](#) is a comprehensive, multimedia resource for technical and product information pertaining to NI AWR software features, applications and solutions. Recent additions to [AWR.TV](#) include:

- How to: Analysis of Power Amplifiers for 5G and MIMO
- Design Example: OMMIC GaN on Si for PAs
- PA Design: Teledyne's High-Efficiency PAs
- Feature: Python Scripting for Filter Synthesis



Resource Library

The Resource Library on ni.com/awr is a dedicated and searchable landing page for technical content on NI AWR software products, and solutions. Recent additions to the [Resource Library](#) include:

Webinars

- An Enhanced Design Flow for Cavity Combine Filters
- Virtual Antenna Matching-Circuit Design and Integration for IoT Devices
- GaN Electrothermal Modeling for 5G MMIC Power Amplifier Design

White Papers

- A Designer's Primer on Internet of Things (IoT)
- A Designer's Primer on 5G Communications
- Software Solutions for RF Module Development
- Design and Physical Realization of Phased-Array Antennas for MIMO and Beam-Steering Applications

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



Online Training Modules

The E-learning portal offers self-paced video modules that enable users to learn at their own pace and as their schedule permits. Current modules include harmonic balance, layout, EM simulation, and more.

Visual System Simulator: ▪ Components ▪ Co-Simulation ▪ Model Option ▪ RF Link ▪ Phased Array

Microwave Office: ▪ Environment ▪ Hotkeys ▪ Drawing ▪ EM Extract

Harmonic Balance: ▪ HB Basics ▪ Measurements ▪ Two-Tone ▪ Sweeps/Power ▪ Mixer

Layout: ▪ Drawing Basics ▪ Import/Export ▪ Layout Cells

EM Simulation: ▪ Project Creation ▪ Properties/Setup ▪ AXIEM ▪ EMSight ▪ Analyst

EM Advanced Features: ▪ Process Creator ▪ Data Sets ▪ Shape Modifiers ▪ EM Extraction

Analyst 3D FEM EM: ▪ 3D Cells ▪ Coil ▪ Extrusion ▪ Intersection

Multi-Technology: ▪ Libraries/PDKs ▪ Multiple Libraries ▪ Units/Position ▪ EM Multi-Tech

Antenna Synthesis: ▪ Wi-Fi Antenna ▪ AXIEM Export ▪ Analyst Export



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.

Recent Additions

RF PCB Import Wizard: ▪ 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

Learn more at awr.com/elearning.

COMMSCOPE®

Inverted-F Antenna

Challenge

Johannes Steigert, an RF engineer at multi-national network infrastructure provider CommScope, was challenged to develop an inverted-F antenna (Figure 1) for a mobile communications sub-1 GHz band. The dimensions of the PCB severely limited the available space for the antenna, requiring difficult tradeoffs between the theoretical design and gain, efficiency, and broadband performance.

Solution

The design entry and management capabilities of Microwave Office circuit design software combined with the speed of the AXIEM EM simulator helped the team cut the number of various prototype design spins and delivered a first-time-right solution. Microwave Office software and the AXIEM EM optimizer functionality (Figure 2) were used to match the antenna for the LTE Band 13.

Steigert found that NI AWR software, in comparison to similar products, provided the best modeling of the real antenna, thus saving significant development time and costs compared to conventional prototyping approaches. He highlighted the ease of use of the software combined with its simulation speed and ability to deliver highly complex solutions in a short time as key benefits of using NI AWR software. Of particular note were the outstanding technical support, exhaustive examples, and widespread knowledgebase.

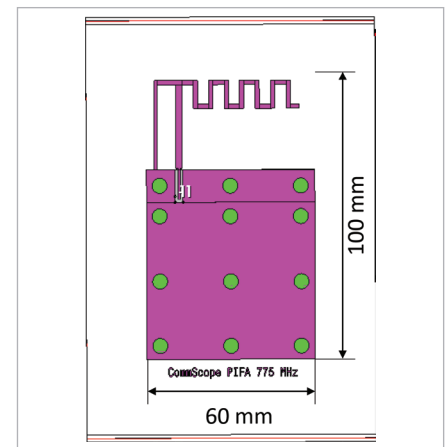


Figure 1: Planar inverted-F antenna.

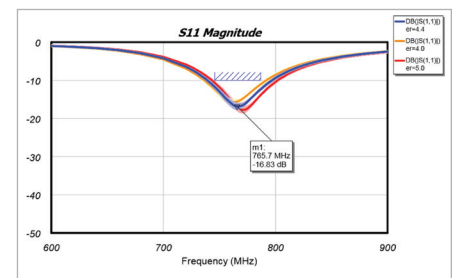


Figure 2: Yield analysis used to verify the LTE Band 13 matching performance.



“NI AWR software combines simplicity with the ability to deliver highly-complex solutions in less time compared to conventional development approaches.”

Johannes Steigert, CommScope



24-GHz Radar Antenna Array

Challenge

Designers at Lexiwave Technology Ltd., a communications RF system and integrated circuit (RFIC) provider, required a sophisticated software platform that would enable them to efficiently design commercial sensors such as the 24-GHz short-range, object-detection, and distance-measurement radar antenna array shown in Figure 1.

Solution

The designers chose NI AWR Design Environment software, specifically AXIEM and Analyst EM simulators, as well as the AntSyn antenna design and synthesis tool, based on the design features, ease of use, and fast and robust meshing technology, as well as their confidence in the software's ability to efficiently run simulations and accurately predict performance. NI AWR software enabled Lexiwave designers to quickly and accurately predict the input impedance, radiation pattern, and efficiency of their antenna design. This enabled the designers to eliminate two design cycles, enhancing their productivity and lowering development costs. Figure 2 shows the AXIEM layout of the antenna array for the 24-GHz radar module design.

NI AWR software enabled Lexiwave designers to quickly and accurately predict the input impedance, radiation pattern, and efficiency of their antenna design. In addition, the company credits their design success to an RF design suite that offers design and simulation in one environment, as well as the AntSyn antenna design and synthesis tool, which accelerated their design start and helped them to more fully explore their design options.

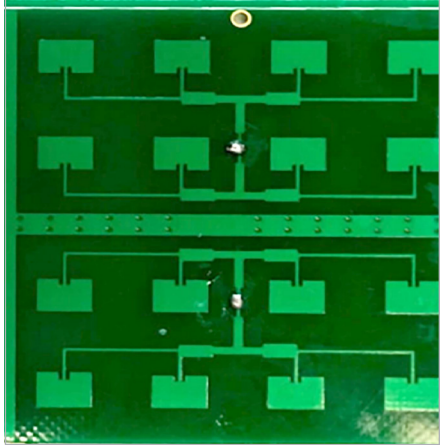


Figure 1: Photo of the 24-GHz antenna array.

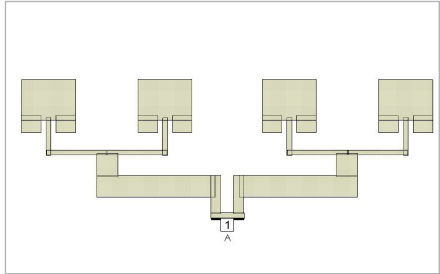
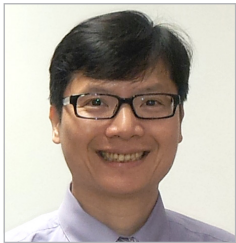


Figure 2: AXIEM layout of the antenna array for the 24-GHz radar module.



“NI AWR software is the only design platform that offers not only a complete suite of tools for efficient and accurate antenna design and simulation, but also an antenna synthesis tool, which shortened our design time significantly.”

Henry Lau, Lexiwave Technology Ltd.

TOMORROW'S DESIGNS REQUIRE
SMARTER
SOFTWARE TODAY



NI AWR Design Environment software provides a seamless platform for developing next-generation wireless electronics and communications systems, from concept to product. Its powerful interface, integrated system, circuit, and electromagnetic simulation technologies, and design flow automation ensures your design success.

Visit awr.com/smarterdesign to learn more.