AWR Design Magazine

Vol.18.0

- Network Synthesis
- PCB & Phased-Array Wizards
- New EM Ports & More

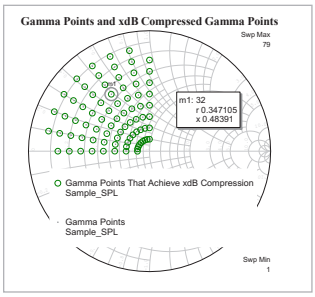
NI AWR SOFTWARE V14 PREVIEW

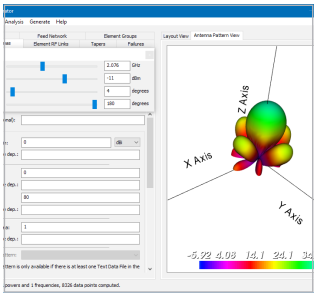
ni.com/awr

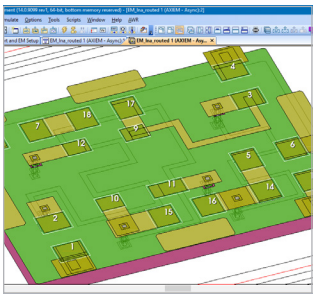
NATIONAL INSTRUMENTS

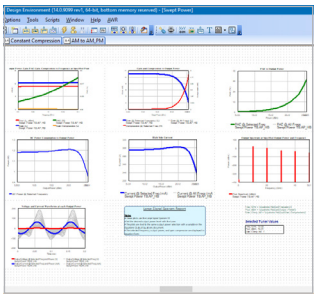
V14 Debuts at IMS2018

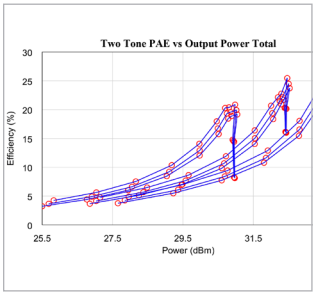
The upcoming V14 release of NI AWR Design Environment software continues our commitment to building products that empower RF/microwave designers with a superior user experience, enabling them to focus on developing solutions that meet stringent customer performance and product delivery requirements.

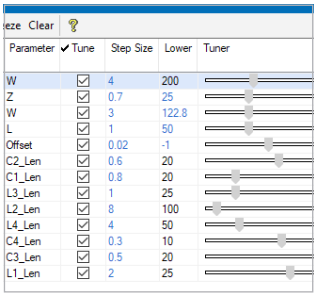












With new technologies like network synthesis, V14 jumpstarts and streamlines design by empowering engineers with the ability to interactively develop networks optimized for noise, power, or matching networks between amplifier stages or between different components, such as an amplifier and antenna.

V14 does so with powerful automation and specialized design wizards, including new editing capabilities for EM verification of complex printed circuit boards (PCBs) and a proprietary phased-array antenna wizard that expedites the creation of antenna systems for communications and radar applications.

V14 does so with centralized management of measurement data sources and parameters to create and manage great looking reports with automation that reduces engineering effort.

And lastly, V14 does so with additional enhancements to design tools such as a major upgrade to its innovative tuner bar that accelerate RF product development.

To learn more about the breadth of new features and enhancements in V14, read through the pages of this magazine and visit the dedicated V14 landing page at awrcorp.com/whatsnew.

Best regards,

Sherry Hess
Vice President of Marketing
AWR Group, NI

Happy 20th Birthday Microwave Office

We're proud to note that IMS2018 marks the 20th anniversary of Microwave Office software debuting at this show in 1998.

Readers can follow along online as we celebrate this occasion with a dedicated blog series at awrcorp.com/blogs. The first one features our innovative new tuning bar and more will follow that spotlight the many innovations introduced in our software product line over the years.

Table of Contents

Customer Spotlight: Wolfspeed, A Cree Company

Compact PA solution using novel GaN process and NI AWR software

Software Spotlight: Network Synthesis

Automated interactive matching circuit design addresses broadband/multiband PA requirements

Customer Spotlights: Fractus Antennas, SARAS Technology, & Slipstream Design

From antennas to power amplifiers, NI AWR software drives customer success

Application Spotlight: PA Design

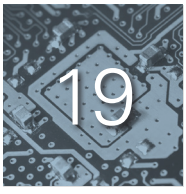
Quasonix achieves first-pass success for telemetry system designs

Software Spotlight: V14 Preview

Accelerating RF/microwave designs from concept to product

Application Spotlight: 5G Communications

Test bench supports base-station PA design

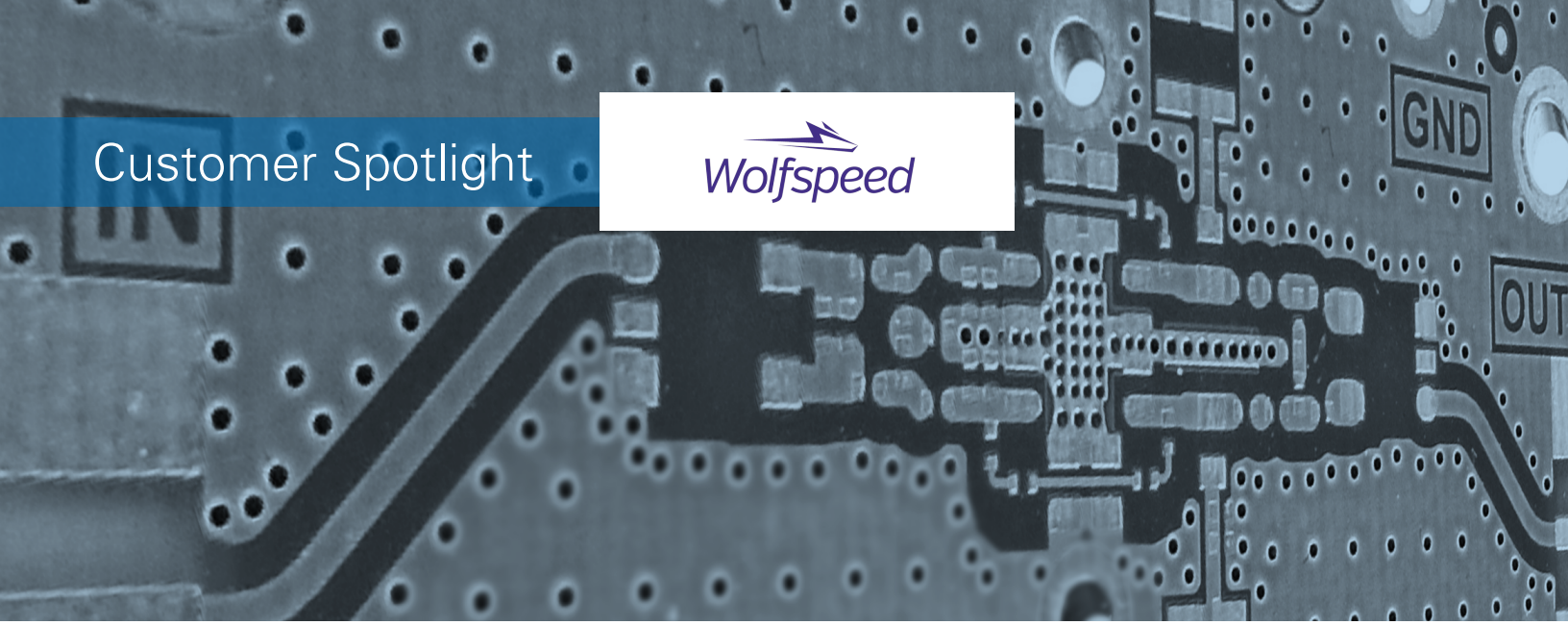


Application Spotlight: PCB Design

Advanced editing tools power PCB EM verification flows

Customer Spotlights: NC State, DST/Macquarie, & Heriot-Watt Universities

From radio design to filters, NI AWR software inspires student success



Customer Spotlight

Wolfspeed

Wolfspeed Designs a Compact Power Amplifier Solution Using a Novel GaN Process and NI AWR Software

Company

Wolfspeed, a Cree company, is a premier provider of the most field-tested silicon carbide (SiC) and gallium nitride (GaN) power and RF solutions in the world. As a leader in wide bandgap semiconductor technology, Wolfspeed partners with the world's designers to build a new future of faster, smaller, lighter, and more powerful electronic systems.

Challenge

Modern electronic warfare (EW) and battlefield awareness require reliable, high-output, high-efficiency, and large-bandwidth power amplifier (PA) solutions. With many applications requiring single PA compact solution covering a broader frequency range, GaN on SiC has become the technology of choice due to its high-power density, high-frequency capability, and robust design ability. Designers at Wolfspeed were tasked with using the next-generation 28 V GaN process technology (G28V4, 0.25µm) to design a wideband, general-purpose device capable of meeting the demands of the EW market for dismounted or man-portable applications that operate from battery power. Wolfspeed selected the 0.25 µm process for its benefits of 6 W/mm power density, >120 V breakdown, and 28 V operation, which deliver the highest power gain possible from a single-stage RF device.

Design goals for the PA were to create a single-ended amplifier with the ability to deliver over 70 W (CW) from 0.5 - 3.0 GHz, while maintaining an efficiency high enough to operate at a case temperature of 65 °C. Other critical parameters included gain flatness of +/- 1 dB for easy system integration and good input/output return losses.

Compact PA solution designed at Wolfspeed using a next-generation 28 V GaN process technology.

"The ability to quickly add a full ANSYS HFSS package transistor model in Microwave Office software along with a full AXIEM EM simulation of the PCB enabled the team to analyze the circuit in detail and achieve industry-leading performance in a short period of time."

Kasyap Patel, Wolfspeed, a Cree company

To achieve the large bandwidth, a packaged input-matched approach was used to reduce the burden on the input-matching network (IMN), while maintaining a small form factor. An input equalizer design was implemented on the PCB to shape the gain across the band to meet the required specification. A key requirement for the equalizer was to maintain the gain flatness in band and add stability margin, while handling the maximum input power needed to drive the transistor into saturation without requiring non-surface-mount components. For this reason, careful simulations were needed to understand the dissipation in each of the components on the PCB and ensure the power ratings were not exceeded during operation.

Solution

The Wolfspeed design team chose the NI AWR Design Environment platform, specifically Microwave Office circuit design software, for the design of this device. The final product (CG2H30070) demonstrated 80 - 115 W of output power from 0.5 - 3.0 GHz with greater than 48 percent drain efficiency. The input equalizer enabled the gain flatness to be within +/- 1 dB of the nominal value. Because surface-mount components were required to reduce the complexity of the PCB, aluminum nitride (AlN) thick-film chip resistors were used on the equalizer network to handle the high-power requirement, as shown in Figure 1.

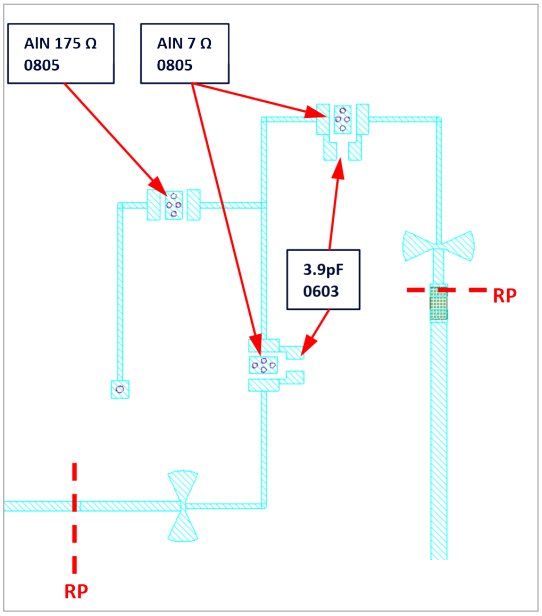


Figure 1: Equalizer network used on IMN to achieve gain flatness across required bandwidth.

Electromagnetic (EM) simulations, in conjunction with harmonic balance, were used to verify the power dissipation in each of the components and to confirm that the maximum rating was not exceeded. Using Microwave Office graphs, the dissipated power versus input drive was plotted to determine the maximum rated input power of the PA, so that a first-pass design was feasible on the bench.

For the full design, a high degree of correlation was achieved between the simulations and measured results, as demonstrated in Figure 2. The predicted drain efficiency was typically within 2 percent of the measured data and the output power was within 0.5 dB across the frequency range.

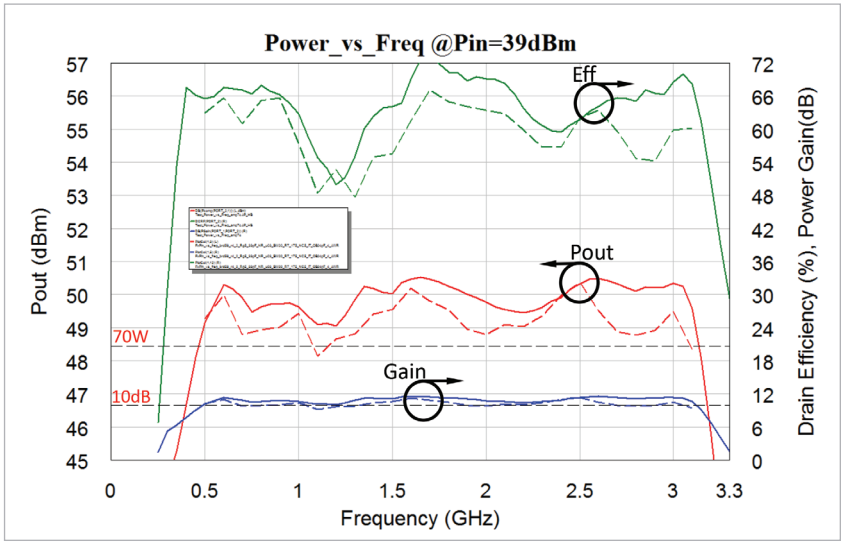


Figure 2: Measured (dashed) versus simulated (solid) data showing a high degree of correlation.

Conclusion

The Wolfspeed design team chose NI AWR software for the design of the CG2H30070F 0.5 - 3.0 GHz GaN on SiC PA, utilizing a packaged pre-match to reduce the required transformation ratio and on-board equalizer to achieve optimal gain flatness. The ability to quickly add a full ANSYS HFSS package transistor model in Microwave Office software along with a full AXIEM EM simulation of the PCB enabled the team to analyze the circuit in detail and achieve industry-leading performance in a short period of time. The resulting measured-to-model correlation validated the approach and enabled quick release of a full device model.

Special thanks to Matthew Pizzella, RF design engineer, and Brad Millon, applications engineering manager, for their contributions to this success story.

New Network Synthesis Wizard Automates Interactive Broadband/Multiband Matching-Circuit Design

Reducing product development time requires design tools that support and expedite all stages of development, from translating performance requirements into an initial design through to optimization, physical realization, and final verification—all before fabrication and test.

From the beginning, the NI AWR Design Environment platform, specifically Microwave Office circuit design software, was conceived and developed to offer a more efficient RF/microwave workflow, empowering engineers with capabilities to tackle design entry and simulation prior to manufacturing, while allowing a smooth transition to fabrication and test with minimal design iterations.

Complementing recent advances in design automation and initiatives in specialized design support features such as load-pull analysis, the latest V14 release of NI AWR software introduces another breakthrough: network synthesis for the development of impedance-matching networks (Figure 1).

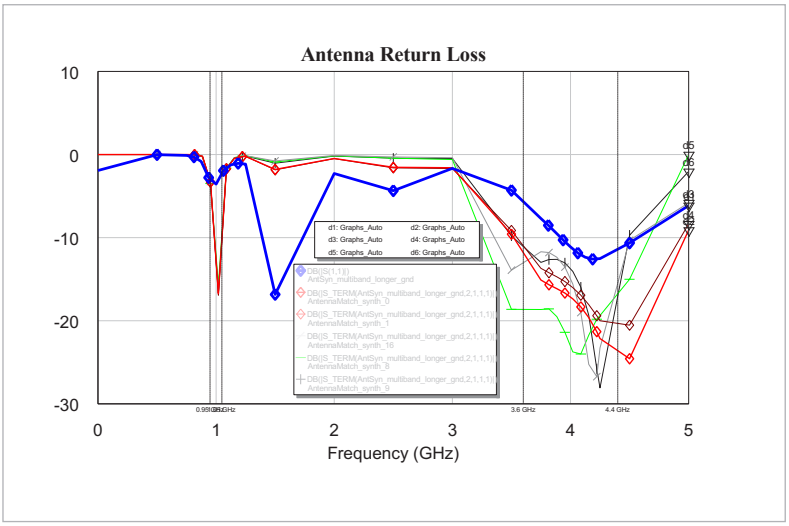


Figure 1: Network synthesis addresses multi-band matching challenges.

This latest innovation accelerates design starts and enables designers to more fully explore design options through the creation of optimized two-port matching networks with discrete and distributed components based on user-defined performance goals (Figure 2).

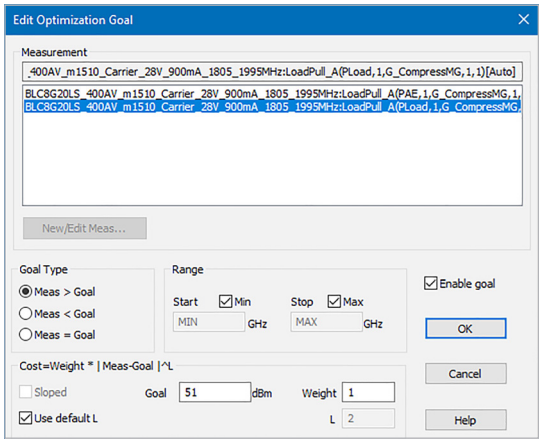


Figure 2: Optimization goal specification panel.

This feature joins other synthesis tools within the NI AWR product portfolio, including iMatch™ impedance matching module, iFilter™ filter synthesis module, and AntSyn™ antenna design, synthesis, and optimization module, all of which enable faster and easier microwave component design. With a given set of user input specifications (performance requirements), these synthesis algorithms search circuit topologies and optimize component parameter values.

The capabilities within the new network synthesis wizard are made possible with advanced optimization methods leveraged from the evolutionary algorithms employed within AntSyn™ antenna design, synthesis and optimization module (awrcorp.com/antsyn). The optimizer is able to rapidly and robustly explore difficult design spaces. This results in a more efficient and faster approach to investigating a wide range of design possibilities and identifying optimum solutions.

The network synthesis user interface (Figure 3) allows designers to interactively develop an unlimited number of networks optimized for noise and power, or matching networks between amplifier stages or between different components, such as an amplifier and antenna. The optimum reflection coefficients are specified over frequency and can be provided in the form of load-pull data, network parameter data files, or circuit schematics. Within the synthesis definition tab, users can specify a default impedance or the impedance of the desired source/load network, as well as the desired match frequencies.

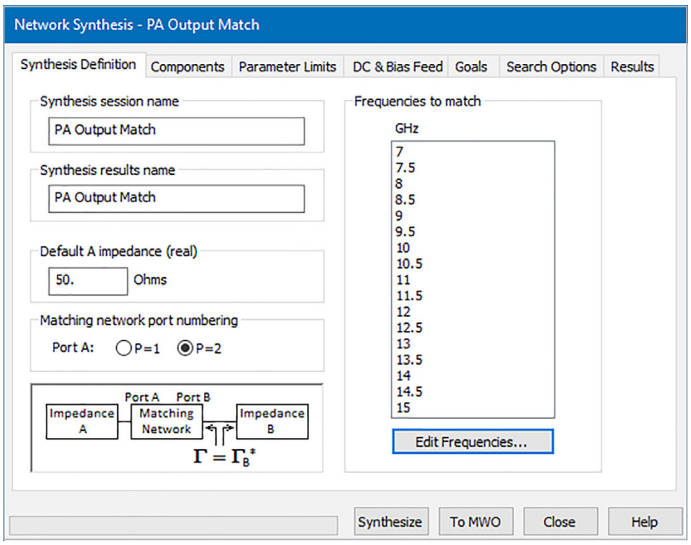


Figure 3: After the synthesis wizard creates the matching networks, the user-selected networks are generated in the Microwave Office project schematics.

This new-to-market synthesis tool, available as an add-on module with the release of V14, is particularly helpful for challenging broadband or multiband single- and multi-stage amplifiers, as well as antenna/amplifier matching networks. The tool also helps designers develop impedance-matching networks between front-end components.

As the footprints of RF components shrink to meet market demand for smaller embedded radios in internet of things (IoT) smart devices (Figure 4), the network synthesis wizard helps designers save space, consolidating component-to-component matching networks by directly transforming the impedance between each component rather than to an intermediary characteristic impedance, for instance, 50 ohms.

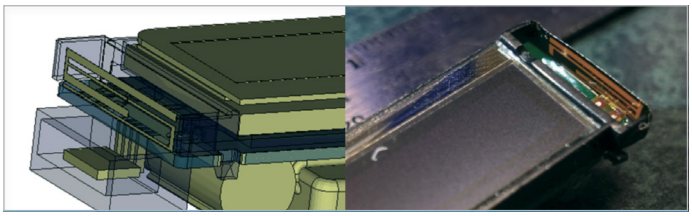


Figure 4: Embedded antenna and RF front-end in wireless wearable device (image courtesy of Striiv).

The interactive wizard provides a smart interface to guide the designer through the synthesis setup, defining the matching criteria by specifying the two target networks to be matched from an automatically populated list of project networks (schematics), and providing options for tailoring the set of network topologies for the optimum topology searches. The designer can also set certain constraints on the matching network, including the number of sections, topology, component type, and configuration (series/shunt), as well as parameter limits.

Valid topologies are determined by the types of components selected and the value specified for the maximum number of sections. Each section is either a series component or a shunt component. The wizard considers topologies having the maximum number of sections, for instance N, and with fewer, down to N-3 sections. Further options allow the user to specify DC constraints on the networks and optimally attach a user-provided bias-feed network to the circuit. The component parameter values may also be confined within minimum and maximum limits, as well as constrained to discrete values.

With the introduction of the NI AWR Design Environment V14 release, this new network synthesis wizard combines with existing design-aid wizards, like those for mixers and multipliers, to guide RF engineers through the early design exploration stages, ultimately accelerating the overall product development cycle.

Filter Synthesis

iFilter software is an integrated filter synthesis module, running seamlessly as a wizard within the NI AWR Design Environment platform and enabling designers to create filter designs, which can be integrated into the entire, managed circuit design project.

Antenna Synthesis

AntSyn software is an automated antenna design, synthesis, and optimization tool that takes designer input specifying their antenna engineering requirements and produces antenna designs as outputs. AntSyn was designed by antenna engineers to support all levels of experience, from novice designer to expert.

FRACTUS ANTENNAS

Innovates a New Class of Miniature Chip Antenna Components

Challenge

Fractus Antennas designs matching networks for a new class of off-the-shelf, surface-mount technology (SMT) chip antenna components called antenna boosters based on the company's proprietary Virtual Antenna antenna-less technology. The challenge faced by Fractus Antennas designers is that the antenna booster component, which fits within any application, mobile/IoT, and/or device, needs a matching network that is more sophisticated than the typical T or Pi network needed for a conventional antenna.

Solution

The design team chose the NI AWR Design Environment platform, specifically Microwave Office software, as the ideal complement for Virtual Antenna, describing it as "a smart software with great optimization and tolerance analysis features that helps to complete the design from concept to production in a fast and effective way."

Microwave Office software provides a number of optimization and tolerance analysis tools that helped the team design the sophisticated matching networks needed for Virtual Antenna. The matching response became "live" with the smart tuning elements, providing key insights on the role of each component in the network and providing the exact values for the optimal design. In addition, tolerance analysis enabled the team to assess and tune the final and production-ready designs, making the whole design process productive, reliable, and effective.

Conclusion

The key benefits of using NI AWR software together with Virtual Antenna technology are twofold: the reduction of design time and the accuracy of the solution. Powerful tools such as the smart tuning and optimization function significantly reduced the time for simulating the most appropriate matching network for each particular design. Once the proper matching network topology was selected, NI AWR Design Environment software enabled the team to reduce the simulation time by a factor of 10 over a manual design, while at the same time providing highly accurate solutions. The combination of live tuners for the network components, the ability to integrate real, commercial, off-the-shelf components from NI AWR software libraries, and the tolerance analysis and optimization tools were the most beneficial features of the software.

Fractus Antennas antenna booster.

"Microwave Office circuit design software is the ideal complement to the new generation of Virtual Antenna products. The combination of the standard nature of our chip antenna components with the power and intuitiveness of Microwave Office software makes going wireless fast, easy, and very cost effective."

Dr. Carles Puente, Fractus Antennas

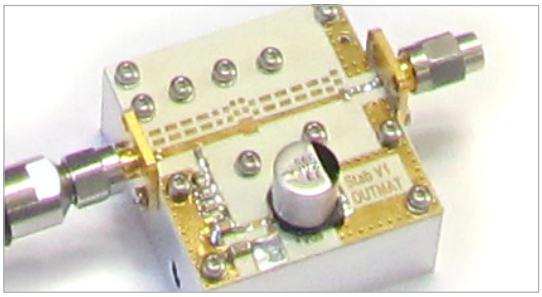
Designs Broadband and Efficient RF Power Amplifiers

Challenge

Demand for multiple 5 - 10 W linear-coded orthogonal frequency-division multiplexing (COFDM) PAs covering the frequency range 1.5 - 2.8 GHz inspired designers at SARAS Technology to develop an approach for designing broadband and efficient RFPAs) using optimal impedances and matching networks. Time-to-market pressures coupled with the need for the PA design to deliver performance based on customer expectations meant the design had to be right the first time.

Solution

SARAS Technology designers chose NI AWR Design Environment software, specifically Microwave Office circuit design software, which greatly streamlined the design process and provided an accurate model of final amplifier performance, enabling the company to deliver its RFPA products to market quickly without compromising on performance.



RFPA prototype.

"The flow we developed requires and an integrated RF/microwave software package that incorporates load pull, circuit design, EM simulation, and layout. Microwave Office software provides this complete, integrated flow in an easy-to-use, powerful, and productive environment."

Jack Brunning, SARAS Technology Ltd

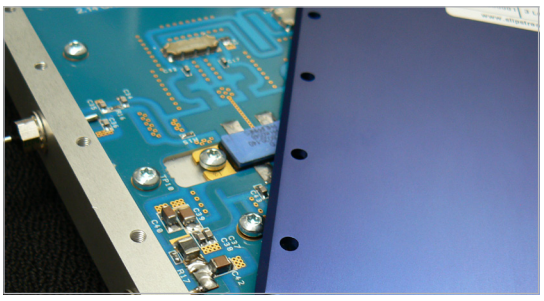
Successfully Develops a Modified Three-Level Doherty Amplifier

Challenge

Slipstream Design engineers were designing a complex, modified three-level Doherty PA for use in security-related counter-terrorism equipment. The PA had large-signal dynamic load-pull effects that had to be carefully modeled prior to fabrication and it was important to balance the PA performance to operate optimally at both high- and low-power levels. The project had a tight design schedule and pressure to deliver a right-the-first-time prototype.

Solution

The Slipstream Design team chose the NI AWR Design Environment platform, specifically Microwave Office circuit design software, for its innovative PA design due to the software's superior nonlinear large-signal harmonic balance technology. As the design developed, it was important to understand, in detail, the large-signal performance as it related to terminating load impedance, a key factor in determining Doherty PA operation. Using the large-signal modeling tools in Microwave Office software, the team was able to implement the entire RF layout and simulate the full amplifier prior to committing to the PCB.



2.14 GHz three-way Doherty amplifier.

"Microwave Office software is an invaluable tool we use in all stages of product development, from providing confidence in quoting to detailed and in-depth modeling (both nonlinear and EM) through the final delivery phase."

Dr. Michael Roberts, Slipstream Engineering Design

Leveraging High-Accuracy Models to Achieve First-Pass Success in PA Design

Quasonix has developed a novel design flow for first-pass design success of a PA that leverages the NI AWR Design Environment platform, specifically Microwave Office circuit design software, and high-accuracy Modelithics model libraries, inclusive of Modelithics® CLR and Modelithics-Qorvo GaN Library accurate nonlinear power transistor models. Not all devices have suitably accurate models or data available, thus, there is a cost associated with the development of high-accuracy models, whether the needed model is provided by the manufacturer, developed in house by the design group, or developed by a third-party model provider.

Nonlinear Device Models

Designing a PA requires trading off gain versus power, efficiency versus linearity, and return loss versus bandwidth. Matching a nonlinear amplifier to load-pull derived source (Z_S) and load (Z_L) target impedances is straightforward for designing a narrowband, single-linear stage amplifier at a single bias point, but significantly more difficult when optimizing a multistage broadband amplifier. Assuming a nonlinear device model is available for the transistor(s) of interest, NI AWR Design Environment platform can accurately simulate nonlinear circuits, facilitating the design of the input and output matching circuits to optimize gain, output power, efficiency, modulation linearity, and even harmonic levels across the entire frequency band.

Amplifier Example

The requirements for the medium-power telemetry transmitter PA example in this application note include frequency range of 2200 - 2400 MHz, minimum output power of 1 W at 85 °C, maximum current draw of 300 mA at 12 V, output power design goal of 32 dBm at 25 °C, and a footprint not to exceed 2.8 sq. in. Because of its small size, high gain, and low current consumption, the TGF2965-SM was also chosen for the driver stage on this transmitter. This design (Figure 1) also incorporated a bandpass filter to reduce the transmit noise level at GPS L1 and L2 bands.

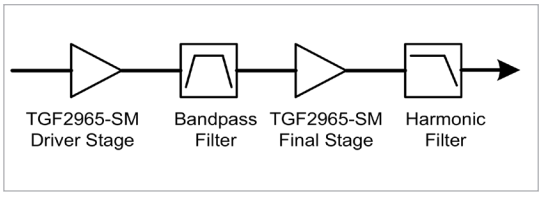


Figure 1: Transmitter amplifier block diagram.

Matching

The first effort was to determine the optimal input and output match, which produced the desired gain, output power, and efficiency across the operating frequency. Starting with a nonlinear model provided by Modelithics for the Qorvo TGF2965-SM device, the final stage input and output match was optimized for performance across the 2.2 – 2.4 GHz operating bandwidth using the harmonic balance tuner (HBTUNER) within the NI AWR Design Environment platform, specifically Microwave Office software (Figure 2).

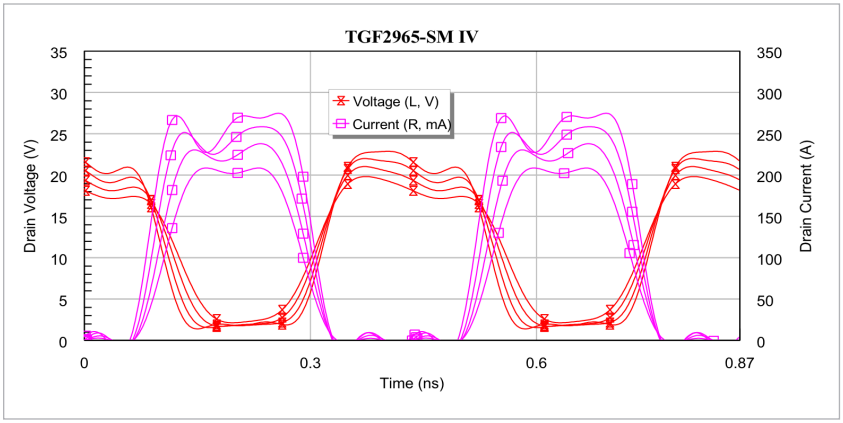


Figure 2: Transistor die simulated drain voltage and current at intrinsic reference plane.

Design of Cascaded Amplifier

After the final stage matching was complete, the driver stage and an interstage surface-mount bandpass filter were introduced. Since nonlinear transistor models are available for the chosen transistor, it was straightforward to simultaneously optimize the cascaded non-50-Ohm driver stage output match, bandpass filter, and final stage input together using NI AWR Design Environment simulation capabilities. Recall that this design has a maximum current requirement of 300 mA at 12 V, at 32 dBm output power. Knowing the current draw of the nonlinear components early in the design process provided assurance that the customer specifications would be met without building a prototype.

The level of the harmonics can be simulated using the nonlinear model, as shown in Figure 3. In this case, the final stage output match was adjusted slightly to compensate for the return loss of the harmonic filter and to reduce the level of the fourth harmonic.

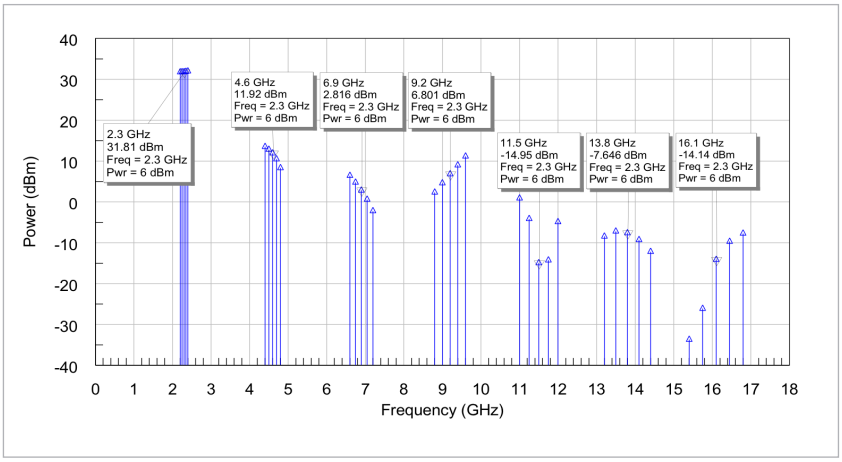


Figure 3: Simulated amplifier harmonics before adding harmonic rejection filter.

Given the maximum permissible power levels of -25 dBm at the second and third harmonic frequencies, and -80 dBm for higher harmonics, the requirements for the harmonic filter could be determined. Including a 5 - dB margin, the design parameters for this filter are +13.5 dBm - (-30 dBm) = ~44 dB rejection across 4.4 to 7.2 GHz, +30.5 dBm - 85 dBm - 11.1 dBm = 66 dB rejection 8.8 to 9.6 GHz, and 55 dB rejection for higher frequencies.

A combined discrete and distributed harmonic filter was designed to meet the above requirements and was incorporated into the simulation. Appending the filter to the output of the PA reduced the simulated level of the harmonics below the required levels.

The ability to determine the requirements of the harmonic filter while still in the paper design phase was a key enabler for the successful first-pass transmitter design, since the harmonic filter was an integral part of the transmitter.

Conclusion

Accurate simulations of microwave circuits can be computed if the component parasitics and nonlinearities are included in the simulations. Traditionally provided transistor Z_S and Z_L source and load impedances generally allow optimized design of a single stage amplifier at specific frequencies. Nonlinear transistor models facilitate the simultaneous optimization of gain, output power, efficiency, and linearity across the desired frequency band even for cascaded amplifiers. These models can substantially reduce the development schedule and cost for new amplifier programs.

In the presented two-stage, 1 W PA example, a first-pass design success was realized with excellent measured-to-simulated agreement and rapid cycle time. With this approach, an existing design can be easily optimized to meet other customer requirements with minimal development cost and risk. A complimentary return-on-investment (ROI) analysis done by Quasonix designers proved the benefits of this design flow, which improved engineering productivity by 150 percent due to a 3X savings in the development schedule, 3X fewer circuit design iterations and a 3X reduction in total cost.

Special thanks to Ted Longshore, Quasonix, and Larry Dunleavy, Modelithics, for their contributions to this application note.

Software Spotlight: V14 Preview

A Smarter User Experience
Accelerating RF/Microwave Designs From Concept to Product

The NI AWR Design Environment platform tackles the design challenges of today's highly-integrated RF/microwave devices being driven by next-generation communications and radar systems such as 5G, IoT, and smart vehicles.

As component performance requirements become more stringent due to market demands, designers must deliver novel designs with unique topologies and architectures based on greater exploration of the design space.

To meet these challenges, the V14 release focuses on RF/microwave design with an emphasis on expediting all stages of design, from initial starts using powerful network synthesis to circuit/system and EM simulation technology for performance optimization. Coupled with design automation, NI AWR software provides an unmatched user experience from which to accelerate RF/microwave designs from concept to product.

Learn more at awrcorp.com/whatsnew

Highlights

Design Environment, Layout, and Automation

- Create data dashboard displays with dynamic document/measurements
- New PCB import wizard for streamlined layout edit/capture
- Enhanced intelligent net (iNet™) routing
- Improved layout manager

System Simulation and Models/Libraries

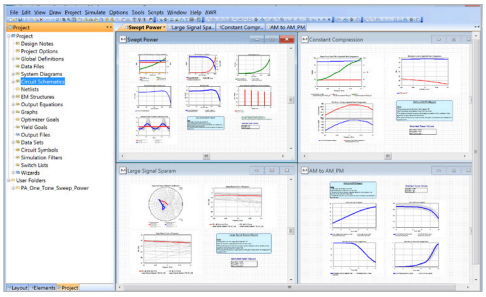
- Enhanced MIMO/phased-array model support (add-on module)
- New spatial channel models
- System bus support
- Low-density parity check (LDPC) encoder/decoder

Circuit Simulation and Models/Libraries

- New network synthesis capability for impedance matching (add-on module)
- New tuner interface for large-scale parametric design
- Loop gain stability analysis
- Enhanced generic measurement data interchange format (GMDIF) model

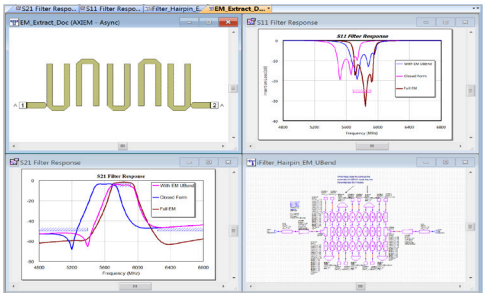
EM Simulation and Modeling

- Port points for component/EM integration
- 3D internal wave ports for complex structure modeling
- 3D frequency-dependent materials
- Support for conformal structures such as embedded IoT antennas



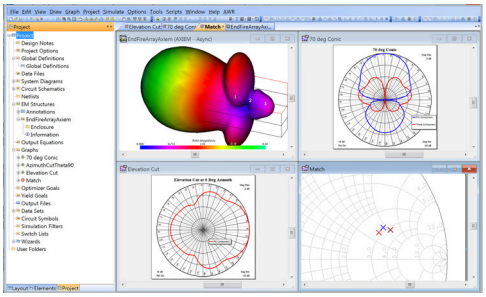
Amplifiers

V14 software introduces genetic algorithm-based network synthesis for interactive impedance matching of challenging PA types such as broadband/multiband and large periphery power amplifiers. Network synthesis, combined with the industry's leading load-pull analysis and new output plotting features, provide PA designers with the insights to develop robust designs faster.



Filters

Synthesize complete filters, inclusive of stop-band nulls and control of pass-band edge responses with the iFilter filter synthesis wizard. New filter reference projects help accelerate design starts, while new iNet routing and layout editing capabilities support post-synthesis physical design and analysis.

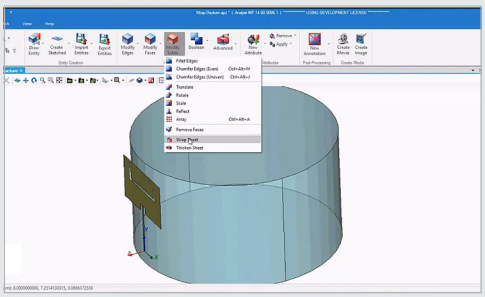


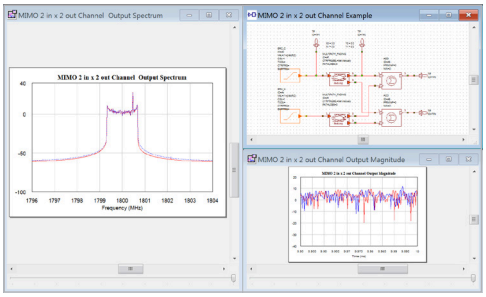
Antennas

Network synthesis supports development of antenna impedance-matching networks to 50 ohms or directly to the feed network, PA, or low-noise amplifier (LNA) output impedance. Designs initially developed with the AntSyn antenna synthesis tool can be imported into AXIEM, Analyst™, or third-party EM tools for further EM analysis and design optimization/integration.

Spotlight: EM Modeling

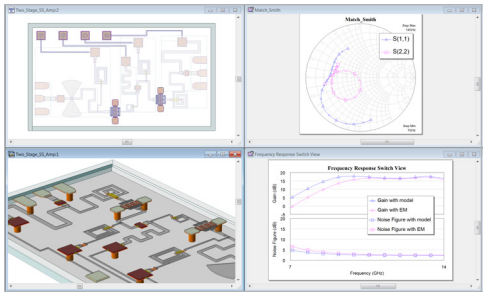
Multiple new features and enhancements in V14 improve design flows and analysis capabilities with enhanced layout editing, new planar body wrapping of conformal structures such as embedded antennas, internal wave ports for 3D EM, port points for exact placement of surface-mount components, and support for frequency-dependent materials and solving inside metal structures.





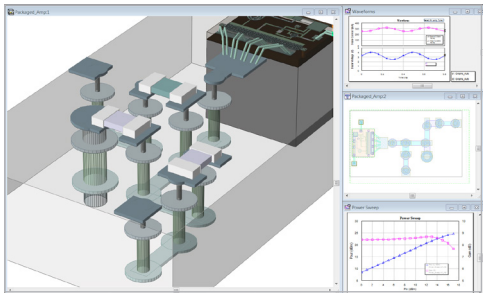
MIMO and Phased-Arrays for 5G and Radar

Multiple-in-multiple-out (MIMO) and beam-steering phased-array antennas are enabling technologies for achieving the over-the-air spatial efficiency called for by 5G and emerging radar applications such as self-driving cars. Ongoing developments in Visual System Simulator™ (VSS) system design software phased-array models and WINNER II and 5G spatial channel models enable designers to develop and optimize array configurations using measured or simulated antenna radiation data, as well as to rapidly validate end-to-end system performance.



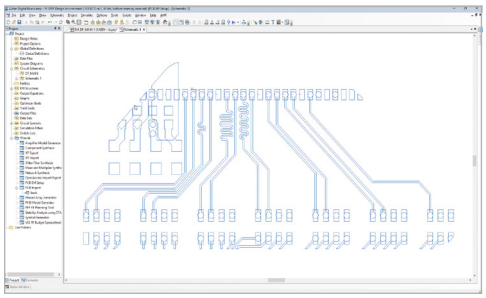
MMIC/RFIC

New 3D EM internal ports support the characterization of complex monolithic microwave integrated circuit (MMIC) structures with excitation internal to a simulation boundary, a new tuner interface for large-scale parametric tuning, enhanced iNet routing and editing capabilities, and process design kit (PDK) developments that provide essential MMIC design automation.



Modules

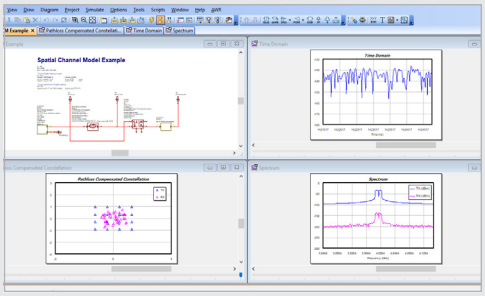
Customer-driven V14 features address advanced multi-chip module development with design flow automation, EM analysis for heterogeneous structures, and dense high-frequency interconnects. Advanced shape preprocessing, hierarchical simulation, and improved EM mapping of stackup layers ensure accurate and timely results.



RF PCB

V14 software further streamlines design flows between RF circuit design and system board layout tools from leading vendors with new capabilities added to the PCB Import wizard and an EM verification flow that includes more powerful net and area selection, automated and user-managed component and ports import, and a new point port for more precise locating of lumped-element component placement within an EM structure.

Spotlight: Link Budget and Wireless Communications Test Benches



VSS software provides standard-compliant models to support accurate link budget analysis, inclusive of over-the-air channel effects for spectral interference mitigation and component performance specifications.

Standards-based signal generation and pre-configured virtual test benches for popular uplink/downlink communication systems help component and system developers simulate real-world operating conditions.

5G

The library offers signal generation and analysis capabilities according to the latest 5G specifications for 5G New Radio (NR) as well as previous 5G candidate waveforms such as FBMC, GFDM, etc.

NB-IoT

The library offers standards-based signal generation and test benches for narrowband internet of things (NB-IoT), providing analysis capability in VSS software to address challenges in spectral coexistence.

Try AWR

Try NI AWR Design Environment today and see for yourself how easy and effective it is to streamline your design process, improve end-product performance, and accelerate time to market for MMICs, RFICs, RF PCBs, microwave modules, antennas, communication systems, radar systems, and more.

Download your trial at awrcorp.com/tryawr

Application Spotlight: 5G Communications

Verizon 5G Downlink Test Bench For Base-Station PA Design

In a study commissioned by Qualcomm, 5G mobile technology could enable $12.4 trillion of global economic output by 2035, which will encompass other emerging ecosystems such as IoT and self-driving cars. The radio access for these systems will offer many opportunities and challenges for RF/microwave component manufacturers and designers.

Evolving system requirements will drive component performance goals and put new requirements on simulation-based product development. 5G implementation will rely on many technologies including the adoption of new digital waveforms.

The ideal waveform will support wide bandwidths and high data-rates, enabling energy-efficient operation with low latency for long and short-burst transmission modes, along with fast switching between the uplink and downlink.

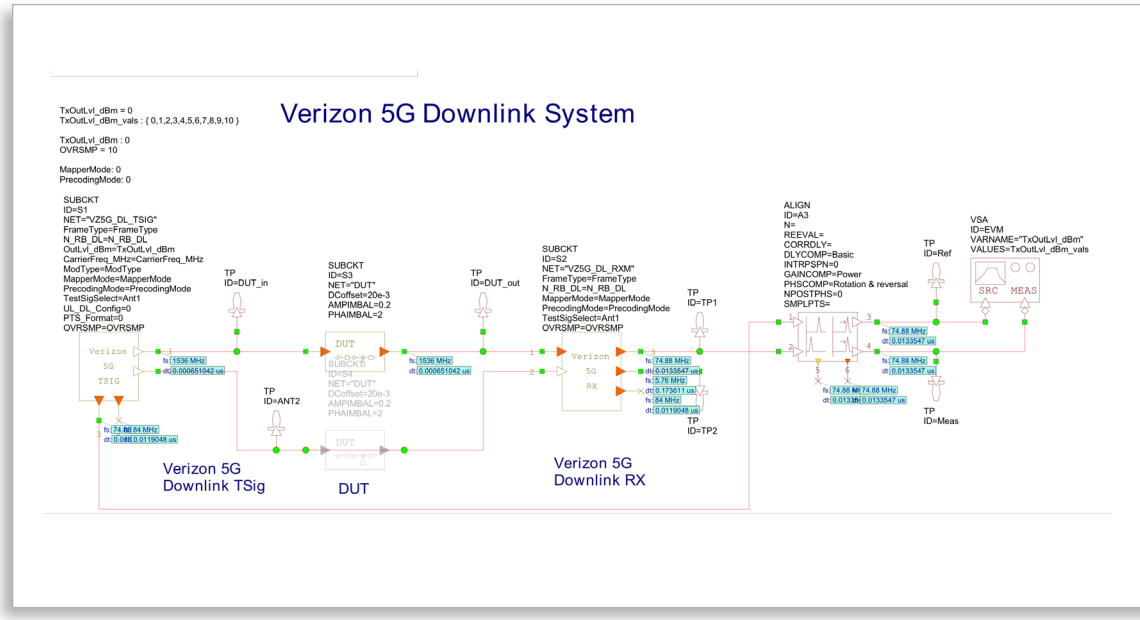
The Third Generation Partnership Project (3GPP) standards organization and Verizon 5G (VZ5G) Technical Forum are both converging toward the use of cyclic-prefix OFDM (CP-OFDM) as the waveform of choice for 5G NR, with VZ5G using a variable 15-120 kHz carrier spacing.

CP-OFDM is compatible with multi-antenna technologies such as MIMO, offering high spectral efficiency, low implementation complexity, and lower susceptibility to phase noise and Doppler effects compared to other multicarrier systems. One challenge for PA designers will be to address the impact of this waveform's high peak-to-average power ratio (PAPR) on the linearity of the amplifier without sacrificing other performance metrics.

To maintain reasonable linearity, PAs under high PAPR are often operated with the power level backed-off in relation their 1-dB output compression point. However, operating at this lower power level adversely affects the amplifier power-added efficiency (PAE). Therefore, designers must design PAs that achieve the optimum tradeoff between linearity, efficiency, and a number of other performance metrics.

Load Pull for 5G

The Microwave Office load-pull analysis capability provides PA designers with a powerful tool for identifying the fundamental- and harmonic-frequency load impedances that offer optimum capability in relation to design goals and performance targets. The analysis generates constant performance contours for measurements such as output power and PAE, as well as linearity metrics such as ACPR and EVM for devices operating under digitally-modulated RF waveforms.



To simulate the 5G waveform-specific response, the VSS Verizon 5G test bench enables designers to simulate PAs or other devices under test (DUTs) in the Verizon 5G downlink system and, alternatively, perform EVM and ACPR measurements. Verizon 5G is an industry effort initially geared towards fixed wireless communications at 28 GHz and 39 GHz bands. The VSS test benches can be used for testing RF components intended for wideband fixed wireless systems in 28 and 39 GHz bands.

VZ5G Downlink System Test Bench

The following example demonstrates the VZ5G downlink transmission, which includes the physical broadcast channel (PBCH), physical downlink control channel (PDCCH), and physical downlink shared channel for data (PDSCH). Along with a behavioral amplifier DUT, the corresponding transmitter and receiver have been set up with re-configurable options such as number of frames per sweep and frame/modulation type, number of antenna ports, carrier frequency, transmitted power and more, to support user-defined system specifications, as shown in the inset image.

The default configuration allows the user to perform various measurements such as spectral regrowth resulting from device nonlinearity and complementary cumulative distribution (CCDF), as shown in Figures 1 and 2, respectively. The example demonstrates a parallel-power sweep measurement being performed on the signal operating on the AM-to-AM curve (Figure 3).

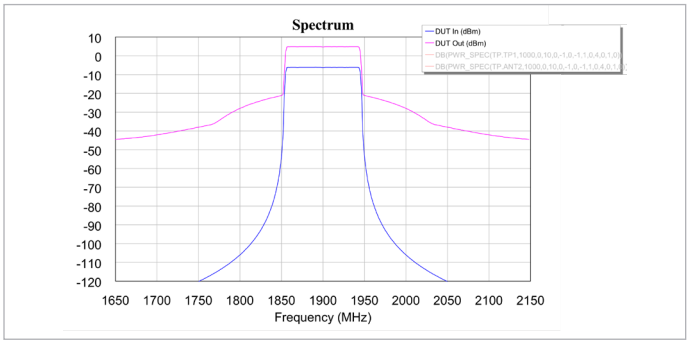


Figure 1: 100-MHz-wide signal before and after the DUT.

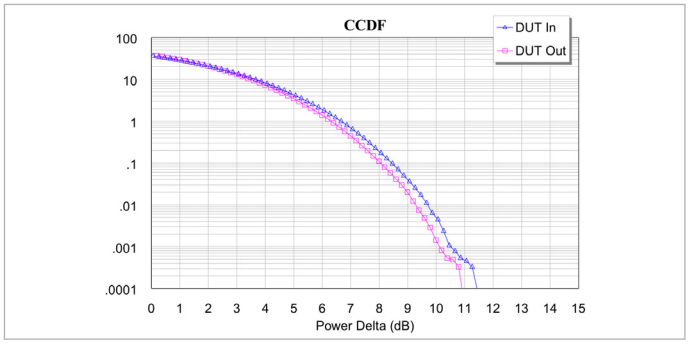


Figure 2: CCDF measurements with input and output to the DUT.

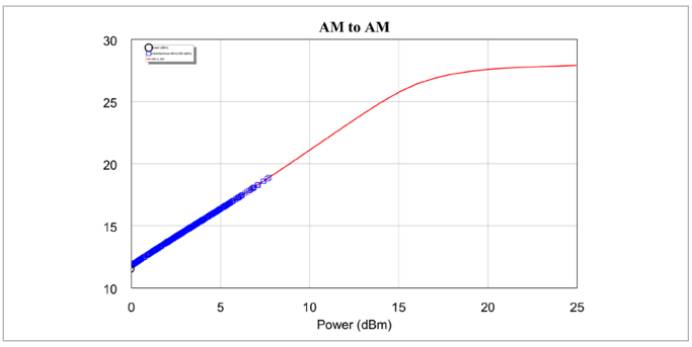


Figure 3: CCDF measurements with input and output to the DUT.

The IQ constellation plot in Figure 4 shows the received demodulated IQ constellation for both the xPDCCH and xPDSCH. Figure 5 shows ACPR measurements at the 100 MHz and 200 MHz offset.

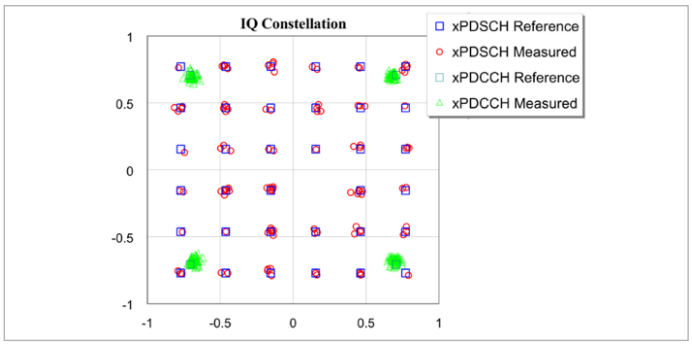


Figure 4: Plot of received demodulated IQ constellation.

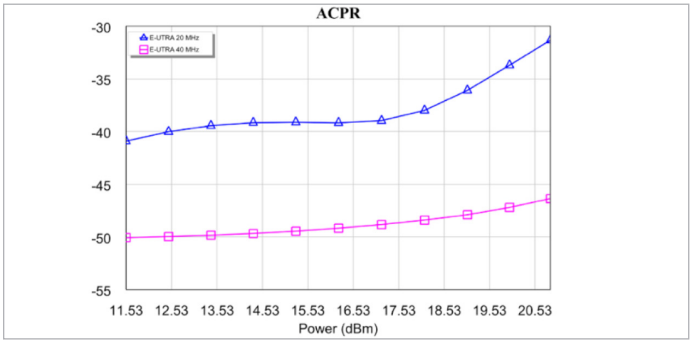


Figure 5: ACPR measurements for the VZ5G specification.

The EVM versus input power and output power sweep measurement in Figure 6 shows the EVM characteristics as a function of output power.

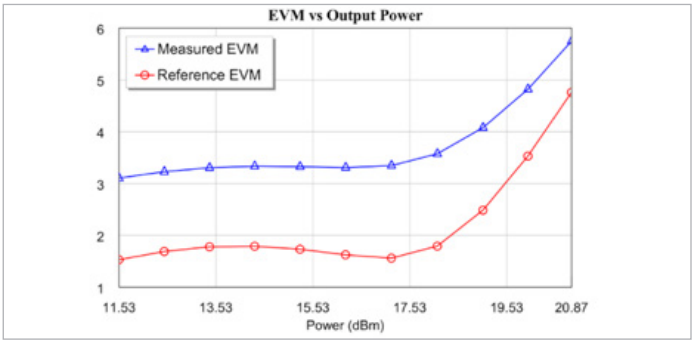


Figure 6: EVM versus output power sweep measurement.

Conclusion

The VZ5G downlink system test bench within VSS software enables designers to simulate 5G DUTs in the Verizon downlink system and also perform EVM and ACPR measurements. Because VZ5G specifications are in the early stages and therefore changing constantly, the current VSS implementation will be updated according to developments. The VSS signal generator is built from basic building blocks, so when specifications change, the parameters in the root blocks can be updated without having to change hard code.

Resource Spotlight: Resource Library

White Papers

- Primer: Load-Pull Primer for Optimizing PA Performance
- Primer: MIMO/Phased Array Antennas for 5G
- Primer: System Simulation for RF Link Budget Analysis
- Basics of Design: Designing IoT Antennas

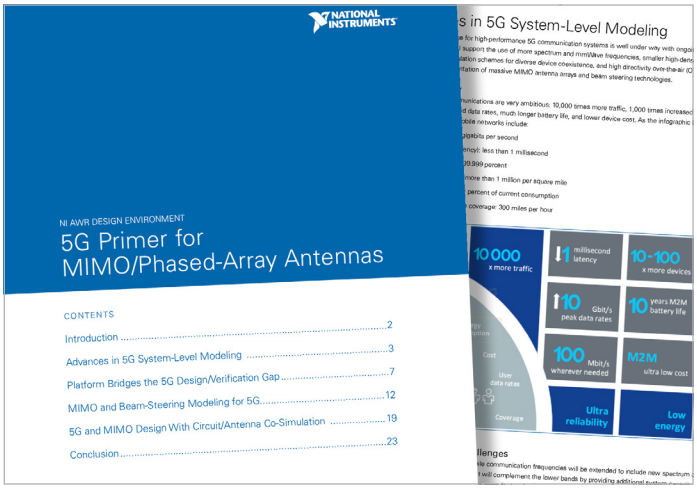
Application Notes

- Leveraging High-Accuracy Models to Achieve First-Pass Success in PA Design
- mmWave Automotive Radar and Antenna System Development
- Synthesizing MIMO Antennas for Compact Devices

Customer Stories

- Quasonix Telemetry Systems Development Design Flow Improves Productivity 150 Percent
- Wolfspeed Designs a Compact PA Solution Using Novel GaN Process and NI AWR Software

Learn more at awrcorp.com/resource-library.



Resource Spotlight: E-Learning

Online Training Modules

The E-learning portal offers self-paced video modules that enable users to learn at their own pace and as 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

- Intro
- Drawing Basics
- Import/Export
- Layout Cells

EM Simulation

- Intro
- Project Creation
- Properties/Setup
- AXIEM
- EMSight
- Analyst

EM Advanced Features

- Process Creator
- Data Sets
- Shape Modifiers
- EM Extraction

Analyst 3D FEM EM

- Intro
- 3D Cells
- Coil
- Extrusion
- Intersection

Multi-Technology

- Intro
- Libraries/PDKs
- Multiple Libraries
- Units/Position
- EM Multi-Tech
- Recap

Antenna Synthesis

- Intro
- Wi-Fi Antenna
- AXIEM Export
- Analyst Export

Learn more at awrcorp.com/elearning.

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.

Advanced Editing Tools Power PCB EM Verification Flows

To support increasing functionality, PCBs are employing more complex board structures designed for a range of specialized applications. For PCBs in mobile devices, board dimensions are shrinking as designs rely on a smaller number of highly-integrated modules, each with high pin counts, to consolidate board space. This trend reduces the overall surface-mount component count to save cost and space. At the same time, boards for networking and computer applications are getting larger, with more interconnects and plane layers.

Within these densely-populated, multi-layer boards, integration of high-speed data lines and RF circuitry poses a potential risk to system performance as a result of coupling (cross talk) and other parasitic behavior along the signal traces. PCB design based on EM analysis is critical to verifying performance and enables designers to mitigate the effects of parasitic behavior.

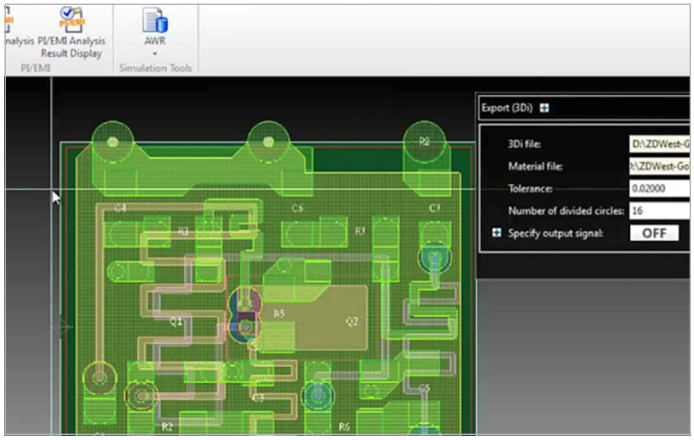
As PCB designs further integrate RF and high-speed digital traces, incorporation of EM analysis into the design verification flow evolves with enhanced automation, fitting the needs of a diverse range of applications. With complex PCB designs, this flow includes interoperability between tools via open data exchange, the ability to easily set-up the EM analysis for the board section or traces of interest, as well as the EM analysis itself.

EM Verification Workflows

Implementing the ideal PCB verification flow depends largely on the design focus and available engineering team resources. In some cases, the layout team may "own" the flow, sending select board data to the RF team for EM analysis and using editing features within the layout tool to select the critical board sections or nets to be analyzed.

For example, CR-8000 Design Force from Zuken includes an interface to the NI AWR Design Environment platform, enabling the computer-aided engineering (CAD) team to specify the areas to be analyzed. Alternatively, the NI AWR software interface utility in Design Force allows selection of critical signals from a list to generate a PCB import file output.

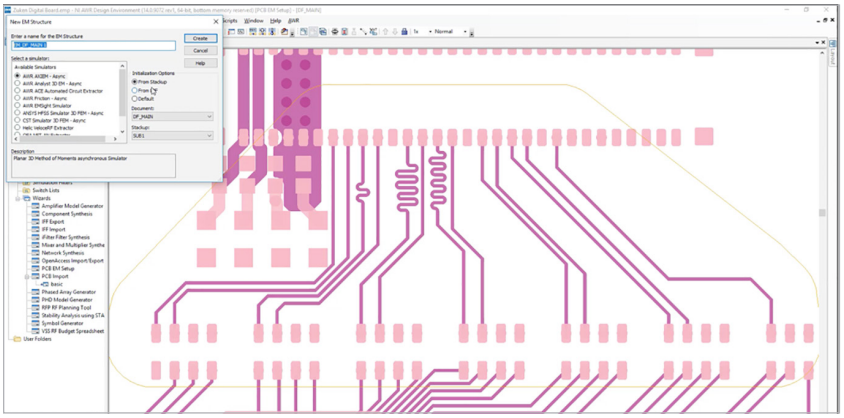
Using AWR Connected™ for Zuken, the PCB Import data can then be imported for further EM analysis with AXIEM or Analyst EM analysis.



In cases where the layout engineer is uncertain what will require EM analysis, it is best to send the entire design to the RF designers, who can better decide which board structures/interconnects need further analysis. The RF team will still want to isolate sections of the board or individual /groups of traces but won't necessarily have access to or familiarity with the CAD layout interface in order to make these selections/board edits. For this scenario, an alternate workflow is necessary.

PCB Import/Editing for EM

For this type of workflow, V14 software introduces powerful new editing capabilities that allow RF designers to easily set up complex imported PCBs for analysis in AXIEM or Analyst EM solvers. The new smart editing tool lets users interactively isolate board sections and multi-layer traces and vias, automatically define EM ports from the imported data, generate an EM structure with schematic view for surface mount component insertion, and more.



The new editing feature operates on imported PCB data read directly from industry-standard IPC2581 or ODB ++ file formats used to exchange PCB design information between design and manufacturing, and design tools from different EDA/ECAD vendors. By supporting these file types, the NI AWR Design Environment platform supports an EM design verification flow to industry-leading third-party layout tools. The PCB import wizard directly reads all layers, nets, and stack-up information. Additional enhancements in the V14 release include new EM port points, which support well-defined connection points for inserting circuit components, and more powerful shape-preprocessing, which helps users clean up designs prior to EM analysis, thereby improving meshing operations and speeding simulation times.

Conclusion

NI AWR Design Environment V14 software provides new and enhanced 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 multi-chip module 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.

To learn more about V14 software, follow my blogs at awrcorp.com/blogs

Best regards,

David Vye
Technical Director
AWR Group, NI

Resource Spotlight: AWR.TV

Module/MMIC Design

- Design Flow/Simulation of Multi-Technology RF Modules
- Multi-Chip Module Verification and Yield Optimization

PA Design

- Load Pull With Nonlinear/Linear Models to Design RF PAs
- Digital Predistortion of RF PAs

Filter Design

- Challenges in Microwave Filter Design
- Optimized Hairpin Filter

Antenna Design

- Antenna Synthesis Overview
- In-Situ Analysis of Patch-Array Antenna

PCB Design

- PCB Stub Filter
- iNets Routing in PCB

NC STATE UNIVERSITY

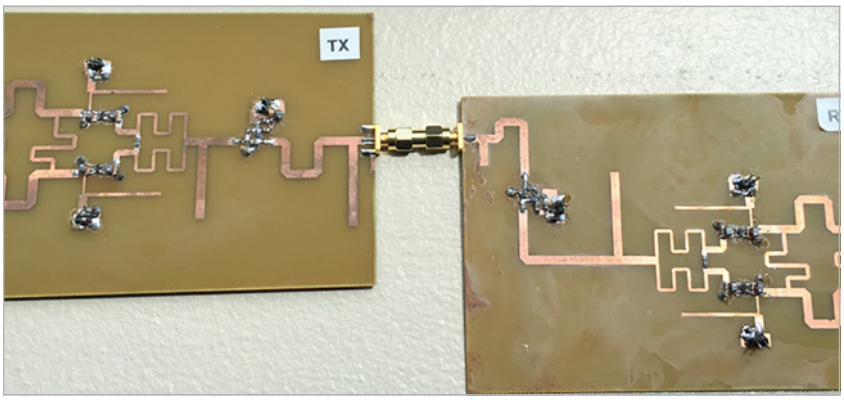
Senior Design Course Inspires a Practical Wireless Communication Industry Workshop

Challenge

Dr. Ricketts, an electrical engineering professor at North Carolina State University (NC State), developed a one-semester senior design course that guides students through the fundamentals of radio communications from design through to fabrication. Following on the success of this course, Ricketts felt the next challenge was to develop an accelerated workshop that offered the same design through fabrication in a single day for working professionals attending industry-related technical gatherings such as the annual International Microwave Symposium (IMS), recently held in Honolulu, Hawaii.

Solution

Dr. Ricketts relied upon his professional connections through the IEEE MTT society to help bring to fruition his idea of a one-day workshop that could be offered to industry as well as academia. He enhanced and streamlined his RF/microwave class materials and combined them with NI AWR software into the interactive Bits to Waves: Building a Modern Digital Radio in One Day workshop for IEEE professionals that is now offered at IEEE conferences throughout the world.



Full radio design fabricated using the techniques learned in the Bits to Waves workshop.

"I would not be able to offer the Bits to Waves workshop without the use of NI AWR Design Environment software since the ability to use the software immediately is key to building the digital radio components within the one-day scope of the class."

Dr. David Ricketts, NC State University

About the Professor

Dr. David Ricketts received his PhD in engineering and applied sciences from Harvard University and BS and MS degrees in electrical engineering from Worcester Polytechnic Institute. Prior to academia, he spent eight years in industry developing more than 40 integrated circuits in mixed-signal, RF, and power management applications. Ricketts's research crosses the fields of physics, materials science and circuit design, investigating the ultimate capabilities of microelectronic devices and how these devices are harnessed by differing circuit topologies to produce the highest performing systems.

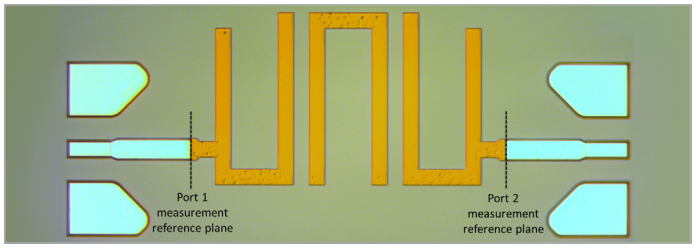
A 94-GHz Hairpin Filter Design

Challenge

DST Group and Macquarie University collaborate on research projects that develop cutting-edge mmWave ICs. The challenge for this project was to investigate how well simulation agreed with measurement for a hairpin filter design.

Solution

The filter's initial design was conducted in a schematic simulator using closed-form models. The layout of the filter was then extracted to AXIEM EM solver within the NI AWR Design Environment platform. Additionally, thick metal meshing was used within AXIEM EM solver to accurately account for the coupling between the lines. Measured and simulated results for the 94-GHz hairpin filter agreed well.



Die image of the bandpass filter showing measurement reference planes.

"The measured vs. simulation results we achieved to 145 GHz strengthens our confidence in 3D planar simulation using AXIEM simulator."

Leigh Milner, Defence Science, Technology Group

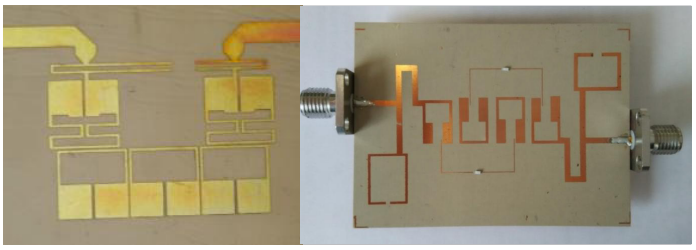
Novel RF Filter Designs

Challenge

Planar RF/microwave filters are very useful for applications where size, weight, and cost are important. For example, significant filtering requirements exist for planar and drop-in receiver filters at IF frequencies in the up- or down-converter of wireless communication systems, including satellite payloads. Sharp rejection and flat pass-band insertion loss are required, which results in high-Q resonators. Lossy and predistorted design theory for filters can provide the required rejection and flatness, avoiding the use of high-Q materials, which are more expensive, and providing the required compactness.

Solution

A team of researchers at Heriot-Watt collaborated on the design of a lossy extracted-pole filter to meet the challenges of compact and inexpensive planar filter design. To develop this filter, the team relied on NI AWR Design Environment, which was available to faculty and students at Heriot-Watt University through the NI AWR software university program. The filter was fabricated using PCB to achieve a light weight and small footprint/profile.



Sample of the fabricated design.

"The ease of use and intuitiveness of the software helped us get up and running quickly. In addition, the help we received from the support team enabled us to overcome several of the more sophisticated design challenges we faced."

Jiasheng Hong, Heriot-Watt University

ONE PLATFORM, ZERO BARRIERS

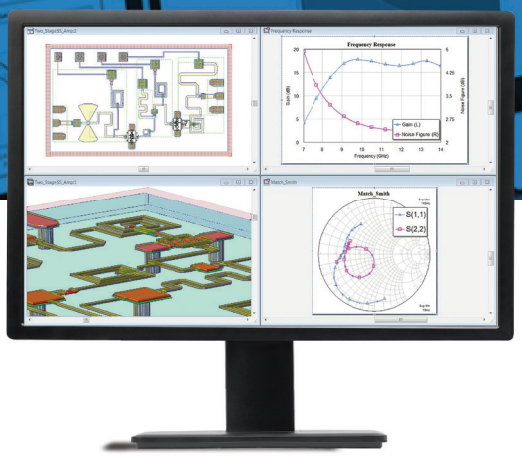
SIMPLY SMARTER

NI AWR DESIGN ENVIRONMENT

NI AWR Design Environment is a single platform that integrates system, circuit, and EM analysis for the design of today's advanced wireless products, from base stations to cellphones to satellite communications. Its intuitive use model, proven simulation technologies, and open architecture supporting third-party solutions translates to zero barriers for your design success.

Simply smarter design.

Learn more at ni.com/awr



NATIONAL INSTRUMENTS™

Microwave Office | RF and Microwave Circuit Design Software

AWR-MG-V18-0-2018.8.2