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CADENCE AWR DESIGN **MAGAZINE**

A quarterly publication highlighting Cadence® AWR® RF/microwave design software for product development through white papers, application notes, and success stories.

Volume 20.14.Q4

Highlights

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Glen Clark on AWR Integration

AWR and Integrand Integration

AWR and Integrand have been part of Cadence for nearly a year now. Both groups have been able to keep to their development schedules for releasing new products, allowing us to meet our customers' expectations for continued product development. R&D and Marketing successfully released new products while integrating their operations and people into ours. We have been working on a roadmap and plan to execute future platform interoperability that encapsulates RF/mixed-signal IP development, manufacturing flows, and signoff. Our ability to offer tighter design flow interoperability is going to help our customers develop innovative designs and differentiate themselves.

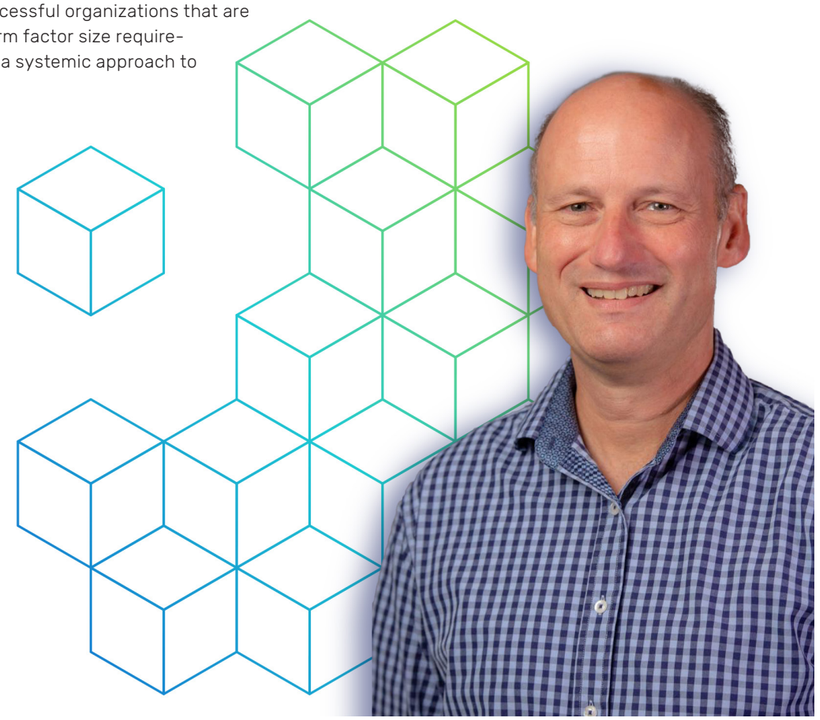
Intelligent System Design Strategy

The Cadence Intelligent System Design™ strategy helps technology leaders differentiate themselves with products that have the right combination of performance, size, and cost advantage made possible through electronic design automation (EDA) and IP. Successful organizations that are meeting performance and form factor size requirements are doing so by taking a systemic approach to design.

The Microwave/RF Market in 2021

We have a very clear vision of the direction we want to take our products and we have a plan on how we will get there, which we are currently executing. I can say that 2021 is going to be a very exciting year for what we will be able to offer our customers and any company developing and/or integrating RF/microwave IP.

Listen to the full Discussion with Glen Clark, CVP R&D at Cadence, About RF Products podcast.



RF mmWave Front-End Component Design Trends for 5G Communications

RF front-end architectures grow more complex with each generation of communication systems. To accommodate these architectures, more densification and miniaturization is taking place with electronic systems implemented through innovations in system-in-package (SiP) design. Cadence offers the broadest, most integrated design solution to bring the Intelligent System Design strategy to the communication products of the future.

The Third Wave of Wireless Communications

5G and subsequent systems will close the gap between the physical and cyber worlds. Today, mobile consumers use wireless connectivity to access the web from almost any location. In the future, high-speed coverage will be more widespread and faster, and there will be greater emphasis on uplinking information from real-world events and human and/or internet of things (IoT) activity to the internet.

The next wave of communications focuses on the three areas of service:

- Enhanced mobile broadband (EMBB) extends the current mobile experience with high data throughput on the order of more than 10Gbps, high system capacity on the order of more than 1000 times that of LTE, and a much better spectral efficiency than LTE (three to four times that of LTE). Its use cases are high-speed mobile broadband and virtual reality, augmented reality, gaming, etc.
- Ultra-reliable low latency services (URLLS) focus on low-latency, high-reliability, and high-availability aspects. The expectation is of the order of less than one millisecond of latency and availability on the order of 99.9999%. This is basically for mission-critical use cases and applications.
- Massive machine-type communications (mMTC) technology provides connectivity to a huge number of devices whose traffic profile is typically a small amount of data spread sporadically. So latency and throughput are not a big concern. The main concern is the optimal power utilization of those devices because they are battery powered and the expectation of battery life is around 10 years or so.

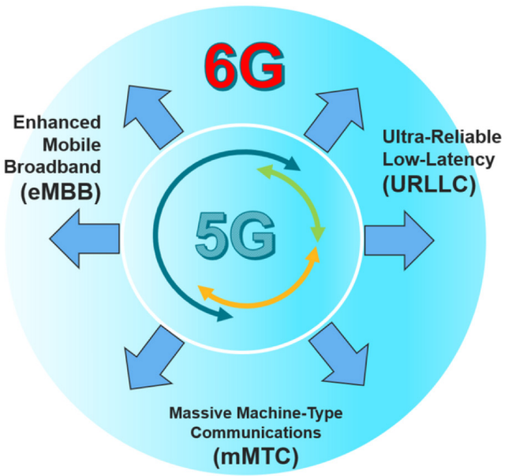


Figure 1: New business services enabled with the third wave of communications, initiated with 5G

The technical challenges presented by 5G and future 6G development is an extension of what the Cadence AWR Design Environment® platform customers focus on today in the pursuit of higher broadband capacity for greater range resolution in radar applications and high-speed data rates for communications. Throughout the digital communication revolution, Cadence and AWR have been providing EDA solutions to support the wireless industry.

To address off-silicon RF design, including III-V monolithic microwave integrated circuit (MMIC) and discrete components, modules, and RF board design, the AWR Design Environment platform provides RF system, circuit, and electromagnetic (EM) design entry and analysis (Figure 2). Cadence AWR Visual System Simulator™ (VSS) communications and radar systems design software is primarily concerned with the top-level radio and radar design, operating from behavioral block models to provide link budget and spurious heritage analysis, as well as time-domain baseband through RF communications/radar system simulation.

AWR VSS software works seamlessly with Cadence AWR Microwave Office® software, which supports RF design at the transistor, trans- mission line, and RF-aware passive component level with frequency domain, nonlinear harmonic balance simulation. AWR Microwave Office software is used for RF front-end component design, including power and low-noise amplifiers, filters, mixers, matching networks, and more. The Cadence AWR AXIEM® 3D planar analysis and Analyst™ 3D finite element method (FEM) solver provide fully integrated EM analysis for antenna design and broadband characterization (S-parameter extraction, far fields, and currents) of passive structures.

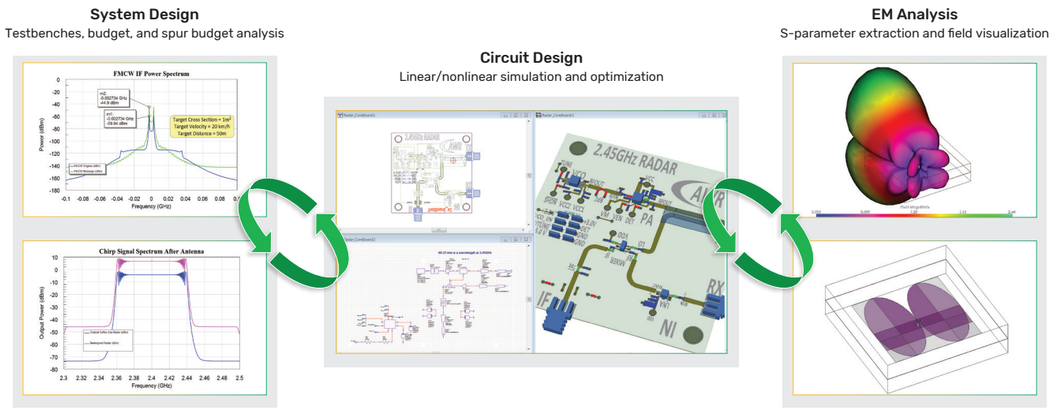


Figure 2: Design solutions in the AWR Design Environment platform

Conclusion

Next-generation communication systems targeting 5G/6G functionality will provide massive connectivity to the internet with extreme capacity, coverage, reliability, and ultra-low latency, enabling a wide range of new services and business opportunities. The anticipated performance will be made possible through a range of innovative technologies, implemented though complex RF front-end architectures and highly integrated multi-fabric electronics. RF to millimeter-Wave (mmWave) design and multi-fabric design and manufacturing software will be critical to the development of these technologies.

To power the technologies and products that will realize 5G/6G performance across chips, IP, packages, and PCBs, Cadence has developed the Intelligent System Design strategy for delivering its world-class computational software capabilities across all aspects of the design of electronic systems. This white paper has presented several examples of how Cadence is uniquely positioned with deep expertise and pivotal leadership in computational software, along with the broadest, most integrated design solution, to bring the Intelligent System Design strategy to the communication products of the future.

Read the full RF to mmWave Front-End Component Design Trends 5G Communications software spotlight.

High-Performance EM Computing Options

The increasing complexity of integrated designs has pushed the limits of computing capabilities beyond a single CPU process. The ability to utilize remote and parallel computing can dramatically reduce the overall simulation time for resource-intensive problems, as well as optimization routines requiring hundreds or thousands of iterations.

To provide designers with access to more compute power for complex designs, the AWR Design Environment platform has evolved to support various remote/parallel simulation features. Remote computing allows users to set up an EM simulation in the AWR AXIEM 3D planar analysis or AWR Analyst FEM solver on a local computer and simulate the structure on a different computer. By setting up dedicated, remote computers for resource-intensive simulations, designers can use local computers to continue working on other design tasks or perform smaller simulation problems.

Simulation Times for Different Configurations

Figure 1 illustrates the length of time it takes to run a simulation job with the four different options: local, local parallel, remote, and remote parallel. The timeline illustrates how simulation time can be cut dramatically from almost an hour to six minutes, depending on the configuration used.

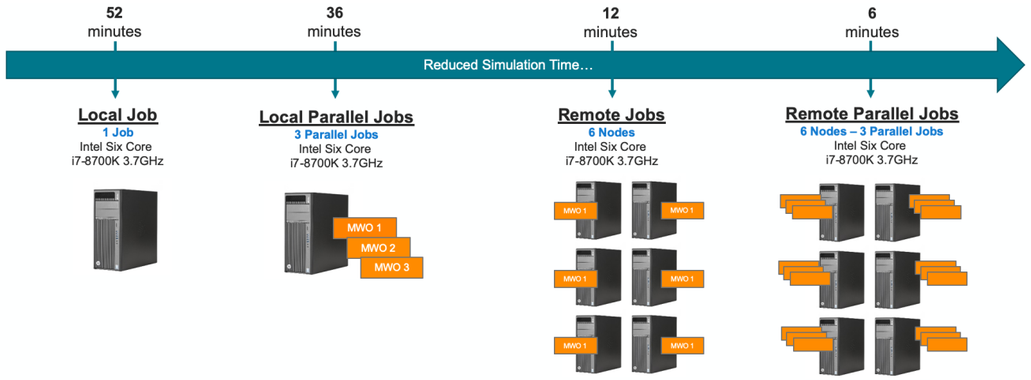


Figure 1: Comparison of simulation times depending upon which computing configuration is used

Conclusion

Highly integrated RFIC, MMIC, and multi-technology modules are developed through powerful design software that benefits from distributed computing in order to reduce simulation run times and streamline optimization. This application note demonstrates how to use the latest high-performance remote and parallel computing features in AWR software to shorten schematic simulation times considerably through remote, parallel, and remote/parallel configurations.

Read the full Using Parallel and Remote Schematic Simulation and Optimization to Reduce Design Time application spotlight.

Design/Simulation of a Planar Inverted-F Antenna

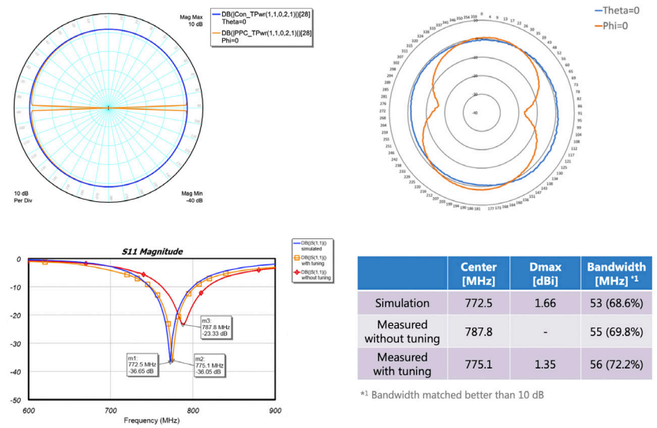
Today's mobile devices often serve different frequency bands with multiple antennas optimized for performance and designed for the smallest possible footprint. To address these concerns, engineers at CommScope implemented an inverted-F antenna (IFA) for sub-1GHz band mobile communications using a combination of antenna theory, circuit analysis, and EM simulation.

IFA Design

The specifications for the mechanical dimensions of the IFA severely limited the available space for the antenna. Consequently, difficult tradeoffs from the theoretical design had to be made regarding antenna gain, efficiency, and broadband performance. An IFA design places the feed from the ground plane to the upper arm that runs parallel to the ground plane. The upper arm of the IFA has a length that is roughly a quarter of a wavelength.

The planar structure of the antenna is well-suited to use AWR AXIEM EM analysis to optimize the in-band return loss performance of the antenna (Figure 1). The current distribution of the antenna is comparable to those demonstrated in theoretical background material. The maximum current is at the intersection between the short and open stubs. The minimum current is located at the open end of the resonator and the skin effect is at the edges. The network synthesis option in AWR Microwave Office software was used to develop an impedance matching network for the antenna operating at LTE Band 13.

Figure 1: The antenna response can be tuned by adjusting the length of the resonator



	Center [MHz]	Dmax [dBi]	Bandwidth [MHz] *1
Simulation	772.5	1.66	53 (68.6%)
Measured without tuning	787.8	-	55 (69.8%)
Measured with tuning	775.1	1.35	56 (72.2%)

*1 Bandwidth matched better than 10 dB

Conclusion

The capabilities of AWR Microwave Office software combined with the speed of the AWR AXIEM EM analysis helped the CommScope team cut the number of various prototype design spins and delivered a first-time-right solution for the given problems. The software detected the influence of the mechanical tradeoffs and helped the team compensate for those problems during the simulation phase.

Read the full Design and Simulation of a Planar Inverted-F Antenna customer spotlight.

Design and Verification for 5G and Beyond

RF and microwave devices will be integrated into an unprecedented number of connected smart devices and systems enabled by the latest wireless technologies. Developing these systems requires a significant advance in multi-domain analyses, simulation capacity, design automation, and seamless interoperability between RF/microwave EDA and the broader portfolio of mixed-signal IC, PCB, SiP, and system-on-chip (SoC) design tools. These tightly stacked components behave as mechanical systems with sophisticated electronics, transporting RF and high-speed signals through a complex network of interconnects. To function properly, mixed-technology systems require co-design and co-optimization across multiple domains of RF, analog, and digital simulation, aided by large-scale EM and thermal analysis, with robust design verification and signoff.

The V15 Advantage

Version 15 (V15) of the AWR Design Environment platform offers new and enhanced technologies that provide greater design efficiency and first-pass success to engineering teams developing or integrating III-V ICs, multi-technology modules, and PCB assemblies for 5G, automotive, and aerospace/defense applications.

Engineering productivity is improved with new analyses, faster and higher-capacity simulation technologies, time-saving design automation, and 5G New Radio (NR)-compliant testbenches that support power amplifier (PA) and antenna/array design, EM modeling, and RF/microwave integration across heterogenous technologies. Table 1 provides highlights of the new capabilities within this latest release.

AWR Design Environment Platform V15 Highlights				
Environment/ Automation	**Circuit Simulation**	**EM Simulation**	**System Simulation**	**Physical Design/ Layout**
Load-pull contours on rectangular plots	Fast, rigorous stability analysis	Faster, more robust adaptive meshing	Preconfigured 5G NR testbenches libraries	Real-time DRC compliant iNets routing guides
Template-based measurements	Low-frequency load-pull for two-tone excitations	Fast, accurate DC solver	Phased array MIMO bus support	Mixed physical units/ grid support
Add/edit optimization goals directly on graphs	Integrated TX-Line calculator/synthesis	Peak antenna measurements	PA linearization with digital predistortion (DPD)	Two-click data entry mode
Edit axes directly on plots	Network synthesis with PDK/vendor components			Resize layout objects with property page editing
Color-coded markers				Gerber file import for EM analysis
Equation grouping				

Table 1: AWR Design Environment platform V15 highlights

Design Environment and Automation

New design environment and automation features in AWR V15 software help individual engineers and engineering teams be more efficient in their design entry, data display, and project management. Designers can adjust optimization goals directly from response plots, route design rule-compliant intelligent nets (iNets) in real-time, import Gerber-based layout designs into the AWR Design Environment platform for EM analysis, and provide more user capabilities for the design task at hand.

EM Simulation Enhancements

Earlier this year, Cadence expanded its software solutions to better support RF integration within SoC and SiP designs through the acquisitions of key enabling technologies, including AWR and its portfolio of RF and EM design tools, as well as Integrand's EMX® Planar 3D Solver for analysis/extraction of large ICs and advanced packages. The Cadence Clarity® 3D Solver addresses larger and more complex structures such as critical interconnects for PCBs, IC packages, and system on IC (SoIC) designs. Together, these products enable broader system design, from software down to the physical chip design.

Integrating EM Technology Into an RF/Microwave Design Flow

5G networks and devices support greater connectivity by relying on spectrally efficient modulation techniques and mmWave and multiple-in multiple-out (MIMO) antenna technologies. As a result, RF front-end architectures have become considerably more complex. Now that AWR is part of Cadence, accessing additional EM tools like the Clarity 3D Solver is possible. The EM Socket tool was first introduced by AWR in 2003 and the EM Socket II architecture was enhanced in the 2013 V13 release. This revolutionary technology enables interoperability between third-party EM simulation tools and the company's flagship high-frequency AWR Microwave Office software, enabling designers to choose the best tool for the job at hand. EM Socket software continues to be a vital part of the AWR Design Environment platform by allowing designers working in AWR Microwave Office software to access the abilities of the Clarity 3D Solver.

PA Simulation and Design Support

AWR V15 software allows designers to optimize PA linearity performance through video band load-pull analysis of PAs operating under two-tone excitations (Figure 1). Designers can plot intermodulation distortion (IMD) and third-order intercept point (IP3) results as a function of (F2-F1) impedance, directly investigating IMD products over swept input power. Load-pull analysis also supports impedance tuning at the 4th and 5th harmonics as well as the ability to generate contours on rectangular plots for enhanced visualization of performance versus load impedance.

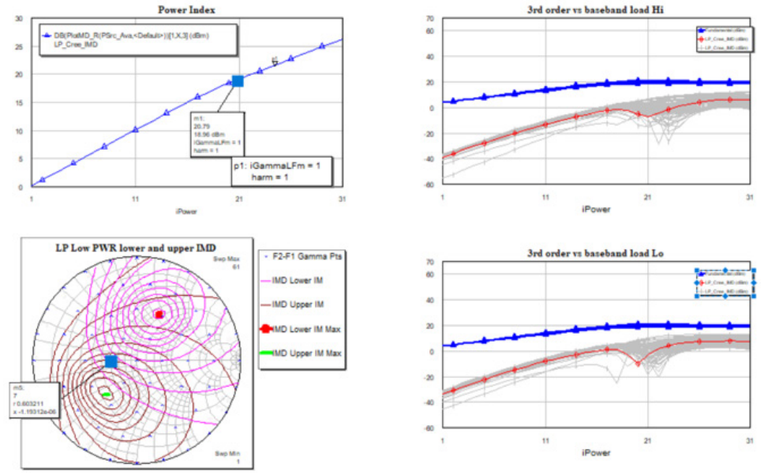


Figure 1: Video-band load pull supports low-frequency impedance optimization to reduce IMD products

5G NR Library and DPD Models

The 5G NR library offers easy-to-configure signal sources and receivers that can be used to evaluate RF components and/or RF links using system-level measurements. New testbenches accelerate the component design and evaluation process with preconfigured 5G NR transmit (TX) and receive (RX) blocks and measurements supporting TX/RX functionality for both downlink and uplink.

Conclusion

The AWR Design Environment platform V15 brings new and enhanced RF/microwave design and simulation to the Cadence portfolio of EDA solutions. Advanced design automation optimizes engineering throughput and productivity by reducing manual design tasks and supporting tool interoperability.

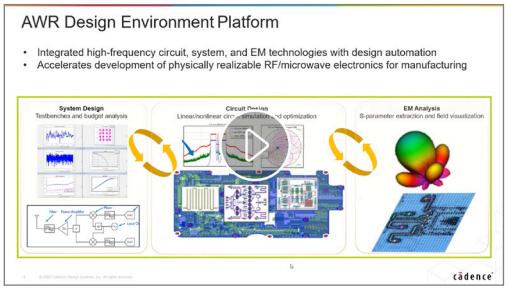
Read full RF/Microwave Design Software software spotlight.

ON-DEMAND **CONTENT**

5G NR, Connected Cars, PA Design Playing Now

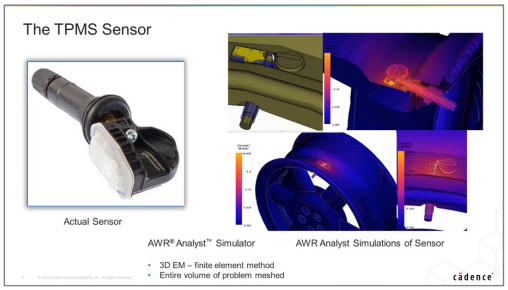
RF to mmWave Front-End Component Design for 5G NR

The RF to mmWave Front-End Component Design for 5G NR webinar looks at some of the design challenges in developing high-frequency components that support 5G NR communications - from beam-steering antenna arrays to mmWave MMIC PAs using gallium-nitride (GaN) semiconductor technology. Presenter David Vye overviews typical 5G NR system requirements and discusses how these requirements impact component performance specifications and physical implementation. Several case studies are presented in which designers overcame design and integration challenges using RF/mmWave simulation software.



RF/MW Design in the Era of Connected Cars

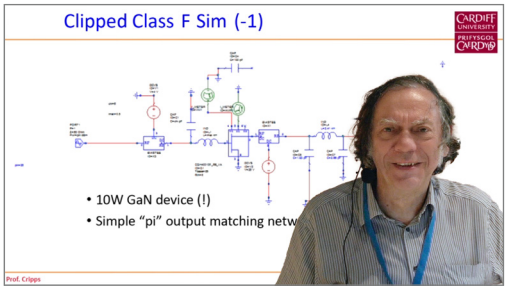
The Connected Cars webinar highlights wireless communications and mmWave radar systems that will enable next-generation vehicles with a host of functions, ranging from safety and navigation features to infotainment and remote entry/control. Noted EM technologist Dr. John Dunn highlights the specialized simulation/measurements, high-frequency device models, and design automation features in the AWR Design Environment platform that enable engineers to develop these high-frequency, automotive-centric components and systems.



PA Design Forum

The 2020 Virtual PA Design Forum showcases the latest technologies within the AWR Design Environment platform for PA design and includes the following presentations:

- KEYNOTE: Class-F PA Design Based on a New Analytical Formulation
  Dr. Steve C. Cripps, Cardiff University
- Designing a Broadband GaN PA Covering 400-3000MHz for Saturated Applications
  Jack Brunning, Ampleon
- Effect of Load Mismatch on PA Performance
  Dr. Dominic FitzPatrick, AMETEK-CTS
- Modelithics Modeled Qorvo QPD1009 PA Design Using AWR Software
  Chris DeMartino, Modelithics and Benny Haddad, Cadence
- Loop Gain Envelope Stability Analysis of MMIC PAs
  Dr. Michael Roberg, Qorvo
- Load-Pull Based Design Flows for High Power Amplifiers
  Christian Bean, Cadence



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