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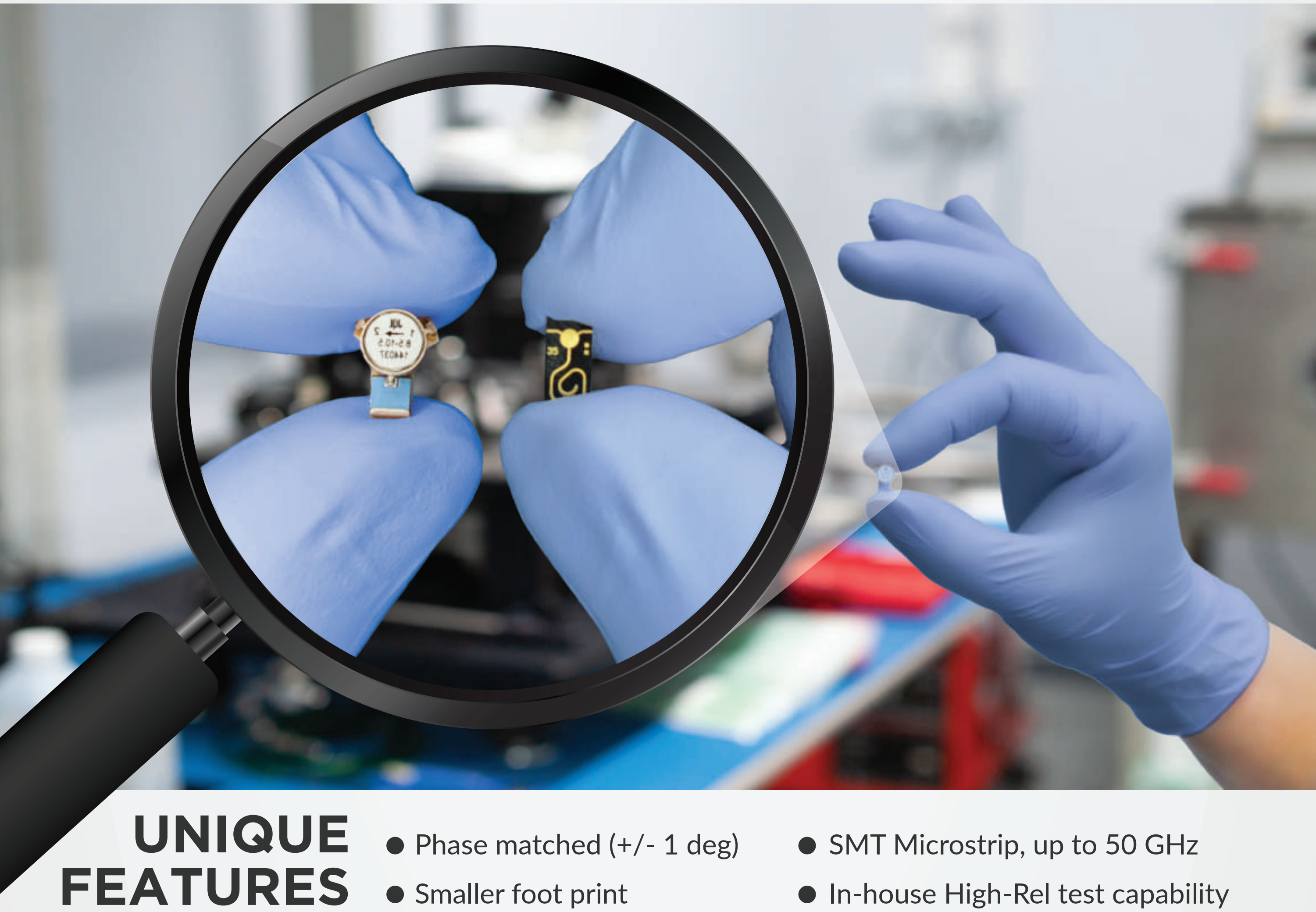

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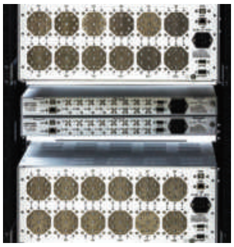

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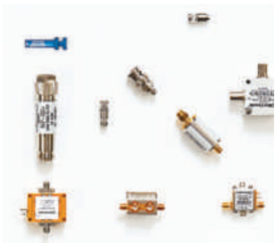

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P5T-500M40G-60-T-55-292FF-5G40G

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P2T-100M56G-100-T	0.1 - 56	5	100	50 ns	+5 V @ 100 mA -5 V @ 100 mA	SP2T, Absorptive 1.0" x 0.75" x 0.4" 2.4mm (F)
P3T-500M40G-60-T-55-292FF	0.5 - 40	6	60	50 ns	+5 V @ 35 mA -5 V @ 15 mA	SP3T, Absorptive 1.0" x 1.0" x 0.5" 2.92mm (F)
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P6T-2G18G-60-T-512-SFF-LV	2 - 18	4	60	50 ns	+5 V @ 121 mA -12 V @ 33 mA	SP6T, Absorptive 1.5" x 2.0" x 0.4" SMA (F)
P7T-0R8G18G-60-T-SFF-SMC	0.8 - 18	4.3	60	75 ns	+5 V @ 300 mA -5 V @ 100 mA	SP7T, Absorptive 1.5" x 1.5" x 0.7" SMA (F)
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P9T-500M40G-60-R-55-292FF-OPT1222	0.5 - 40	6.5	60	100 ns	+5 V @ 450 mA -5 V @ 75 mA	SP9T, Reflective 4.5" x 1.5" x 0.4" 2.92mm (F)
P12T-0R5G18G-60-T-SFF	0.5 - 18	5	60	100 ns	+5 V @ 300 mA -5 V @ 100 mA	SP12T, Absorptive 6.0" x 2.0" x 0.4" SMA (F)
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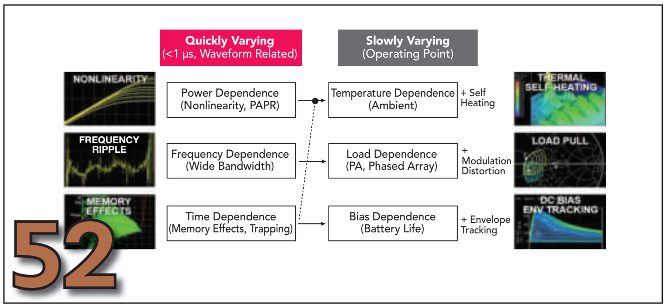

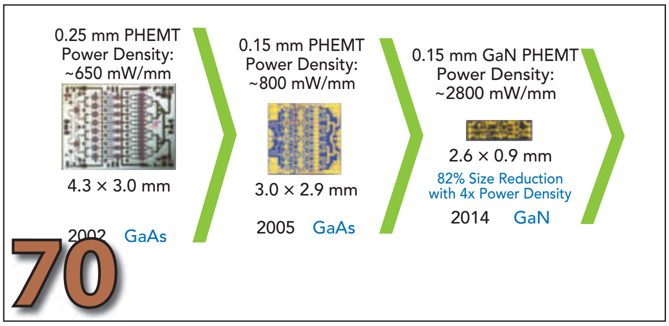

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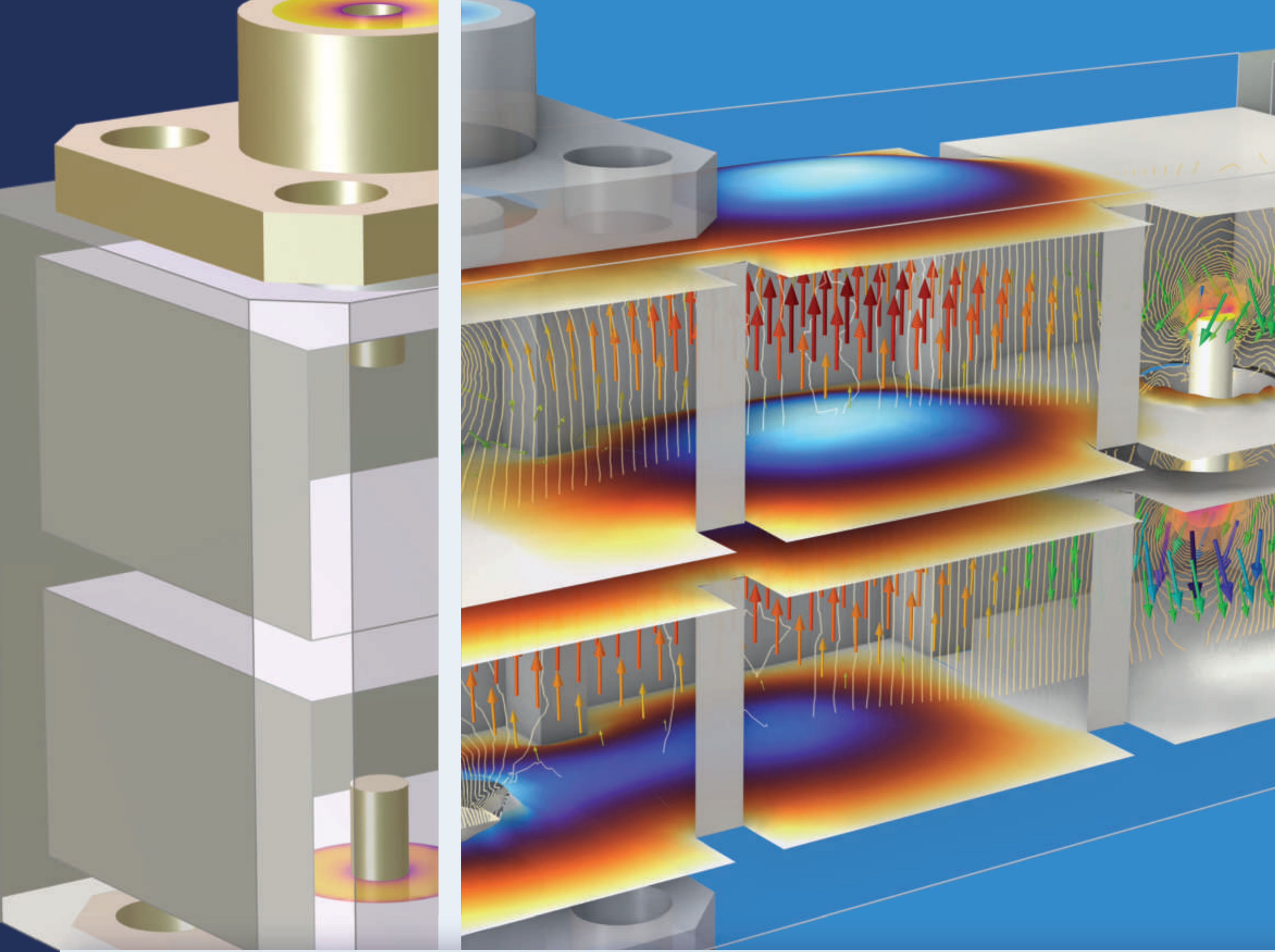

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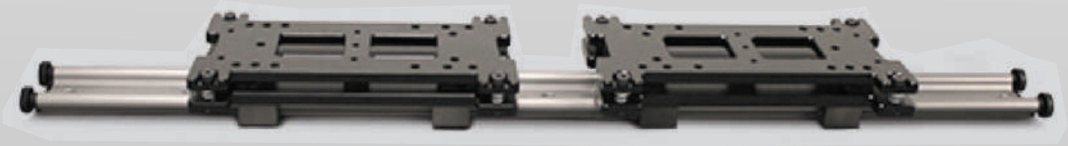

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INVITED PAPER

Improving System Simulation Accuracy with Measurement-based Behavioral Mode

Wissam Saabe
AMCAD Engineering, France

Zacharia Ouardirhi and Tony Gasseling
AMCAD Engineering, Canada

With communication systems evolving quickly, the main challenge for manufacturers is to design intelligent, secure and energy-efficient systems. This development is driven by the traffic generated by the various uses of mobile communications and new associated applications, necessitating the frequent introduction of new technologies to meet these requirements. The arrival of the new 5G standard has brought a radical change in the architecture of base stations with the development of active antenna systems (AAS).

To understand the complexity of these new communication systems, ***Figure 1*** shows an abstract high-level representation of the system where the problem is broken down into three parts:

- The antenna made up of many radiating elements
- The RF front-ends composed of various analog functions (like power amplifier (PA), low noise amplifier (LNA), mixer, filter and phase shifter)
- The digital modules that manage the signal processing (DSP), the beamforming control algorithms, and the non-linearity compensation of the RF circuits (DPD).

This system's design decomposition results in the interaction of several specialized teams with various levels of maturity (R&D or production, for example) and in an asynchronous design time. Controlling the cost of the overall project can be challenging if a dependency exists between these teams. For example, the sizing and adjustment of the PA linearization system entrusted to the DSP team can only be made when the circuit team produces the PA. Thus, these cascaded tasks that are required for the prototyping of certain elements result in a long time to market.

If the overall system does not meet the targeted specifications due to poor coordination between teams, very costly and time-consuming testing and adjustment phases may be necessary after the demonstrator has been manufactured. This cycle of development and production is illustrated in ***Figure 2***.

TOP-DOWN DESIGN FLOW

In Figure 2, the "Top-Down" design flow of the system consists of breaking down the system's global specifications into sub-specifications. The work of the system architect then consists of defining the sub-specifications of each circuit, making up the overall solution by balancing the constraints on each block as well as making it possible to optimize the design and production costs of the entire chain.

The more the specifications tar-

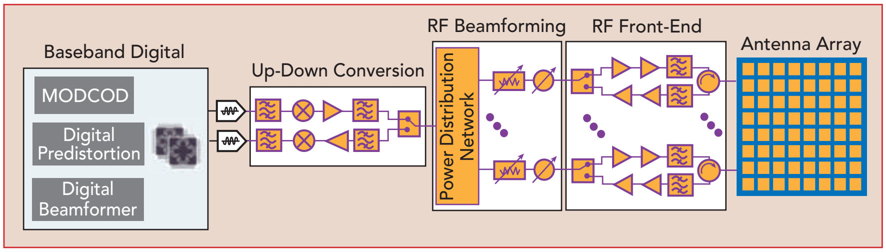

Fig. 1 Active Antenna System architecture.

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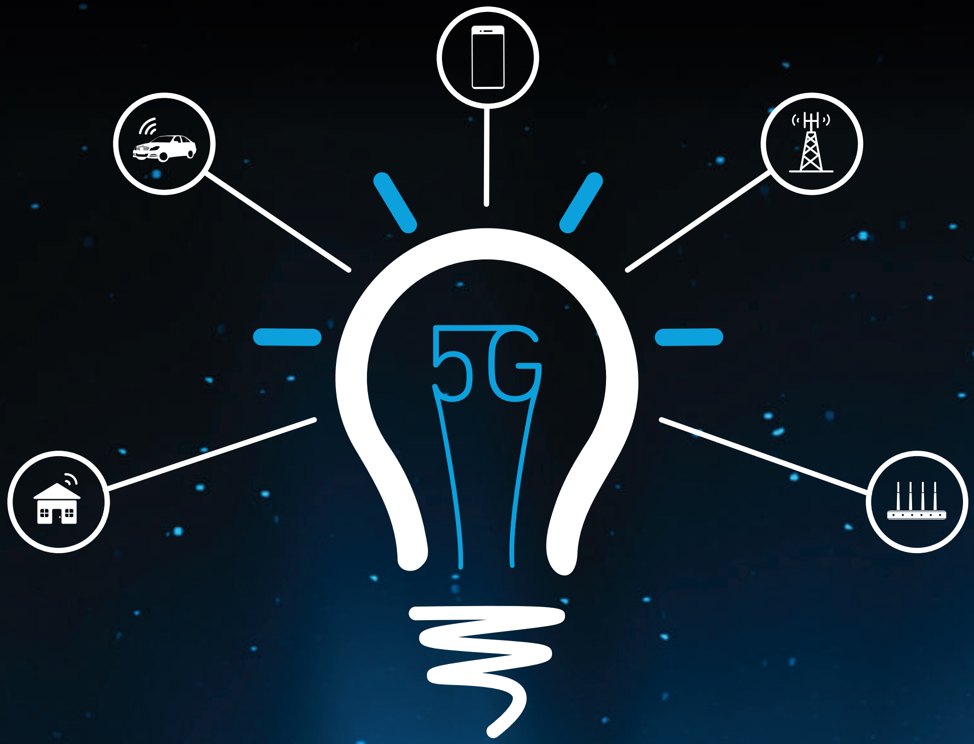
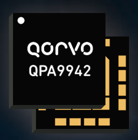
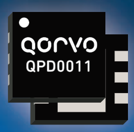


Massive MIMO Amplifier Supports DPD Linearization



The QPA9942 HBT amplifier delivers <-50 dBc ACPR DPD linearized at +28 dBm Pout across 3300 to 3800 MHz. 31 dB of gain. 1.8 V logic.

Dual-Path GaN Transistor for 5G Massive MIMO



The QPD0011 provides two single-stage transistors for 15 Watts average (90 W peak) power in 3.3 to 3.6 GHz asymmetric Doherty® configurations.

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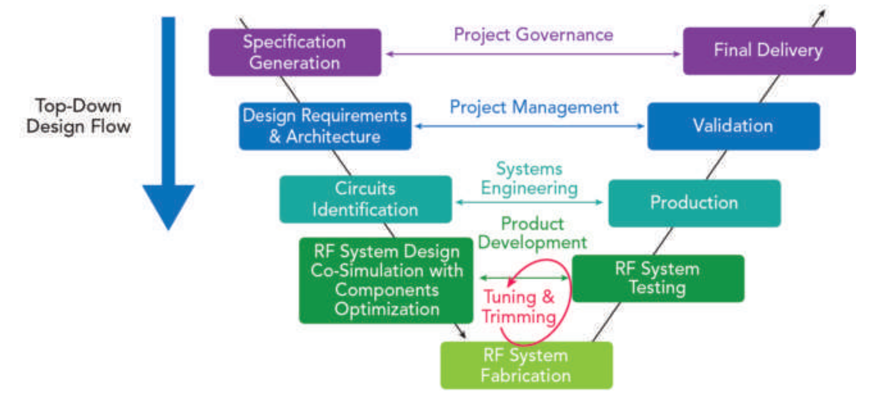
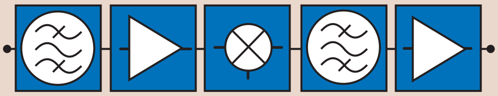


Fig. 2 V-Model design cycle based on experimentations.



	RF Filter	LNA	Mixer	RF Filter	PA
Stage	1	2	3	4	5
Gain (dB)	–3.5	12.1	–7.3	–0.8	21.2
NF (dB)	3.5	1.8	5.6	0.8	7
OIP3 (dBm)	Inf	20	Inf	Inf	Inf

Fig. 3 Preliminary system simulation made during the V-design cycle.

geted for an element of the chain are restrictive, the more the cost of this circuit is important. The system architect indicates which specific circuits have to be developed and which circuits are already available on the shelves that have to be integrated.

The sizing of each circuit is therefore very important. Theoretical models of each circuit can be used to pre-estimate the overall performance. Thus, the optimization of the communication system design requires simulation tools to evaluate and validate the global performance with more or less theoretical models indicating the gain, the noise factor or even the linearity criteria of each element (see ***Figure 3***).

Different options are available to the production team once each circuit composing the system has been used. The historical method is to conduct a first system assembly and see if it meets the targeted specifications. Depending on the sophistication and complexity of the signals processed by the chain, optimization and engineering phases are necessary to achieve the desired performance, as illustrated in the feedback loop in Figure 2. Depending on the system's complexity, each iteration can represent several months of work and hundreds of thousands of dollars, or even more if it is an active antenna composed of several thousand elements.

MODEL-BASED SYSTEM ENGINEERING

The preferred method of system architects now is to anticipate, as early as possible, the impact of each technological choice on the entire chain, even before the production phase, to avoid any pitfalls. Recently, manufacturers have been leaning toward a design methodology called "Model-Based System Engineering (MBSE)."[1] The approach consists of including models to support the tasks of the definition of specifications, design, analysis, verification and validation of the system at all stages of development.

Precise models for each element of the chain are then necessary. As illustrated in ***Figure 4***, the iterative loops for refining the specifications are conducted only during the simulation and are no longer in the post-manufacturing stages. In this case, total confidence is placed in the accuracy of the circuit models in the system simulation. It then makes it possible to implement a genuine bottom-up design flow

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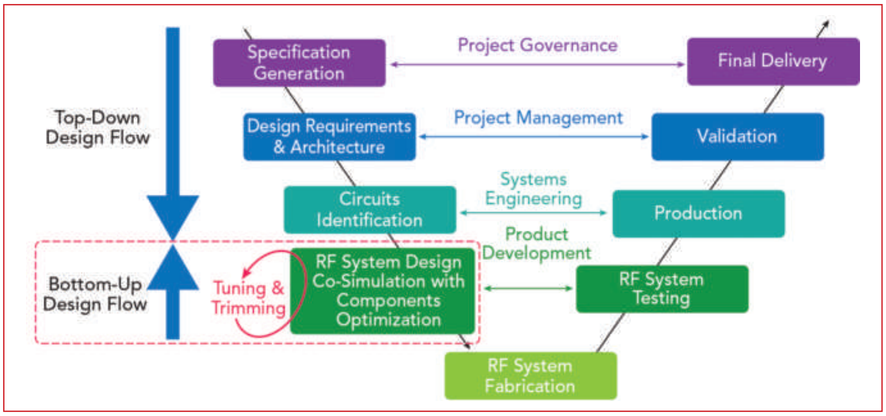

Fig. 4 V-Model design cycle based on a Model-Based Design approach.

methodology, consisting of checking the overall specifications of the system before production.

The top-down design methodology has largely proven itself in designing ICs for the digital part of systems.[2] This approach makes it possible to conduct the synthesis of the circuit from the specifications. It integrates a bottom-up verification phase through dataflow simulations in the time domain (timed dataflow). These simulation techniques have proven effective due to their speed and reliability, thanks to the high level of abstraction of the digital blocks by a high-level description language.

Similar approaches are desirable for the analog part of the system, but considering critical effects coming from the RF/microwave circuits in this type of simulation is more problematic. Taking into account behaviors such as non-linearity, memory effects and mismatches, are essential for verifications at the system level. Unfortunately, circuit-type simulations have proven to be unsuitable at this high level of abstraction because of the significant computational effort and the resulting long simulation times to process wideband modulated signals.

To enable accurate and fast system simulations, a reliable behavioral modeling solution for each RF circuit is necessary to simplify each circuit's description without losing quality concerning the knowledge of the behavior of each block. This uses mathematical equations describing the relationships between each circuit's input and output ports.

These equations are used for accurately reproducing the behavior of the observed circuit, either from measurements obtained on a test bench or from more physical circuit simulations, where each elementary component constituting the circuit itself makes the object of precise modeling beforehand.

In recent years, many efforts have been made on this topic that we describe here. This article is mainly interested in PA behavioral modeling for system simulation, which is critical in analyzing and optimizing communication systems.

RFPA BEHAVIORAL MODELING

Various specialized commercial software allows the communication system's architecture design to evaluate the performance in terms of bit error rate throughout a transmission chain. These simulators are a timed dataflow type and allow the efficient simulation of information encoded in the form of a digital signal in the time domain. However, the simulation can only be realistic if it considers the degradation caused by the analog front-end blocks, particularly by the PAs.

Unfortunately, designers face a lack of effective methodology to properly model PAs at the system level, either from measured or simulated data at the scale of each circuit. Although circuit-type models make it possible to obtain realistic behaviors on relatively simple signals (CW, two-tones) thanks to analysis techniques in the frequency domain (Harmonic Balance Method), the problem is too big to

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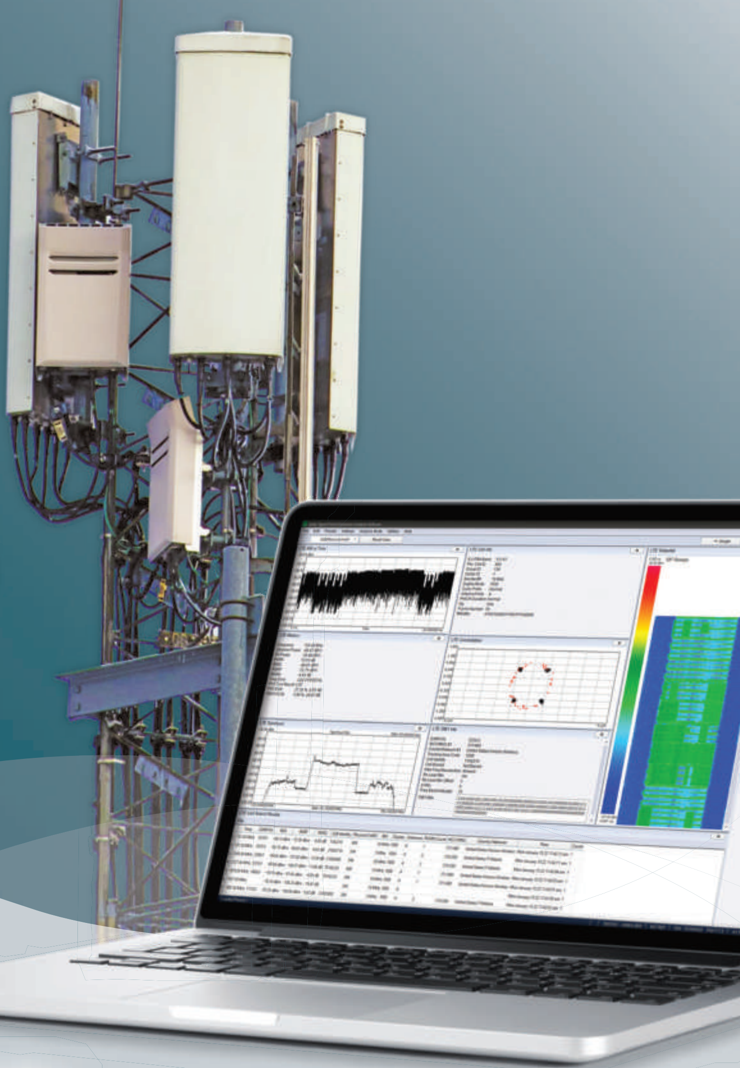

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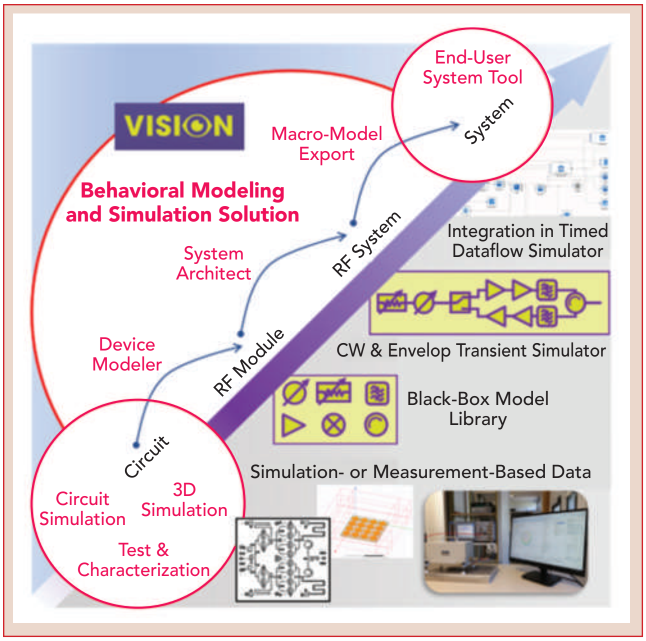

Fig. 5 A comprehensive modeling workflow.

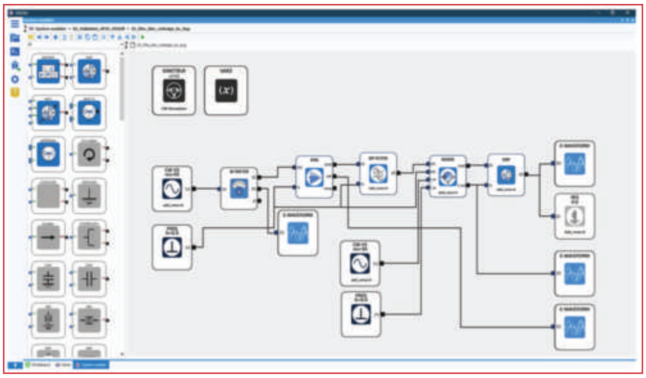

Fig. 6 System simulation schematic.

be solved in the time domain, especially with the Envelop Transient (ET) method, resulting in prohibitive simulation times. Simulation convergence problems can also be observed. Means of characterization in measurement now make it possible to know the real performance against application signals. On the other hand, the quantity of data quickly becomes important if one wishes to measure each variation of circuit parameters (load impedance, bias, temperature) and the signal (average power, peak-average ratio, bandwidth).

Currently, models proposed in these system simulators can accurately reproduce the circuit's behavior only for stimulation conditions relatively close to those used to extract the model. For example, the Poly Harmonic Distortion Model,[3] defined as a non-linear extension of the S-parameters. This model is treated in the system simulator as the static non-linear gain of the device. Even though this model proves to be relatively precise for simulating the circuit's response when the latter is excited by a CW signal, it quickly exhibits significant inaccuracy when simulated with modulated signals.

Conversely, the Generalized Memory Polynomial Model[4] makes it possible to faithfully reproduce the output of a circuit subjected to a modulated signal. Nevertheless, the extraction of the model is only possible from measurement data due to the limitations of circuit simulators (ET simulation) and the accuracy is guaranteed only for signals having the same characteristics as the identification signal (bandwidth, average power, frequency, PAPR).

Many models presented in the literature[3] are based on variants of the Volterra series or Neural Networks. However, no implementation of these models is available in commercial simulators. Even when integrating custom models is possible, it requires specialized skills that only a few engineers master, creating a real risk for manufacturers in developing and maintaining these models.

Finally, manufacturers find themselves without an effective procedure to virtualize the behavior of their communication system realistically and benefit from all the

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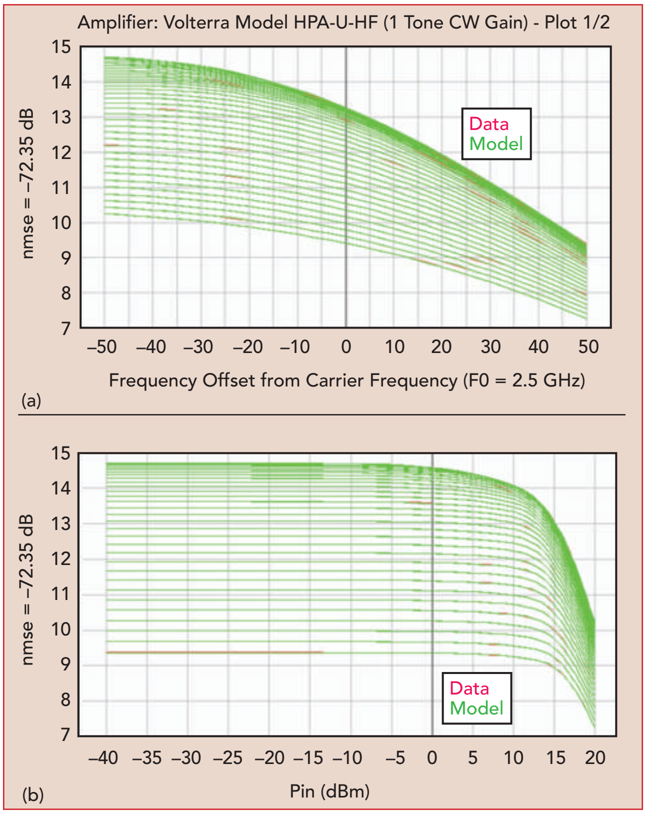

Fig. 7 **Power amplifier non-linearity modeling integrating the frequency dispersive aspects.**

advantages that the MBSE approach can bring for different use cases without the RF signal statistics being perfectly known in advance. Therefore, the solution to solve this challenge is to have available circuit behavioral models that are more general in terms of their use while limiting the complexity of the extraction procedure.

COMPREHENSIVE MODELING WORKFLOW

A comprehensive modeling workflow needs to offer a practical solution to extract, simulate and use these behavioral models in system simulators. An example of this is the VISION modeling tool. A key point offered by this procedure is to be able to extract a model from measurements or simulation results obtained at the circuit scale (see ***Figure 5***). For example, a behavioral model of a linear circuit can be obtained by a simple S-parameters characterization using a VNA or a circuit simulation.

Since this frequency-domain characterization is not directly compatible with a dataflow type system simulator, a "Device Modeler" tool can automatically create a description function in the time domain, as shown in ***Figure 6***. The user can apply this model directly in the "System Architect" environment using an "ET" simulation with broadband application signals and see the impact of the frequency dispersion of the circuit on the signal (ripple, roll-off, etc.).

Exporting the model to a system simulator allows the system engineer to obtain more realistic simulation results instead of using the circuit's nominal gain or loss (S21) value. Also, the exported model integrates the solver, which calculates the implicit relations between voltage and current at each model port, thus making it bilateral. More precisely, the incident and reflected waves at each port are available at the system simulator level.

This method allows the global evaluation of a communication system, considering the impedance mismatch of the RF block in a system simulation environment. This methodology described for a linear circuit is completely transposable to modeling non-linear circuits such as PAs. The proposed solutions benefit from the work carried out from the continuous-time modeling theory,[5] which manages large impedance mismatch and short-term memory (see ***Figure 7***).

By completely designing the architecture of the RF front-end in the comprehensive modeling workflow simulator, the system engineer can benefit from the advanced models of each circuit composing the subsystem and from the simulator's capabilities to predict the models' interactions at each architecture node.

These modeling and simulation capabilities pave the way to creating an RF front-end digital twin. This digital twin hosts an accurate representation of reality, which is used for the simulation, optimization and prediction phases at the system level. In addition, the representation stores and is fed by all the available data of each element during all the development phases of the system.

These possibilities have been echoed in several system-level applications. Now an example is presented as a hot topic for system designers: the accurate simulation of the RF front-end architecture of an active antenna. With this type of analysis, the designer tries to understand the impact on the system in the absence of a circulator in the architecture. Removing the circulator reduces the cost and size of the design. On the other hand, the interaction between the anten-

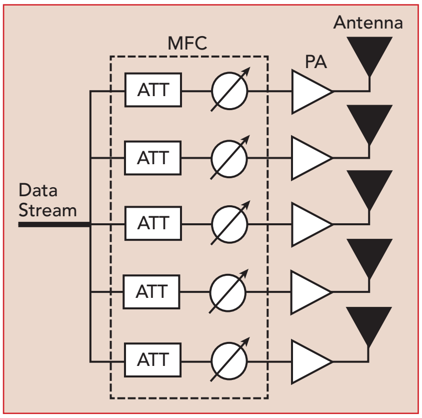

Fig. 8 **Front-end architecture schematic.**

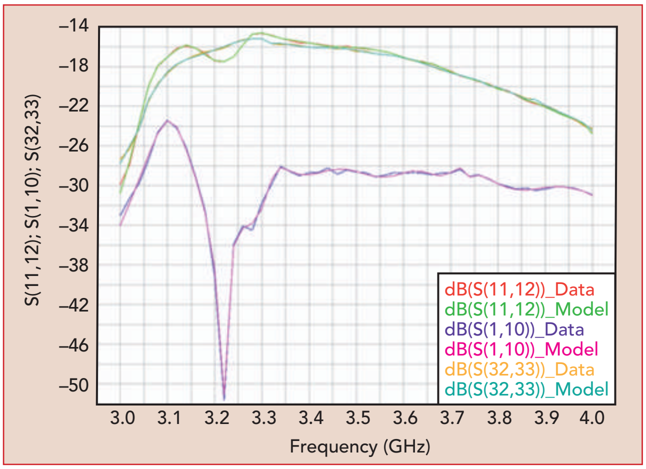

Fig. 9 **Subset of antenna S-parameters.**

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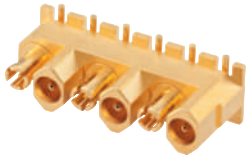

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na and the front-end creates new interference to the PA, affecting the system's overall performance.

ACTIVE ANTENNA'S FRONT-END SIMULATION

The simulation of a front-end architecture is proposed here to show the benefit of using advanced behavioral models. The front-end module comprises a variable attenuator (DSA) and phase shifter (DPS) to achieve the desired beam's steering. The PAs are located after these devices and connected directly to the ports of the antenna, as shown in ***Figure 8***.

The antenna[6] contains 36 radiating elements and is characterized by an S-parameters matrix. Similarly, the DSA circuits and the DPS have been characterized with S-parameters for different digital control states. This module is controlled by two digital ports with seven and eight bits, representing 32,768 states. Each of them is characterized by S-parameters. ***Figures 9*** and ***10*** show the fits of the S-parameters of each circuit for a given command state and its model.

To take into account the mismatch effects induced by the antenna on the PA, the latter was characterized using load-pull measurements. These measurements correspond to

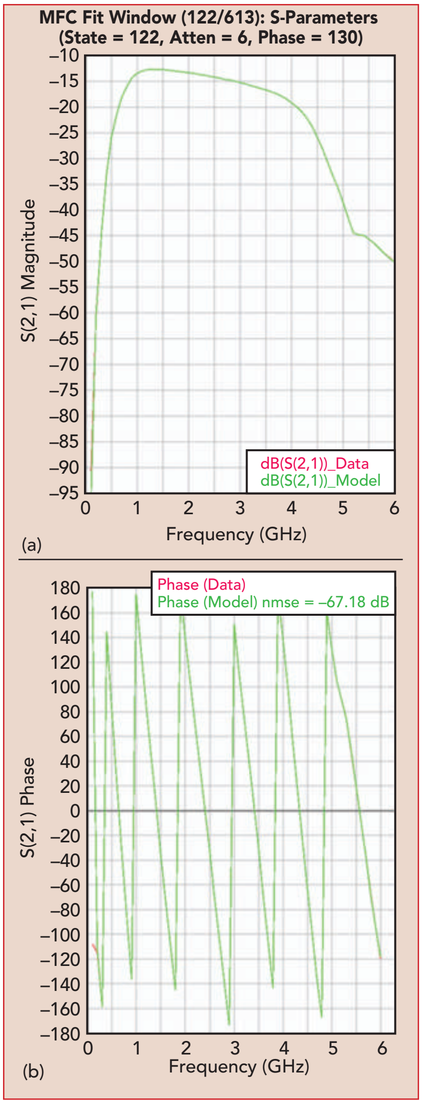

Fig. 10 Subset of DPS+DSA S-parameters.

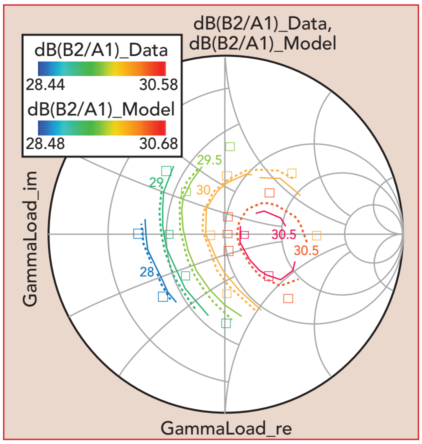

Fig. 11 PA gain contours at a specific compression level.

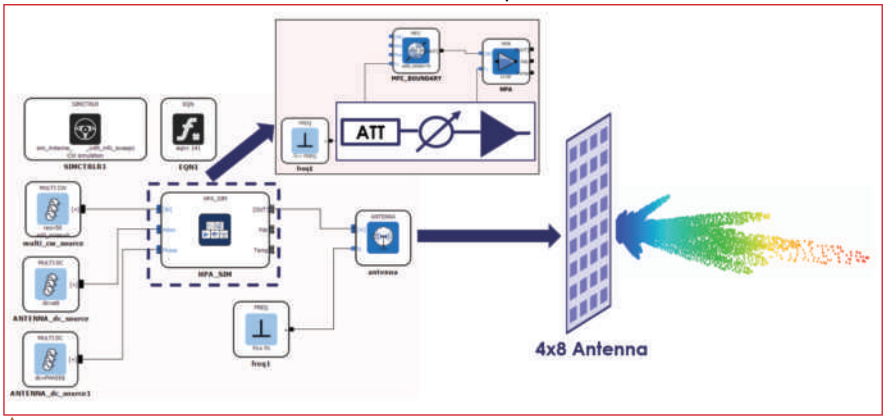

Fig. 12 Active Antenna Schematic in comprehensive modeling workflow system (VISION).

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AM-AM and AM-PM characteristics for different frequencies and load impedances. ***Figure 11*** shows the model versus measurement of gain contours at a specific input power.

Figure 12 shows the implementation of the active antenna architecture in a comprehensive modeling workflow system developed. Because the system is described in the form of command buses, the simulation takes into account the interaction between the 36 PAs connected to the 36 ports of the antenna. The active impedance presented by the antenna as a function of the antenna beam steering command is therefore indicated for each PA (see ***Figure 13***).

Due to the load impedance dispersion, the PA's performance is impacted. A variation of the delivered signal to the antenna in power and the phase may impact the beam steering and the system's overall efficiency. ***Figure 14*** shows the variation of these characteristics as a function of the position of the PA and the angle of the steered beam.

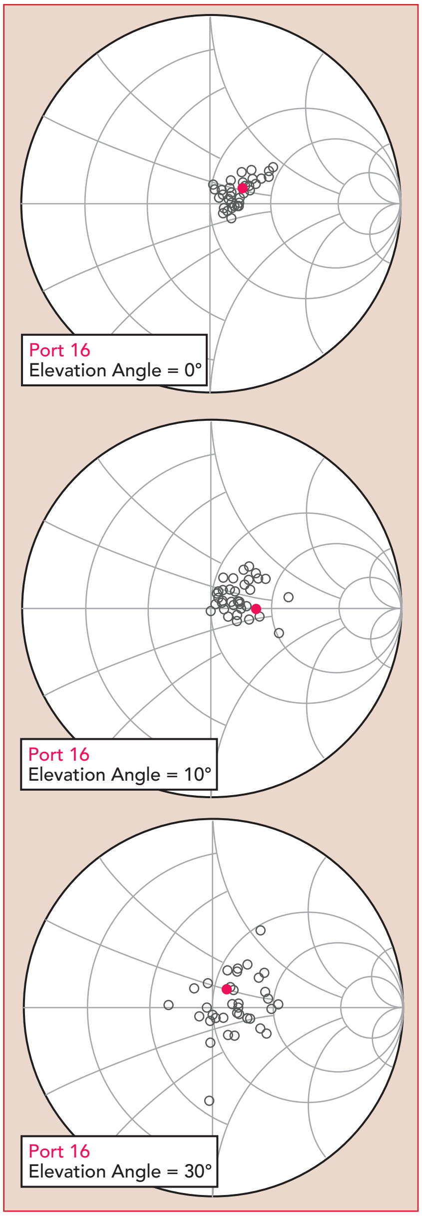

Fig. 13 Reflection coefficient presented to 36 PAs for three different beam steering angles (0°, 10°, 30°).

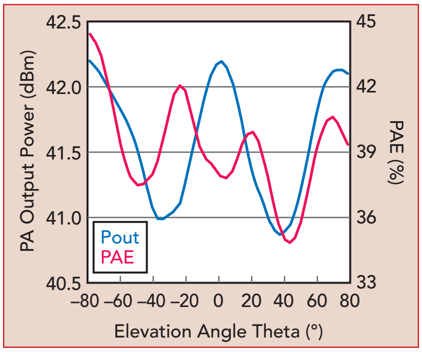

Fig. 14 Pout/PAE vs. theta angle of PA connected to port 16 of the antenna.


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This analysis is possible due to the bilateral behavioral model, which takes into account the mismatch at the output of the PA and the solver, which manages a large number of elements of a complex architecture efficiently. Using this type of simulation, the system engineer can explore different architectures and circuit designs to evaluate the best combination to meet system specifications.

CONCLUSION

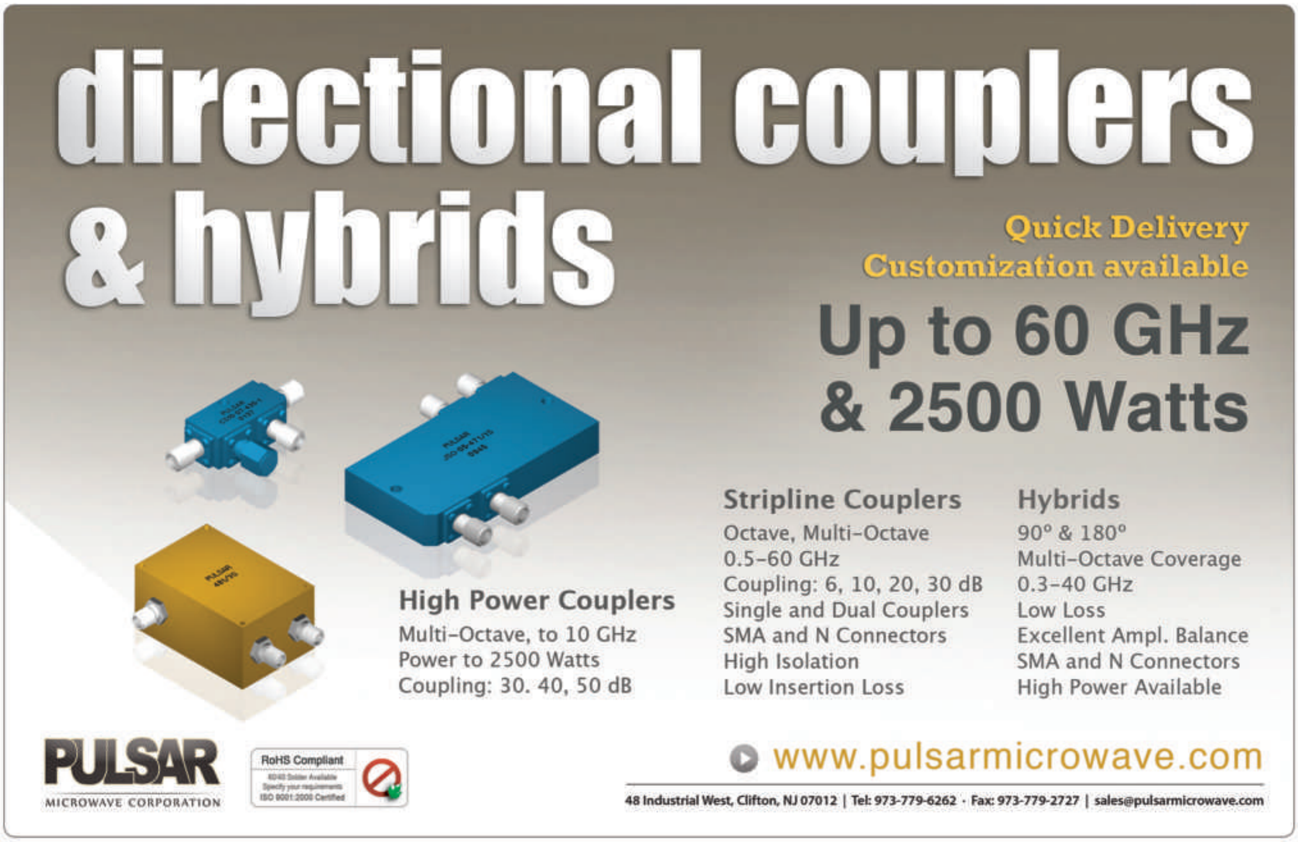
For several years, CAD tools have offered advanced features to adapt to the evolution of communication systems. The complexity of AAS architectures requires the system simulator to combine analyzes in different fields such as electromagnetic for the radiating panel, electrical for the front-end part and digital for the signal processing blocks. The size of the system is so large that simplifications are made for the modeling of the antenna and the front-end to obtain simulation results in a reasonable amount of time. This impacts the overall performance prediction and does not allow engineers to have sufficient confidence in this system simulation procedure.

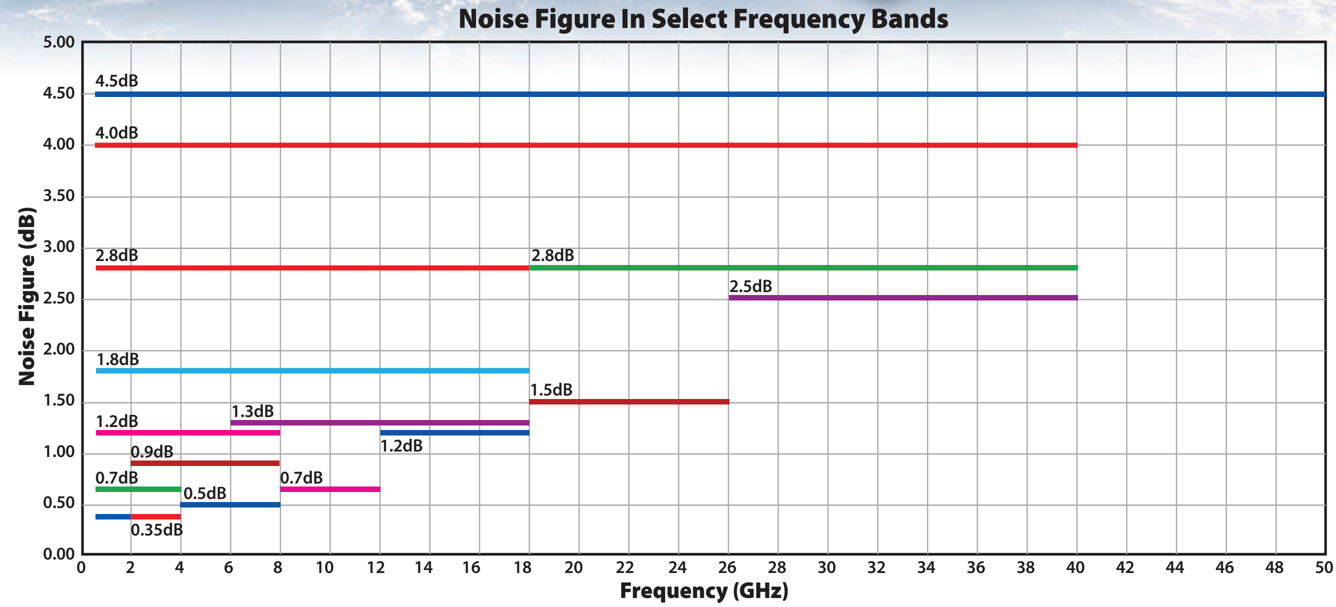
The use of reliable behavioral models is increasingly required to fully exploit the system simulation and thus optimize the operating parameters and better size the RF circuits. This article presented an RF circuit behavioral modeling approach that is part of an industrial process that includes measurement or simulation data, quasi-automatic extraction and implementation in an in-house simulator and system simulators.

Moreover, this new approach has been demonstrated in the bilateral modeling of PA in the context of a simulation of the front-end of an active antenna comprising a large number of RF channels. This type of system simulation is fast and allows performance to be assessed based on operational parameters such as input power, frequency and antenna beam in elevation and azimuth angles. Also, other configurations can be evaluated in which the engineer can change antenna designs or RF circuits. These capabilities pave the way for co-design and system validation processes in simulation and enable system designers to reduce development time and market time significantly. ■

References

1. Y. Wang, T. Steinbach, J. Klein and R. Anderl, "Integration of Model Based System Engineering into the Digital Twin Concept," *Procedia CIRP*, Vol. 100, 2021, pp. 19–24.
2. G. Gielen, "CAD Tools for Embedded Analog Circuits in Mixed-signal Integrated Systems on Chip, Computers and Digital Techniques," *IEEE Proceedings*, 2005.
3. J. Verspecht and D.E. Root, "Polyharmonic Distortion Modeling," *IEEE Microwave Magazine*, Vol. 7, No. 3, June 2006, pp. 44–57.
4. D. R. Morgan, Z. Ma, J. Kim, M. G. Zierdt and J. Pastalan, "A Generalized Memory Polynomial Model for Digital Predistortion of RF Power Amplifiers," *IEEE Transactions on Signal Processing*, Vol. 54, No. 10, Oct. 2006, pp. 3852–3860.
5. E. Ngoya and S. Mons, "Progress for Behavioral Challenges: A Summary of Time-domain Behavioral Modeling of RF and Microwave Subsystems," *IEEE Microwave Magazine*, Vol. 15, No. 6, Sept.-Oct. 2014, pp. 91–105.
6. R. Lamey, M. Thevenot, C. Menudier, E. Arnaud, O. Maas and F. Fezai, "Interleaved Parasitic Arrays Antenna (IPAA) for Active VSWR Mitigation in Large Phased Array Antennas With Wide-Angle Scanning Capacities," *IEEE Access*, Vol. 9, 2021, pp. 121015-121030.





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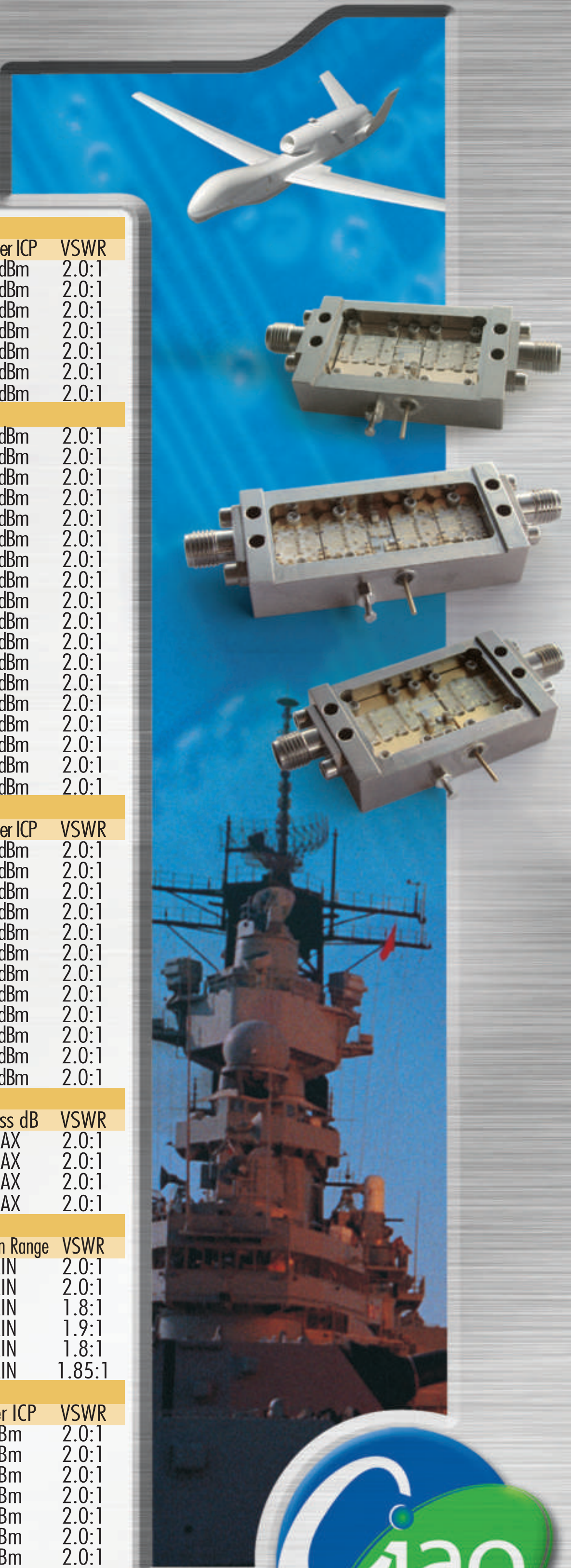

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CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111	4.0-8.0	29	1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA812-3111	8.0-12.0	27	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA1218-4111	12.0-18.0	25	1.9 MAX, 1.7 TYP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA0102-3111	0.1-2.0	28	1.6 Max, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA0106-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max, 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112	0.1-8.0	32	3.0 MAX, 1.8 TYP	+22 MIN	+32 dBm	2.0:1
CA02-3112	0.5-2.0	36	4.5 MAX, 2.5 TYP	+30 MIN	+40 dBm	2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0	22	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA618-4112	6.0-18.0	25	5.0 MAX, 3.5 TYP	+23 MIN	+33 dBm	2.0:1
CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110	2.0-18.0	30	5.0 MAX, 3.5 TYP	+20 MIN	+30 dBm	2.0:1
CA218-4112	2.0-18.0	29	5.0 MAX, 3.5 TYP	+24 MIN	+34 dBm	2.0:1

LIMITING AMPLIFIERS

Model No.	Freq (GHz)	Input Dynamic Range	Output Power Range Psat	Power Flatness dB	VSWR
CLA24-4001	2.0 - 4.0	-28 to +10 dBm	+7 to +11 dBm	+/- 1.5 MAX	2.0:1
CLA26-8001	2.0 - 6.0	-50 to +20 dBm	+14 to +18 dBm	+/- 1.5 MAX	2.0:1
CLA712-5001	7.0 - 12.4	-21 to +10 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1
CLA618-1201	6.0 - 18.0	-50 to +20 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	6.0-12.0	24	2.5 MAX, 1.5 TYP	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25	2.2 MAX, 1.6 TYP	+16 MIN	20 dB MIN	1.8:1
CA1518-4110A	15.0-18.0	30	3.0 MAX, 2.0 TYP	+18 MIN	20 dB MIN	1.85:1

LOW FREQUENCY AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

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MINC Program Aims to Enable Critical Data Flow in Contested Environments

DARPA has selected three teams for the Mission-Integrated Network Control (MINC) program. MINC's objective is to ensure that critical data finds a path to the right user at the right time in highly contested, highly dynamic communication environments using secure control of any available communications or networking resources.

The three teams, comprising industry and university researchers, will develop approaches designed to interoperate with a heterogeneous mix of legacy and future systems to ensure timely and reliable delivery of data that is not guaranteed today. This capability will replace the manual, static configuration of individual, tactical networks and the associated limited internetworking capabilities. The growing emphasis on all-domain warfare compounds the complexity of controlling heterogeneous networks. MINC embraces these challenges by introducing the mosaic warfare concepts of optionality, diversity and rapid adaptability to the orchestration of networks of networks.

The MINC program will realize "on-demand" connectivity to enable effects chains by focusing on the development and integration of three key capabilities. These include creating an "always-on" network overlay to access available networking and communications resources and control parameters; using a cross-network approach for optimizing and managing network configuration and information flows; and creating a mission-driven approach in determining the critical information flows for warfighting services.

"MINC performers are re-imagining the state-of-the-art in commercial networking to develop approaches that will translate mission objectives into network management policies," said Mary Schurgot, MINC program manager in DARPA's Strategic Technology Office. "These mission-driven networking approaches will enable self-healing networks to adapt as the mission and operational conditions evolve, while reducing the overall burden on network operators in manually configuring tactical networks."

NRL Conducts Successful Terrestrial Microwave Power Beaming Demonstration

A team of researchers from the U.S. Naval Research Laboratory recently demonstrated the feasibility of terrestrial microwave power beaming by transmitting 1.6 kW of power over 1 km at the U.S. Army Research Field in Blossom Point, Md., the most significant power beaming demonstration in nearly 50 years.

Microwave power beaming is the efficient, point-to-point transfer of electrical energy across free space by a directive microwave beam. The project, Safe and COntinuous Power bEaming – Microwave (SCOPE-M), was funded by the Office of the Undersecretary of Defense for Research and Engineering's Operational Energy Capability Improvement Fund and led by the project principal investigator, Christopher Rodenbeck, Ph.D., head of the Advanced Concepts Group, NRL.

Within 12 months, NRL established the practicality of terrestrial microwave power beaming and beamed 1 kW of electrical power over a distance of 1 km using a 10 GHz microwave beam. SCOPE-M demonstrated power beaming at two locations, one at the U.S. Army Research Field at Blossom Point in Maryland, and the other at the Haystack Ultra-wideband Satellite Imaging Radar transmitter at the Massachusetts Institute of Technology.

"The reason for setting those targets is to push this technology farther than has been demonstrated before," said Paul Jaffe Ph.D., Power Beaming and Space Solar lead. "You don't want to use too high a frequency as it can start losing power to the atmosphere," Rodenbeck said. "10 GHz is a great choice because the component technology out there is cheap and mature. Even in heavy rainfall, loss of power is less than five percent."

In Maryland, the team exceeded their target by 60 percent by beaming 1.6 kW just over 1 km. At the Massachusetts site, the team did not have the same peak power, but the average power was much higher thereby delivering more energy. Jaffe said these demonstrations pave the way for power beaming on Earth, in space and from space to Earth using power densities within safety limits set by international standards bodies.

Jaffe went on to say that during past experiments with laser power beaming using much higher power densities, the engineers were able to successfully implement interlock systems so if something approached the beam it would turn off. "We did not have to do that with SCOPE-M because the power density was sufficiently low that it was intrinsically safe," Jaffe said.

Antenna (Source: U.S. Navy Research)

Brian Tierney, Ph.D., SCOPE-M electronics engineer, said the Department of Defense (DoD) is interested in wireless power beaming, particularly wireless power beaming from space, and that a similar rectenna (rectifying antenna) array as used for SCOPE-M could be used in space. A

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rectenna is a special type of receiving antenna for converting electromagnetic energy into direct current electricity in wireless power transmission systems.

Besides being a DoD priority, Rodenbeck stated power beaming is the ultimate green technology. Unlike other sources of clean energy, which provides intermittent and sporadic electrical power, power beamed from space to Earth can provide power continuously, 24 hours a day, seven days a week, 365 days a year.

First Airborne GaN-AESA Fire-Control Radar Successfully Flight Tested

Raytheon Intelligence & Space's (RI&S's) preproduction APG-79(V)4 radar system was successfully flown on a U.S. Marine Corps F/A-18 Hornet earlier this year at the Naval Air Weapons Station in China Lake, Calif. This is the radar system's first flight on the aircraft since RI&S delivered the prototype radar in 2021.

The APG-79(V)4 is an APG-79 radar derivative that employs the first airborne GaN-AESA fire-control radar to help pilots detect and track enemy aircraft from greater distances with greater accuracy while meeting the power and cooling requirements of legacy aircraft.

AESAFA18 (Source: Raytheon Intelligence & Space)

"Following successful ground testing and the delivery of the prototype radar, this flight test was critical to observe performance in the air," said Thomas Shaurette, vice president of F/A-18 and Global Strike Radars for RI&S. "It allowed our partners to see the V4 radar's enhanced detection and tracking abilities in real-time."

The U.S. Marine Corps pilot demonstrated the radar's seamless integration with the legacy Hornet avionics. The APG-79(V)4 radar is common in parts and technology with the legacy AN/APG-79 radar used in the U.S. Navy's F/A-18 Super Hornet, thus optimizing cost and sustainment. Flight tests will continue to support weapons system integration on the fleet.

The Naval Air Systems Command recently awarded additional contract modifications to equip the Hornet fleet with more radars in 2021, and the total production value for domestic and foreign military sales customers is over $300 million.

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5G Revenue Dominated by Massive MIMO

Massive MIMO (mMIMO) is the key technology of 5G, and network operators are actively deploying 5G to provide superior experience to both consumers and the enterprise. 5G revenue is dominated by mMIMO and Asia Pacific generates 60 percent of the total revenue in the world market. According to ABI Research, by 2027, there will be 41 million mMIMO deployments worldwide, reaching revenue of US$43 billion, representing 35 percent of the total revenue in outdoor infrastructure. Furthermore, deployment will be led by Asia Pacific due to the large adoption in countries like China, Japan and South Korea.

"Network operators around the world are actively deploying mMIMO and there is regional difference in mMIMO deployments. 5G in China initially started with dense urban areas so they were mainly deploying mMIMO in 64T64R configuration. Since the 2021 move toward the suburbs, the 32T32R mMIMO configuration became preferred. The semiconductor shortage may be another contributing factor. Europe mainly deploys mMIMO in 32T32R configuration as they prioritize simple site migration and the high-power consumption associated with 64T64R," explained ABI Research's 5G & Mobile Network Infrastructure Industry Analyst, Fei Liu. "Due to space and weight constraints, South Korea and Japan favor 32T32R mMIMO. The U.S. operators are aggressively deploying 64T64R mMIMO as 5G in the U.S. still focuses on dense urban areas. 64T64R is the primary use in the Middle East region and this configuration is expected to the adopted in Latin America as well."

The fast-growing power consumption of 5G is burdening network operators with high energy costs and they are demanding equipment that is more energy efficient. "Power Amplifiers represent up to 60 percent of the mMIMO power consumption with high traffic load," Liu said. "Therefore, vendors are switching from laterally diffused metal-oxide semiconductors to GaN for PAs to meet the requirement of high output power and lower energy consumption for 5G mMIMO. The evolution of the amplifiers could promise a 5 percent improvement in energy efficiency every year."

Over 150,000 AVGs to be Deployed in Seaports by 2027

The maritime industry has surged its seaport automation efforts amid ongoing global port congestion issues. In addition to solutions such as gantries, automated port gates and stacking cranes, horizontal transport solutions such as automated guided vehicles (AGVs) that transport containers and loads to and from ships have been the most productivity-enhancing solution in seaports. According to ABI Research, worldwide AGV deployments in seaports will have a CAGR of over 26 percent from 2022 to 2027 and exceed 150,000 global deployments by 2027.

"Automation enhances the reliability, consistency, predictability and security of port operations. From an environmental perspective, automation can lead to lower energy consumption and a reduced carbon footprint. Automated ports are also far safer than conventional ports. The number of human-related disruptions falls as performance becomes more predictable with automation and data capture solutions," explained Adhish Luitel, senior analyst, Supply Chain Management and Logistics at ABI Research.

In addition to AGVs in seaports, the adoption of solutions in other modalities of the global supply chain, such as rail, air and road, have also seen growth. Automaton solution providers, including ThorDrive, Waygate Technologies, Loccioni and Advanced Logistics Systems have been providing various automation solutions such as elevating transfer vehicles, ground tugs, inspection robots and surveillance systems. Inspection robots in rail infrastructure particularly is a growing sector. Over 7000 inspection robots were deployed in rail infrastructure globally in 2021. This number is set to grow to over 12,000 by 2027 with a CAGR of nearly 9 percent, falling in line with the rising rail freight volume. Around 14 billion tons were transported via rail freight and this number is set to grow to nearly 16 billion by 2027.

"Automation in various modalities, despite its benefits, can also bring certain drawbacks that supply chain managers might need to mitigate. Although automation can streamline workflows, it comes at the cost of initial potential productivity losses for equipping workers with the right skillsets to operate and maintain these solutions. There is a change management aspect that managers and authorities need to be more mindful of," Luitel concluded.

Wi-Fi 7, 6 GHz Spectrum, Mesh Networking and Value-Added Services to Drive Consumer Wi-Fi Innovation

Many recent developments are converging to create an era of market revolution in residential Wi-Fi. One of these is the sooner than expected arrival of Wi-Fi 7, with early 2022 witnessing Qualcomm's unveiling of the industry's first Wi-Fi 7 chipset, followed by Broadcom's recent announcement of its Wi-Fi 7 ecosystem, which included the residential access point BCM6726/67263 chipsets.

ABI Research is forecasting shipments of Wi-Fi 7 chipsets to reach over 16 million this year, rising to near-

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ly half a billion in 2026. Alongside this, ABI Research expects the maturing of mesh Wi-Fi networking, with revenue for mesh infrastructure forecasted to undergo a 15 percent CAGR between 2021 and 2026, rising from US$2.9 billion to US$4.6 billion. Meanwhile, the flourishing of new forms of Wi-Fi value-added services is acting to fundamentally redefine connectivity in the home. One such service is Wi-Fi motion detection, with Cognitive, Origin Home and Plume all offering innovative solutions.

"From the release of new Wi-Fi protocols and clean spectrum, to the coming of age of mesh networking and value-added services, it is clear that the residential Wi-Fi market is currently undergoing a period of rapid structural transformation," said Andrew Spivey, industry analyst at ABI Research. "To remain competitive, industry players need to be wary of not becoming complacent and must begin preparing their business strategies now."

The rise of innovation in the residential Wi-Fi space is matched by an increase in market complexity. "For example, although the opening of the 6 GHz spectrum for unlicensed use will usher in a new era of residential Wi-Fi, there remains a myriad of factors acting to dampen its adoption in the home, ranging from a current scarcity of 6 GHz enabled consumer devices, the uneven accessibility of the 6 GHz spectrum globally, low levels of service provider support for the protocol, a lack of consumer awareness of Wi-Fi 6E, proximity to Wi-Fi 7 rollout, and supply chain constraints," Spivey explained.

> Current trends in the residential Wi-Fi market necessitate drastic adjustments to business strategies.

While businesses may take solace in the fact that penetration of 6 GHz into consumer devices will rise rapidly in the coming years (in 2026 the proportions of chipset shipments that are 6 GHz enabled for smartphones and portable PCs will reach 49 and 68 percent respectively), they are still crying out for more clarity on when the other barriers to adoption will be resolved.

Challenges likewise exist for other aspects of the residential Wi-Fi market, including determining which mesh Wi-Fi configurations consumers are most receptive to, knowing which value-added services have the greatest revenue potential, estimating the eventual penetration rate of 5G FWA, determining the optimal MIMO strategy, and knowing when the persistent supply chain disruption will finally be alleviated.

Current trends in the residential Wi-Fi market are necessitating drastic adjustments to the business strategies of all industry players.

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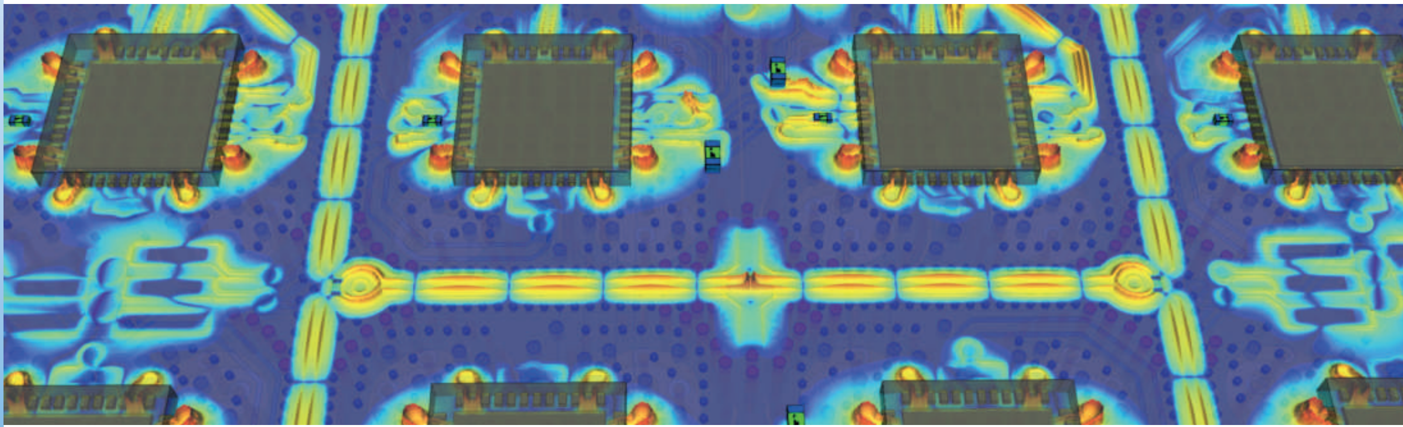

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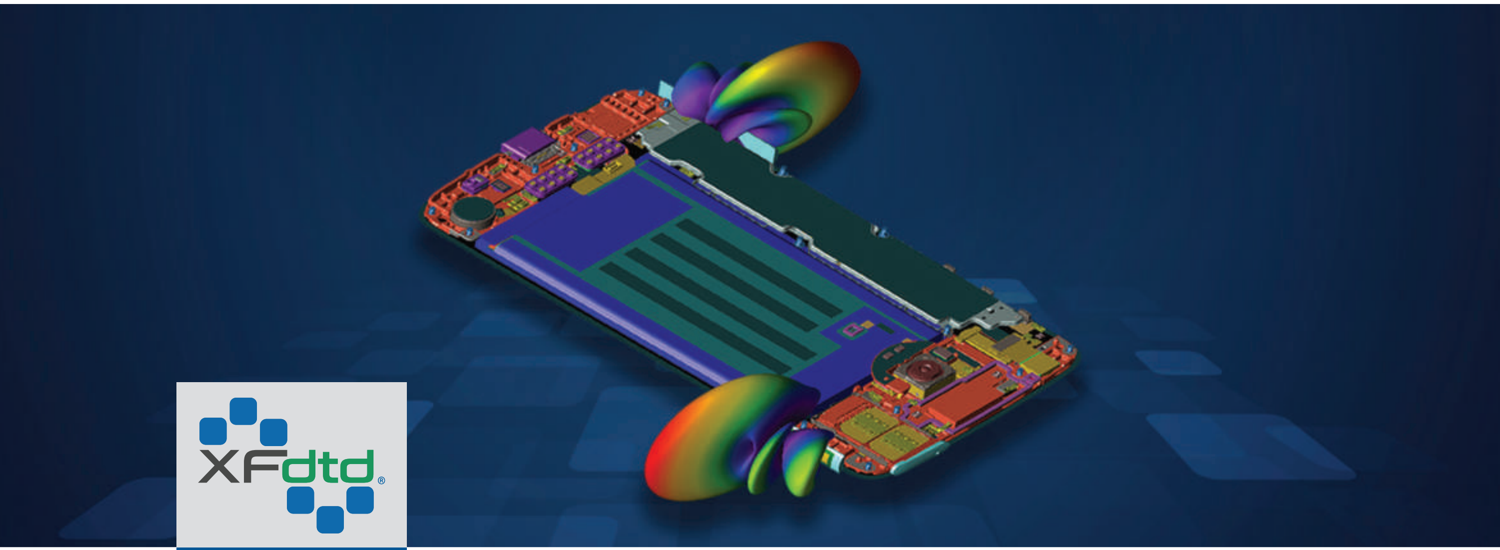

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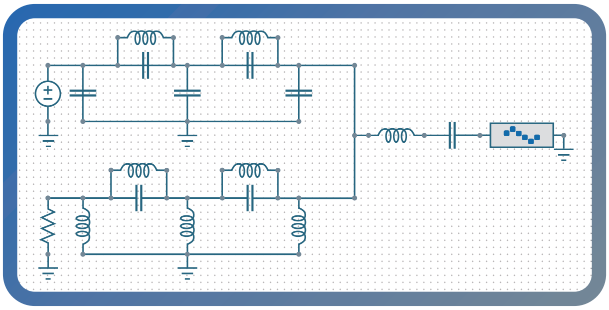

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Around the **Circuit**

Barbara Walsh, Multimedia Staff Editor

IN MEMORIAM

Microwave engineer **Douglas Teeter** and his wife **Terri Stull** died tragically in a multi-vehicle collision on Interstate 81 in Pennsylvania on March 28, 2022. Douglas A. Teeter received a B.S.E.E. degree from the Virginia Polytechnic Institute in 1987, and M.S. and Ph.D. degrees in electrical engineering from The University of Michigan in 1988 and 1992. He was with the Raytheon Research Division and the Raytheon Advanced Device Center Research Laboratories from 1992 to 2000, where he was responsible for development of HBT, pHEMT, MHEMT devices, models and circuits. Since 2000, Teeter was with RFMD and Qorvo, where he led the development of power amplifiers and power amplifier technologies related to wireless communication systems. Teeter was a frequent contributor to MTT and IMS, as author of papers, serving as a reviewer and speaker and as a member of IMS Steering Committees. He was a Qorvo Fellow and a recognized leader in power amplifier development at Qorvo and in the MTT community.

SatixFy Communications Ltd. announced that the company's co-founder, co-chairman and CEO **Yoel Gat** passed away on April 8, 2022. Yoav Leibovitch, co-founder, co-chairman and chief financial officer, issued the following statement on behalf of himself and SatixFy's Board: "We are deeply saddened by the passing of Yoel. He was a tremendous visionary and the driving force behind growing SatixFy to where it is today. I personally have partnered with Yoel for over 30 years and will miss both his personal friendship and business partnership. He was a true entrepreneur, a creator of new companies, technologies and markets. We will continue to follow his vision as we take SatixFy to its next stage of growth. We also extend our heartfelt condolences to his wife, Simona, and his two children. Our thoughts and prayers are with them at this difficult time." Leibovitch has been named interim CEO and will assume Gat's leadership duties for the time being as well as continuing his duties as CFO. SatixFy had previously announced that its new CEO has been hired to begin on June 26, 2022, the culmination of a transition plan that began in the fall of 2021. SatixFy expects to announce the name of the new CEO in the coming weeks.

MERGERS & ACQUISITIONS

RFMW, a specialized distributor of RF and microwave products, announced the acquisition of **Spantech Technology Solutions S.L.U**. Spantech represents industry-leading manufacturers of RF, microwave, mmWave components and satellite communication equipment in Spain and Portugal. The agreement fortifies RFMW's international presence and enhances their prominent position as a global and technically competent sales and marketing organization.

COLLABORATIONS

BT and **Ericsson** announced a multi-million-pound new partnership to provide commercial 5G private networks for the U.K. market—the first agreement of its kind in the country. The two companies have signed a multi-year contract that will enable BT to sell next-generation mobile network technology products to businesses and organizations in sectors such as manufacturing, defense, education, retail, healthcare, transport and logistics. Ericsson Private 5G is a fit-for-purpose, dedicated and agile private network solution that provides guaranteed high performing indoor and outdoor 5G cellular coverage, making it suitable for a range of uses—particularly in environments such as factories, education campuses and other large sites where security and ultra-low latency connectivity are important.

Synopsys Inc. and **Juniper Networks** announced that they have closed a transaction to form a new, separate company that will provide the industry with an open Si photonics platform to address the growing photonic requirements in applications such as telecom, datacom, LiDAR, healthcare, HPC, AI and optical computing. The new company's open Si photonics platform will include integrated lasers, optical amplifiers and a full suite of photonic components to form a complete solution that will be accessible through a process design kit. The platform will enable a new level of integration at an unmatched price point, with the lowest power consumption for high performance photonic integrated circuits. The name of the new company will be announced at a later date.

Isotropic Systems announced a strategic integration partnership with **SpaceBridge**. The partnership secures a fully integrated SpaceBridge waveform option enabling dynamic waveform selection and switching between MF-TDMA, ASCPC or SCPC, optimizing satellite resource usage. Isotropic System's first launch products will offer a powerful SpaceBridge option designed to unlock access to SpaceBridge platforms in a single fully integrated terminal.

Criteria Labs has partnered with **CAES** to consult on systems development and production of die carrier assemblies in support of the U.S. Navy's Advanced Offboard Electronic Warfare (AOEW) program. The AOEW

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SDCHP-140	10 - 400	18.75	1	0.5 / 0.85	27 / 22	25
SBCHP-1100	10 - 1000	10	0.5	1.2 / 1.4	17 / 15	5
KBK-HP-1100	10 - 1000	10	0.5	1.2 / 1.4	17 / 15	5
KDK-HP-255	20 - 550	20	0.4	0.25 / 0.35	23 / 18	27.5
SDCHP-255	20 - 550	20	0.4	0.25 / 0.35	23 / 20	27.5
SDCHP-335	30 - 350	20.1	0.85	0.24 / 0.32	24 / 20	75
SDCHP-484	40 - 840	19.2	0.9	0.3 / 0.4	24 / 20	30
SCCHP-560	50 - 560	14.6	0.7	0.48 / 0.65	23 / 20	75
SCCHP-990	90 - 900	15.2	0.6	0.52 / 0.64	20 / 17	38.3
SBCHP-2080	200 - 800	12.3	0.7	0.64 / 0.80	24 / 18	48.3
SBCHP-2082	200 - 820	11.0	0.5	0.74 / 0.9	22 / 19	22.5
KDS-30-30-3	27 - 512	27.5	0.75	0.3 / 0.4	23 / 15	50
KDS-30-30	30 - 512	27.5	0.75	0.3 / 0.4	23 / 15	50
KBK-10-225	225 - 400	11	0.5	0.6 / 0.7	25 / 18	50
KBS-10-225	225 - 400	10.5	0.5	0.6 / 0.7	25 / 18	50
KDK-20-225	225 - 400	20	0.5	0.2 / 0.4	25 / 18	50
KDS-20-225	225 - 400	20	0.5	0.2 / 0.4	25 / 18	50
KEK-706H	500 - 2500	31.5	2.5	0.28 / 0.4	18 / 12	100
SCS-8012D	800 - 1200	20	0.6	0.22 / 0.25	22 / 18	100
KEK-704DH-2	850 - 1250	30	0.25	0.20 / 0.30	28 / 25	500
KEK-704H	850 - 960	30 5	0.25	0.08 / 0.20	38 / 30	500
SCS100800-10	1000 - 8000	10.5	2	1.2 / 1.8	8 / 5	25
SCS100800-16	1000 - 7800	16.8	2.8	0.7 / 1	14 / 5	25
SCS100800-20	1000 - 7800	20.5	2	0.4 / 0.75	12 / 5	25
SCS-1522B	1500 - 2200	10	--	0.65 / 0.75	23 / 18	100
SCS-1522D	1500 - 2200	20	--	0.32 / 0.38	23 / 20	100
SCS1701650-16	1500 - 15500	17	2.5	1 / 1.4	16 / 5	25
SCS1701650-20	1700 - 15000	21	2.5	0.9 / 1.3	10 / 7	25
SDC360440-10	3600 - 4400	8.6	0.25	0.7 / 1.4	18 / 10	10
SDC360440-20	3600 - 4400	19	0.25	0.7 / 1.2	16 / 10	10

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program will deliver persistent electronic surveillance (detection) capability against naval threats like anti-ship missiles. The new system not only allows the U.S. Navy's fleet to see incoming threats, but to respond to them (countermeasures). Criteria Labs will support the delivery of low-rate initial production lots before the start of full-rate production in 2023 or 2024. Criteria Labs is investing in cutting-edge equipment and expanding internal resources to meet AOEW program needs.

Orolia is providing Atomic Reference Time (ART) Cards to support **Meta**'s implementation of high precision timing protocols within its distributed timing infrastructure. The architecture of Orolia ART Cards is powered by the company's industry-leading mRO-50 mini Rubidium atomic clock technology. Orolia developed the ART Card solution in collaboration with the Meta engineering team to fulfill a new specification that Meta published for the Time Appliances Project Initiative of the Open Compute Project. This new collaborative community is focused on designing from scratch new hardware and software to efficiently support the critical timing accuracy and resilience demands on computer network infrastructure. This project is fully open sourced and available at Orolia's GitHub.

NEW STARTS

Anritsu Company announced that is has expanded its presence in the Americas with the opening of a regional office in New Jersey. The East Coast office will supplement other Anritsu regional offices in Texas and California, allowing Anritsu to optimally address the convergence in the telecommunications ecosystem underway to expand emerging 5G enterprise use cases. Located in Bernards Township, NJ, the new facility is closer to strategic customers and partners. Anritsu staff will conduct sales, support, product marketing and planning and business development at the office. The facility will help Anritsu best serve all its customers, including mobile operators and hyperscalers.

DuPont Interconnect Solutions recently held a ribbon-cutting ceremony with elected officials and business leaders to formally mark the completion of its $250 million capital project to expand production of Kapton® polyimide film and Pyralux® flexible circuit materials at the Circleville manufacturing site. DuPont employs more than 1,000 people across eight locations in Ohio, including 500 people at its site in Circleville. This new manufacturing line uses DuPont proprietary processing capabilities to produce advanced Kapton® polyimide films, which have set industry standards for more than 50 years, offering high performance, reliability and durability.

ACHIEVEMENTS

Richardson Electronics Ltd. is celebrating its 75th anniversary throughout 2022 with activities highlighting the company's history and plans for the future. Richardson Electronics is proud of its 75-year history of engineered solutions and innovation. Beginning in 1947 as a start-up selling war surplus tubes and growing into a global

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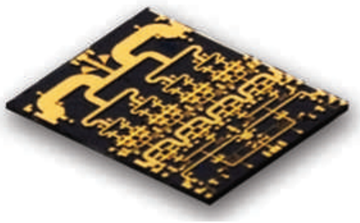

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PRODUCTS:
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NPM2003-KW

© Copyright 2022 Nxbeam // nxbeam.com // info@nxbeam.com manufacturer of patented ultra-capacitor modules for replacing lead-acid batteries in wind turbines, the company has come a long way over the years. Despite its humble beginnings, Richardson Electronics has grown into an international organization with 60+ locations worldwide, supporting more than 20,000 customers and employing hundreds of people around the world in a family-oriented environment.

Socionext Inc. has won the 'Electronic Product of the Year' at the BEEAs event held in London on March 18, 2022. Socionext's single-chip, low-power, highly integrated, 24 GHz radio-wave sensor has been specifically designed for IoT products, smart home applications, mobile devices and industrial equipment.

Checkpoint Systems, a vertically integrated solution provider for retail, has received the Good Design® distinction from **The Chicago Athenaeum Museum of Architecture and Design** for its unique NS40 Electronic Article Surveillance antenna. Launched in late 2020, Checkpoint's NS40 provides grocery retailers with a discreet but powerful in-lane loss prevention solution. Developed to be unobtrusive and effortlessly fit within grocery stores, the antenna can be painted, powder-coated or vinyl wrapped to match any store's visual identity, while custom voice messages and a variety of sounds and colored LEDs can be created for different alarm events.

CONTRACTS

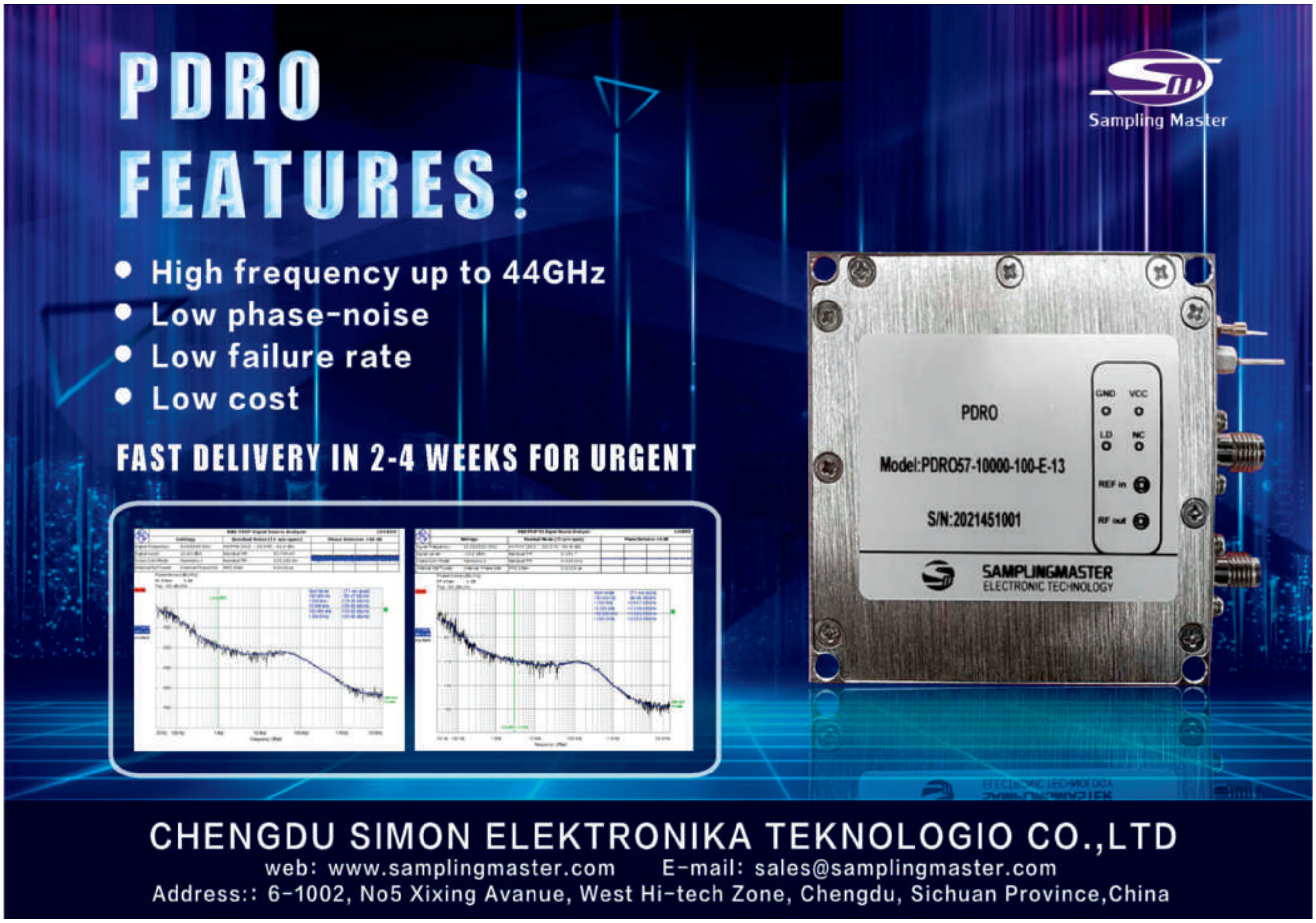
The U.S. Department of Defense (DoD) has awarded **Verizon Public Sector** three Enterprise Infrastructure Solutions task order awards worth $966.5 million. Verizon will provide network modernization services and technical support services to the Pentagon, the DoD National Capital Region and Fort Belvoir. Under the Pentagon task order valued at $515.3 million, Verizon will partner with the DoD to transition the entire Pentagon military and civilian population from copper-based telephony to advanced internet protocol-based services, providing a converged-enterprise environment for the Pentagon's voice and data services.

Verus® Research announced it has been awarded a $1.8 million, three-year contract from the **U.S. Air Force Research Laboratory** (AFRL)'s Space Vehicles Directorate for Position and Navigation Threats Heuristic Engagement (PANTHER) simulator. Verus Research will combine its specialties in electronic warfare, space and autonomy and software development and applications with the goal of maintaining U.S. electromagnetic spectrum superiority in space by assessing potential threats to satellite position, navigation and timing signals.

PEOPLE

▲ *Church Hutton*

Mercury Systems Inc. announced that **Church Hutton** has joined the company as vice president, government relations. Reporting to chief growth officer Mitch Stevison, Hutton will lead an enhanced government relations practice at the federal and state level aligned



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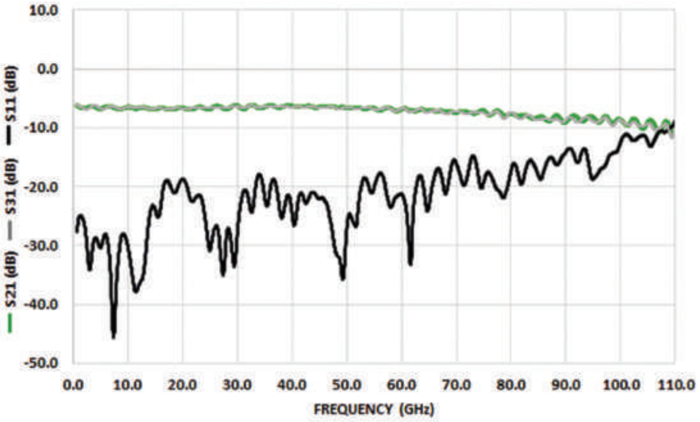

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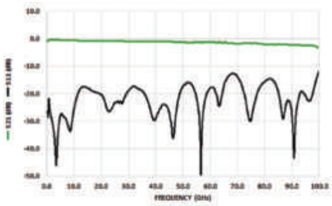
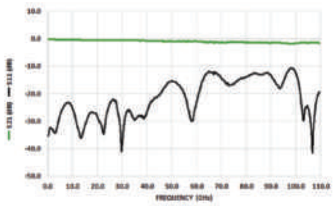


HL9449 BIAS TEE



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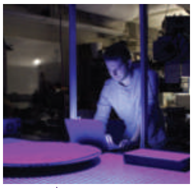
with the company's growth objectives.

▲ *Norm Smith*

The Antenna Company announced it has appointed **Norm Smith** as VP of Sales to lead the company's Sales and Business Development efforts, with an emphasis on IoT and 5G applications. Norm brings more than 30 years of technical sales and marketing experience in the antenna, RF/microwave and test & measurement industries. He has a successful track record of developing new business and growing revenues in the IoT and 5G markets. Prior to joining Antenna Company, Smith held sales and marketing leadership roles with Antenova, Maxtena, Alpha Micro Wireless and WP Wireless.



▲ *Joel Berkson*

Joel Berkson, a third-year doctoral student at the **University of Arizona James C. Wyant College of Optical Sciences and Steward Observatory**, has developed a new way for precisely measuring the surfaces of radio antennas, which are used to collect and focus radio waves for astronomy and satellite communications. These dish-shaped antennas, must be manufactured with an extremely high level of accuracy to work well. To ensure their accuracy, engineers measure the antenna surfaces using metrology, a technique that applies the science of measurement to manufacturing, instrumentation and calibration processes.

REP APPOINTMENTS

Agile Microwave Technology Inc., located in Cary, N.C., a product innovator in RF and microwave component and sub-system market, announced the appointment of its partnership with **Telepro Inc**, a top Canadian manufacturers' representative. Telepro is a leading RF/microwave component, accessories, subsystems and instruments manufacturer's representative with professional support throughout the product lifecycle (all the way from design consideration and specifications through engineering prototype deliveries and volume production). Telepro will be covering the entire Canadian market through three offices located in Montreal, Ottawa and Toronto.

OnMicro, an innovator in RF and SoC semiconductors, announced that it has entered a distribution agreement with Japanese Electronics distributor **Takachiho Koheki (TK) Co. Ltd**. This agreement allows TK to represent OnMicro and promote its RF front-end and SoC products throughout the Japan market. Founded in 1952, TK is one of Japan's leading distributors of electronics components and systems. TK has over 60 years' experience in promoting advanced technologies into the Japanese market and gives its partners the vital support necessary to make their products a success. TK has experience in a wide range of high-tech fields, including hardware, software, systems integration and cutting-edge emerging technologies.

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- Micro-electromechanical systems (MEMS) are used in many applications in everyday life, such as inertial sensors in smartphones, wearables, hearables, smart glasses, or cars. In addition to sensing, MEMS technologies can also perform filter functionalities in radio frequency circuits or tune reactive loads. Leveraging benefits of RF-MEMS like high quality factor, low loss and very high linearity requires adequate component design

  You derive requirements for the components based on the system requirements.
- You are responsible for the RF design, modelling and simulation of novel RF MEMS as a differentiating element of modern wireless communication and RF sensor systems.
- You will take over the characterisation of the RF components with RF measurement technology.
- Last but not least, you work closely with system engineers and technicians.

Your profile

- Education: completed studies in high-frequency technology or comparable
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- Experience and Knowledge: very good knowledge in RF technology, RF component design and RF measurement technology, knowledge in design of RF filters, experience with the simulation tool CST and RF measurment equipment, preferable experience in MEMS Technolgie
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INVITED PAPER

Solving Electromagnetic Densification at the Point of Design

Daren McClearnon
Keysight Technologies, Santa Rosa, Calif.

Don Dingee
STRATISET, San Antonio, Texas

Density, both informational and physical, determines complex RF system success or failure. Systems like 5G and Wi-Fi 7 pack more information into precious spectrum on smaller base stations, access points and devices. Finding density-related problems at prototyping, or later in deployment, adds cost and risk. Traditional RF electronic design automation (RF EDA) workflows are falling behind density challenges, analyzing one problem at a time and missing too much. A new approach: solving electromagnetic (EM) densification at the point of design.

Shift left—earlier visibility on designs in virtual space is the fundamental purpose of EDA tools. When modeling and simulation reflect real-world performance, design problems become easier to fix. Still, complex densification problems have many domains with combined interacting effects. Pulling EDA and test and measurement tools together in a workflow knocks out EM problems earlier, before committing to hardware. This article reviews three examples regarding how these workflows are solving EM densification:

1. Analyzing wideband designs using modulated signals and authentic waveforms[1]
2. Visualizing stability with EM-circuit excitation early in design and physical layout[2]
3. Increasing confidence in EM design integrity through iterative co-simulation.[3]

EM workflows appear across the ecosystem, soon connecting vendors, customers and customers-of-customers through "simulatable datasheets," which is briefly explained.

TAKING ON INFORMATION DENSITY

Wireless systems broke free of some limits, but moving information still has boundaries. When Claude Elwood Shannon explored communication channels, he saw their data capacity maximized by bandwidth, using signals with many noise-like characteristics. Analog systems with inefficient modulation left data-hungry services unsatisfied. Digital systems packed more bits into each transmitted symbol, saving bandwidth, but true to Shannon, complexity rose and specifications tightened.

Today, complex modulations are part and parcel of RF system specifications including 5G and Wi-Fi 7. Digital quadrature amplitude modulation (QAM) arranges data points in a two-dimensional constellation. Higher-order constellations put points closer together, requiring a higher signal-to-noise ratio to keep error rates down. 5G new radio (NR) features 256-QAM modulation delivering eight bits per symbol. Wi-Fi 7 is moving to 4096-QAM modulation for


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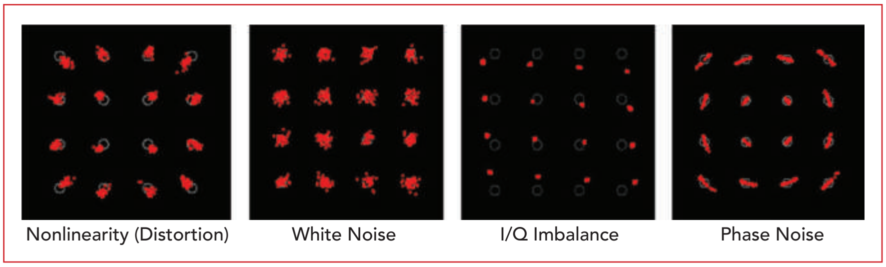

Fig. 1 EVM impairments and symbol errors in a 16-QAM constellation.

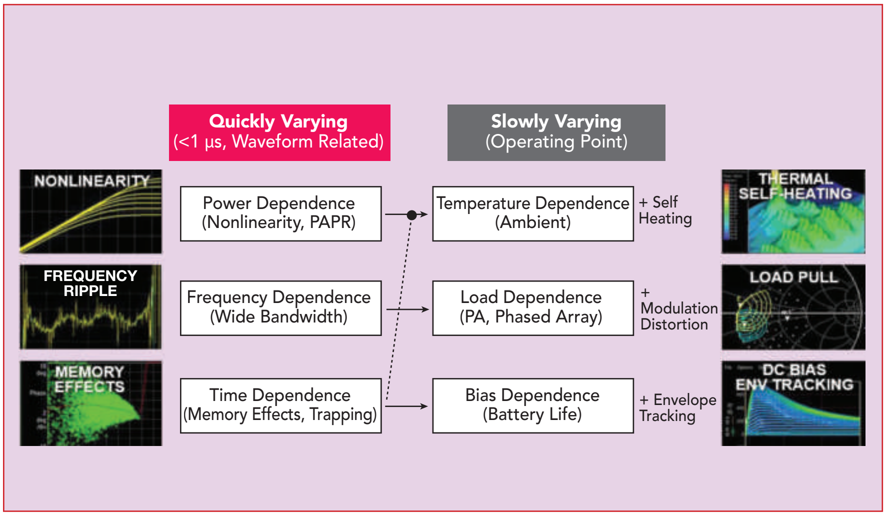

Fig. 2 Factors affecting PA performance and EVM.

12 bits per symbol. Orthogonal frequency division multiplexing bundles dense carrier sets into a narrow bandwidth leading to sudden intense peaks, as much as 10x the average power level, creating dramatic noise-like stresses on radio architectures. Both 5G and Wi-Fi 7 add MIMO antenna technology and spatial multiplexing for increased throughput within a given bandwidth.

In this light, error vector magnitude (EVM) emerges as a critical metric for signal quality and for transceiver and equipment performance. It is an RF designer's proxy for bringing the customer experience forward to the point of design. EVM measures how accurately transmitted symbols match their intended spot in the QAM constellation (see ***Figure 1***). Higher-order QAM constellations put points close together to start. Imperfections in a radio shift constellation points off their mark. These effects include non-linearity, noise, loading and channel interference. When points are close together, accurate discrimination between adjacent points becomes harder.

All this leads to an observation. It is not possible to design a 5G NR or Wi-Fi 7 compliant radio without incorporating a higher-order modulation scheme per specification. To prove such a transmitter works, authentic higher-order modulated signals of sufficiently wide bandwidths are required to measure EVM performance at system validation. In fact, every modern digital RF system relies on complex modulation for achieving its desired information density. For these systems, there is no such thing as a choose your own compliance adventure.

Yet, that is exactly how many designers pursue physical design densification. At the point of design, EDA tools perform schematic capture, physical layout and localized simulations of design choices. Are those choices understood in a system context? Does optimizing one factor have consequences on others? Is it possible to tell what those interrelationships might be? Simulating approximate or incomplete models with simplified sig-

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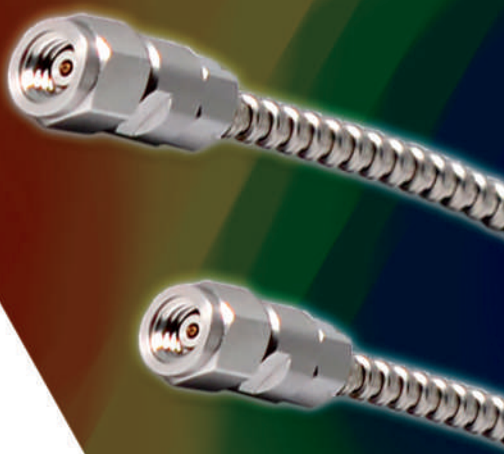

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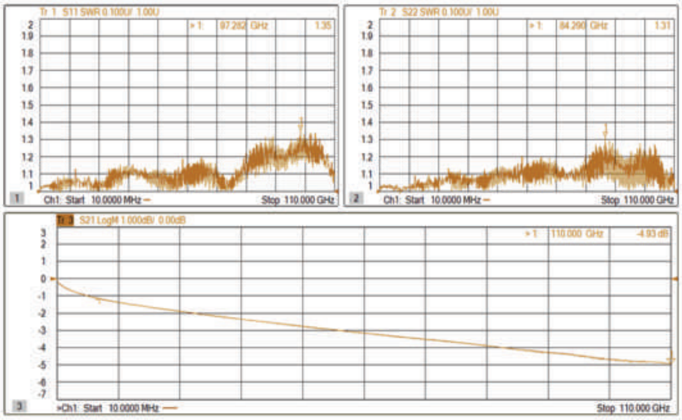
Applications

- Connections of module to module or rack to rack
- Various test systems
- Temperature cycle test in chamber
- Military & commercial millimeter wave equipment

VSWR



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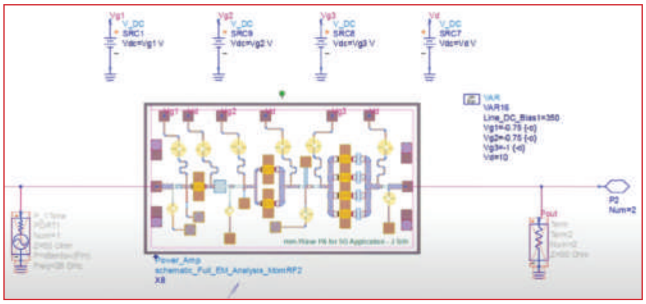

Fig. 3 5G mmWave PA design using PathWave Advanced Design System.

nals looking for one problem is an excellent way to miss others.

Those mysteries lead teams to fall back on physical prototypes for observing and troubleshooting RF issues. Hardware re-spins, however, are expensive schedule killers. Anything from functional design errors to hard-to-reproduce interactions under dynamic conditions can trigger a re-spin. Waiting until prototyping to find any lurking issue leaves RF designers at the mercy of higher risks and project costs.

Let us return to the EVM example and look at why modulated signals are important for accurately characterizing power amplifiers (PAs). S-parameters and pure sinusoidal stimuli provide a modeling baseline of raw PA performance. The same PA in a hardware prototype running against complex modulation may fall apart in unexpected ways. Why? Combining physical densification, power, modulated signals and a host of parasitic effects pushes assumptions, exposing various design weaknesses.

Effects factoring into EVM spread across domains in two categories as shown in ***Figure 2***. Quickly varying effects are waveform-related and are how information density shows up. Besides power effects, demanding signals bring implications in both frequency and time domains. Slowly varying effects impact a device's operating point and are often byproducts of physical density. Thermal, load and bias dependence reveal issues with stability, coupling, resonances, frequency shifts, matching and package interactions.

These effects are not entirely separable. A complex waveform can set off time-dependent memory effects such as charge trapping and self-heating. Sweeping frequency across a wide bandwidth finds linear impedance mismatches and ripple varying across the band. However, a wide bandwidth waveform excites all factors simultaneously, creating "rogue waves" with infrequent and sudden signal peaks 8 to 13 dB above the average power level. Under extreme peak-to-average power ratio conditions in regulated frequency bands, PA energy efficiency, signal quality and output power become harder to optimize. Modulated waveforms with accurate carrier dynamics uncover more issues than one-tone and two-tone analyses using harmonic balance.

This highlights the risk of waiting until hardware prototyping before fully exercising RF designs. Staging physical effects in combination may also be exceedingly difficult, which leads to latent problems cropping up in system deployment. In virtual space, simulators can sweep combinations of parameters in the presence of authentic wideband signals; but higher bandwidth signals also force more data collection, slowing the characterization process.

For increased test coverage of parametric scans, intelligent test and measurement trade-offs on signal complexity reduce measurement time with techniques like signal compaction and modulation distortion (or distortion EVM). These same techniques can apply to simulations, along with intelligent trade-offs for accelerating RF characterization without sacrificing fidelity. An example is fast circuit envelope technology in EM co-simulations, capturing linear frequency responses, loading, power dynamics and bias effects and even memory effects in a run-time, on-the-fly modeling step.

Figure 3 shows a mmWave PA

Continuous Measurements with No Drift

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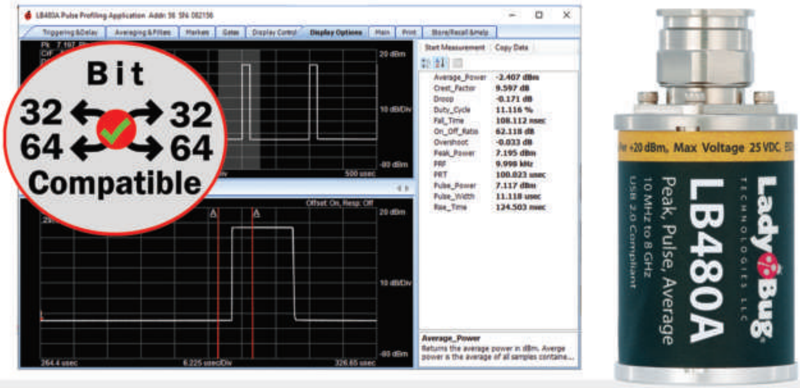

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Adjustable Power
These VNA extenders offer an adjustable outpower power from 0 to 20 dB with the turn of a knob.

Packaging
These extenders come encased in quality rugged equipment box with quality ESD foam along with some extra components such as metrology grade waveguide straights sections and a torque wrench.

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TABLE 1

SIMULATION TIME VS. SIGNAL TYPE

	Simulation Time (s)	EVM (%)	Pin (dBm)	Pout (dBm)	Power Gain (dB)
Envelope (3255 µs)	1371	4.87	–15.4	19.8	35.2
Compact Signal (1000 µs)	386	4.67	–15.4	19.8	35.3
Fast Envelope (Level 1)	93	4.87	–16.2	19.0	35.2
Compact Signal (1000 µs) with Fast Envelope	31	4.68	–15.4	19.8	35.3

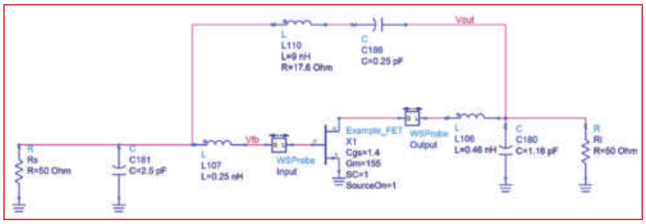

Fig. 4 **WS-Probes inserted in a simple feedback amplifier circuit.**

design and *Table 1* shows the PA simulation results from 50,000 points of a 5G modulated source. Applying both compact test signals and fast envelope techniques improves simulation time by 44x with little change in EVM accuracy. This increase in speed is critical to gaining design insights. It is the difference between simulating an EVM test case once at verification versus simulating EVM contours against a parametric scan and making incremental design improvements.

This two-way workflow between RF EDA and test and measurement algorithms enables designers to probe deeper much earlier, handle changes at the point of design and achieve consistency with measured results. Dense systems can be created, simulated, adjusted and re-simulated with authentic signals and combinations of effects modeled. Margins against system-level metrics are no longer a guess.

Modulated signals also enable the system experience to travel up and down the ecosystem. Understanding performance in a customer's environment is key to achieving information density goals. Next is a look at a deeper example where physical density sets up complex EM interactions.

ONE-PASS STABILITY ANALYSIS

Amplifier instability occurs when gain and feedback mix. With frequencies, bandwidths, complexity and physical density rising, resonances are now common. Bypass capacitors may be a fix. Compact packaging makes placing capacitors hard, and where and how much capacitance to use is unclear.

Simulations have hundreds of stability analysis techniques to choose from, most focused on one issue and some difficult to apply. A classic method is the Rollett stability factor, or K-factor, which produces valid results for a known-stable network when ideally terminated. Its two-port linear network assumptions degrade at higher frequencies with complex modulation. Tone-based (harmonic balance) frequency domain simulations might falsely converge for some frequencies, leaving instability undetected.

A broader technique is the Normalized Determinant Function (NDF), which also requires a known-stable network. For normalization, NDF needs access to every source in the network. It creates a passive network by setting all active sources to constant "off" values—removing them from the response. Estimating the off values can be error prone, and black-box models can prevent source access entirely. Large transistor networks make for huge matrices and lengthy simulations. Required frequency sweeps beyond operating ranges add more time and complexity.

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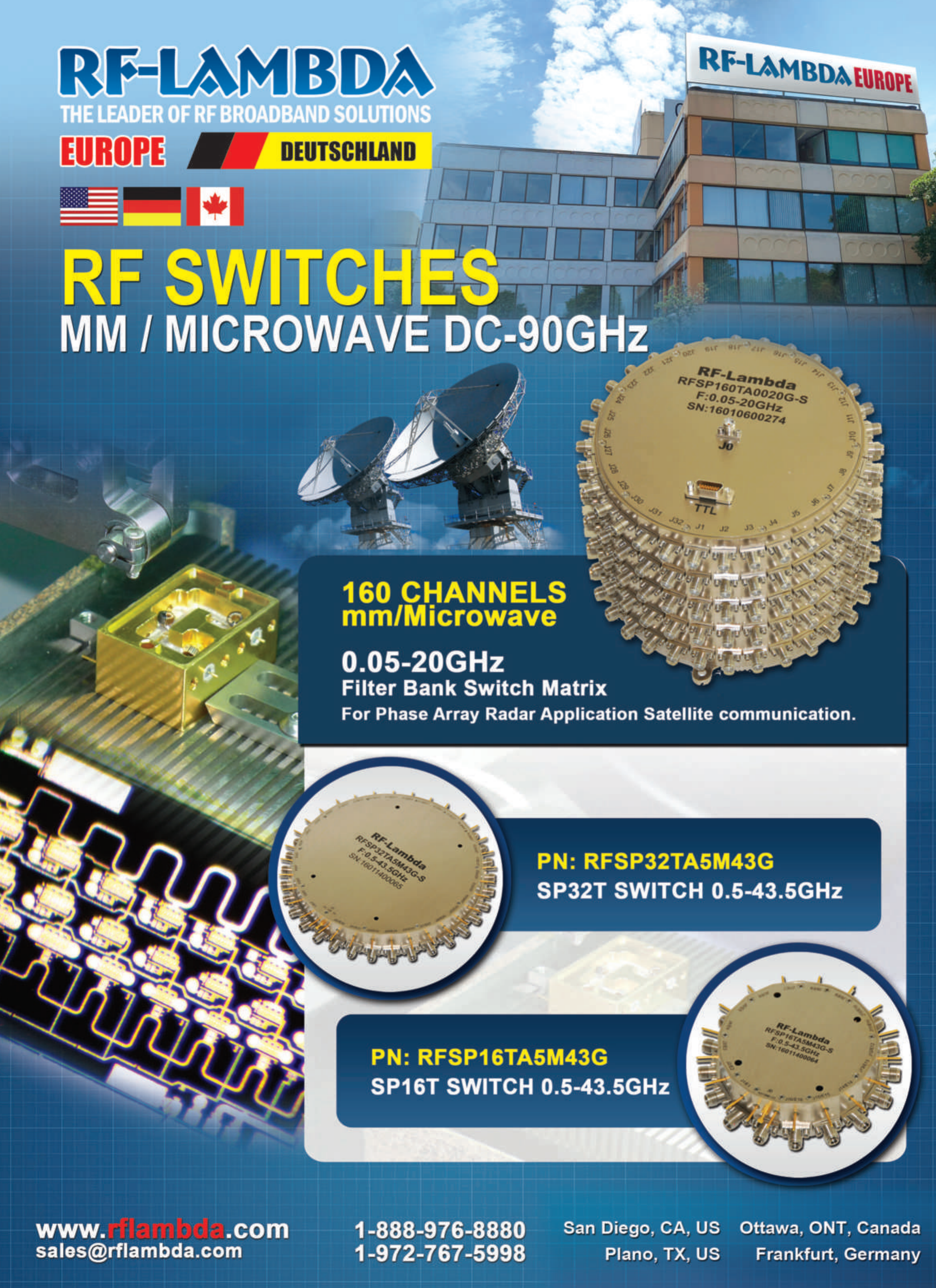
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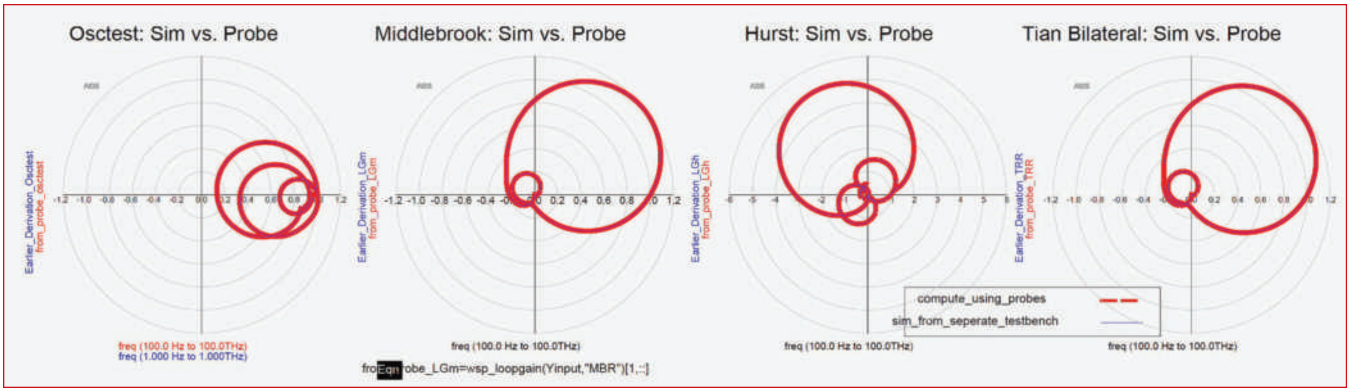
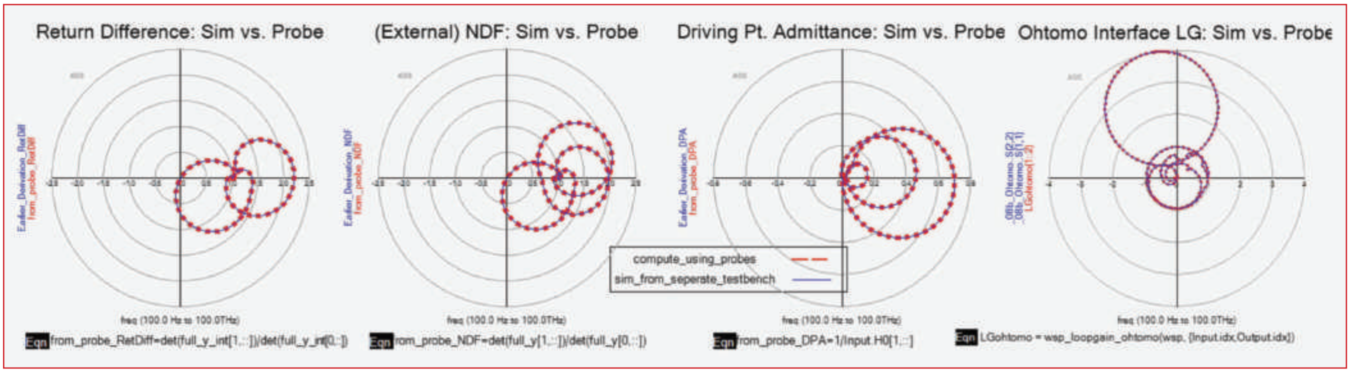
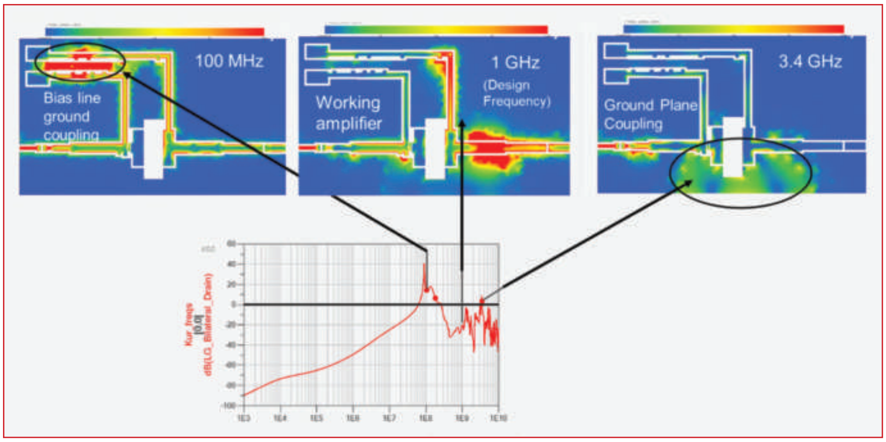


▲ Fig. 5 **Osctest, Middlebrook, Hurst and Tian Bilateral loop gain, comparing test benches with WS-Probe simulations.**



▲ Fig. 6 **Return Difference, NDF, Driving Point Admittance and Ohtomo loop gain, comparing test benches with WS-Probe simulations.**



▲ Fig. 7 **EM simulation of an amplifier in PathWave RFPro, showing instability locations at several frequencies.**

Non-invasive impedance probes hold more promise. The S-Probe uses ideal sources for "in-situ" bidirectional S-parameter computation but struggles with feedback around the probe, losing accuracy. Since feedback factors into stability, the S-Probe by itself is ineffective for stability analysis. The WS-Probe (also known as the Winslow Probe, for its inventor Dr. Thomas Winslow) builds on the S-Probe, providing accurate results in the presence of feedback.

WS-Probes enable comprehensive stability analysis techniques. Output processing can generate an admittance matrix for high impedance termination conditions, like NDF. K-factor can also be derived. ***Figure 4*** shows WS-Probes in a simple amplifier-feedback configuration and ***Figure 5*** simulates its loop gain in manual test benches versus WS-Probes—producing exact matches.

One simulation in Figure 5 with the WS-Probe covers the same metrics as 16 different manual test bench simulations. Coverage grows larger with circuit complexity. ***Figure 6*** shows more metrics including Bode's Return Difference (internal), NDF (external), Driving Point Admittance and Ohtomo loop gain, again with exact matches between manual test benches and WS-Probe results.

There are two other benefits from simulating with WS-Probes. They can aid in a virtual load-pull, examining load-dependent stability by extending results from Driving Point Admittance with Kurokawa stability criteria. They also apply equally well in both small signal and large signal analysis, avoiding staging difficulties inherent with large signals.

The upshot for densification is more powerful EM-circuit excitation techniques via simulation at the point of design and layout. Using nodal voltages and currents to stimulate an EM structure, circuit plus physical layout attributes, produces a visualization of current density and radiation patterns. Instabilities move around the structure as frequencies vary. ***Figure***

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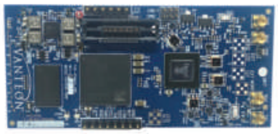

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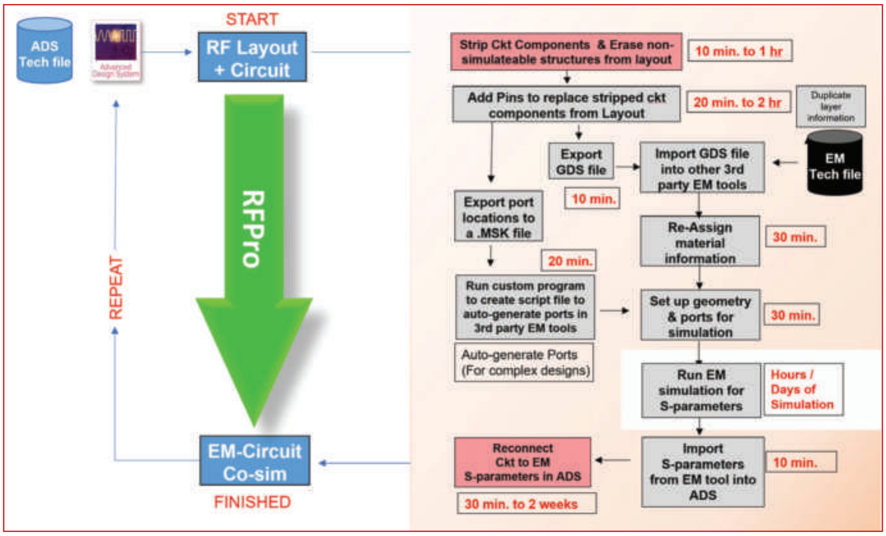

▲ Fig. 8 In-situ analysis using PathWave RFPro streamlines EM simulation workflow.

7 shows a simple amplifier structure at three different frequencies, highlighting a bias feedback problem and a ground plane feedback problem.

These coupling problems would be near impossible to spot in the lab but are laid open at simulation with non-invasive probes and "in-situ" analysis. Straight-forward layout changes (pushing bias lines apart and adding vias to the ground plane) improve stability across the frequency range. Extend this example to more complex circuits and larger dense structures, and the power of an RF EDA workflow merging design, layout and simulation is evident. Next is a look at this workflow in more detail.

ITERATIVE EM-CIRCUIT CO-SIMULATION

In complex RF systems, frequencies and integration density are rising, and 3D multi-technology assembly is everywhere. Parasitic effects from packaging, physical routing and interconnects and interactions between components degrade system performance. Some symptoms are frequency shifts, resonances, instability, mismatches, power losses and poor isolation from interference. Design integrity faces major risks; an uncaught mistake costs a hardware re-spin, a design win is undone or a market window is missed.

Circuit simulation is familiar territory for most EDA users, it is unthinkable not to take advantage of it. Toss in EM structures and effects, and accurate simulation gets more challenging. As previously shown, there are now innovative and effective EM simulation techniques for densification problems. The question becomes how to fit these techniques into RF design workflows.

One reason teams may be treading carefully is that there are different, disjointed EDA tools for different jobs in the workflow. Becoming proficient with each tool requires a learning curve, and once a tool is in a workflow it is tough to part with it even if it lacks some features. On the plus side, circuit design capture, circuit simulation and physical layout tools have already merged. Most package assembly and EM simulation tools, however, still add extra steps, especially if bad results send teams back to the drawing board.

Those extra steps can chew up weeks at a time. The right side of ***Figure 8*** shows data from 10 years of EDA user interviews. It is the process to get a circuit design into a format ready for EM simulation in a third party tool. Some steps are manual, some scripted. Excess components and structures are stripped, EM simulations extract S-parameters and those are then meticulously reconnected back to the original circuit nodes. In every step, especially the first and last ones, there is a chance for an oversight or error.

The left side of Figure 8 shows "in-situ" 3DEM analysis stream-

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lined with PathWave RFPro. It starts with the original circuit file, extracts and reconnects S-parameters, inserts non-invasive probing automatically and jumps to EM-circuit co-simulation within minutes. Because RFPro reads data through an OpenAccess API, it integrates with Keysight EDA platforms or in a mixed-vendor EDA workflow.

One RFPro customer was able to run only three or four EM simulation runs per week using a third party tool—that customer is now able to do 30. It is more than a productivity improvement, however. Bringing EM-circuit co-simulation into an EDA workflow moves simulation from a limited-use verification sign-off tool to an iterative problem-solving tool at the point of design. Analyzing EM effects becomes routine, like analyzing circuit functionality, and fixes can happen on the spot. Teams can efficiently develop predictable designs with critical EM effects fully assessed before hardware prototyping or deployment. Confidence in design integrity goes up, surprises go down.

These changes point to bigger possibilities in the future for the RF design ecosystem. Vendors design parts, those parts integrate into equipment manufacturer modules and boards, and those fit into larger end-customer systems. Vendor design wins rely on designers at the next level correctly stringing together pieces from different vendors. Aligning data from printed data sheets may produce a fit or it may not.

System-level EM simulation with transportable data and models in simulatable datasheets is the next frontier. Simulatable datasheets for parts will drop into system-level models for virtual performance evaluation. Knowledge about how a part works in an application will flow easily from vendor to customers to customers-of-customers, and back. Teams will not spend time sorting out specifications, but instead will focus on anticipating deployment scenarios at the point of design to achieve design wins.

DENSIFICATION AS AN OPPORTUNITY

Densification drives stress for teams, designs and processes and it drives opportunity. EM analysis at the point of the design means that when teams find something, they can do something about it. Three areas were discussed:

1. Information density shows up in far more complex waveforms. Systems demand modulated signals, and so should RF design teams. Seeing, understanding and preserving signal details must be part of the RF design workflow, not an afterthought in verification. RF EDA and measurement science are strongly connected.
2. Physical density, including 3D multi-technology assembly, is spawning more interactions between domains. Interference, crosstalk and parasitic effects can no longer be estimates. Packaging details must be known early. Resonance, thermal and stability concerns need full attention. Finding an issue in hardware is too late and adding EM simulation to workflows is urgent.
3. Shift left will be a competitive advantage. Design in context, in a workflow providing time savings and virtual accuracy using modulated signals and in-situ EM analysis, leads to design wins. If others find issues first, business may be lost. Models and results need to be transportable, ready to connect with other design processes, vendors, customers and environments.

Digital transformation is solving EM densification at the point of design. More versatile analysis engines, behavioral models, tools and IP help designers and their customers create and apply innovative designs in more applications with greater success. ■

References

1. "Accelerate 5G Circuit Designs Using Digitally Modulated Signals," *Keysight*, Web, https://www.youtube.com/watch?v=7CkrICXC9jo.
2. "Designing for Stability in High Frequency Circuits," *Keysight*, Web, https://www.keysight.com/us/en/assets/3121-1255/application-notes/Designing-for-Stability-in-High-Frequency-Circuits.pdf.
3. "RFPro in ADS for EM-Circuit Co-Simulation," *Keysight*, Web, https://www.youtube.com/watch?v=dbq7KkYzKo4.

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The location of IMS2023 is San Diego: very cool. The Convention Center is on the bayfront, adjacent to the Gaslamp Quarter, which is the lively social center of San Diego, with plenty of restaurants for all tastes. San Diego is also home to famous landmarks such as the USS Midway, Balboa Park containing many museums, the San Diego Zoo, and SeaWorld. And cool beaches.

San Diego is the bridge between North America and Latin America. One of our conference themes is to highlight advances in RF and Microwave research in Latin America, and we will have a Latin American flavor to social events throughout the week.

Important Dates

- 16 September 2022 (Friday)
  PROPOSAL SUBMISSION DEADLINE
  (workshops, technical lectures, focus and special sessions, panel and rump sessions)
- 6 December 2022 (Tuesday)
  PAPER SUBMISSION DEADLINE
  All submissions must be made electronically.
- 1 February 2023 (Wednesday)
  PAPER DISPOSITION
  Authors will be notified by email.
- 8 March 2023 (Wednesday)
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  Manuscript and copyright of accepted papers
- 11-16 June 2023
  MICROWAVE WEEK
  IMS2023, RFIC 2023, ARFTG, and Exhibition

IMS2023 Conference Themes

At IMS2023 we will have several focus themes to highlight a number of areas of RF and microwave engineering that are of topical interest or impact. These themes are:

Systems & Applications

The development of RF, microwave, mm-wave and THz systems continues to expand in several areas, with many application examples. This broad topic can encompass design from semiconductor through device and module through to the overall system and applications. We are giving particular focus to:

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Wireless Power Transfer;
Automotive Systems;
Model-Based Systems Engineering.

Space

In this area of Aerospace we are specifically calling out 'Space' as a focus theme. This can include such topics as: satellite communications, design for reliability, radiation hardness, internet of space systems, CubeSats.

Biomedical Applications

Illustrating the use of RF and microwave techniques and technology in biomedical applications.

These technical themes will be identified with different days of the conference, and will comprise special Focused Technical Paper Sessions, Panel Sessions, Invited Speakers, and Workshops. The Exhibition will feature a **Systems Pavilion** illustrating several practical examples of RF through THz systems and applications.

Authors are encouraged to submit technical papers in these themed topics.

In addition to this Call for Technical Papers, there will also be Calls for Focus and Special Sessions Proposals, Panel Session Proposals, and Workshop Proposals. Prospective organizers of these events are encouraged to target the conference themes. The submission date for these proposal is 16 September 2022.

RF & Microwaves in Latin America

In addition to the above technical themes, IMS2023 will feature a Focus Technical Paper Session to celebrate "RF and Microwaves in Latin America." This session is being championed by Professor Jose Rayas-Sanchez and Professor Apolinar Reynoso-Hernandez. There will also be a **Latin America Pavilion** in the Exhibition, and the Latin America flavor will run through the whole of IMS2023.

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- Submissions must be 3-4 pages long, be compliant with the IEEE conference template, which can be downloaded from the IMS2023 website, and be compliant with double-blind requirements.
- The submission must be in PDF format and cannot exceed 4 MB in size.
- Authors must upload their paper submission by midnight Hawaii time on 6 December 2022. Late submissions will not be considered.

Paper Selection Criteria

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Authors will be notified of the decision by 1 February 2023. For accepted papers, an electronic version of the final 3-4 page manuscript along with copyright assignment to the IEEE must be submitted by 8 March 2023.

The submission instructions will also be provided through emails and can be accessed through the IMS2023 website.

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3 **Instrumentation and techniques for guided and over-the-air measurements** – Measurement techniques from microwave to THz for materials, linear and nonlinear devices, circuits, and systems; calibration and de-embedding techniques, measurement uncertainty, and over-the-air measurement methods and novel instrumentation

Passive Components and Packaging

4 **Planar passive components and circuits, excl. filters** – Novel planar transmission-line components; artificial transmission lines, metamaterial structures, and high-impedance surfaces; planar couplers, dividers/combiners, multiplexers, resonators, and lumped-element approaches

5 **Planar passive filters** – Planar passive filters, including lumped elements, theoretical filter and multiplexer synthesis methods

6 **Integrated passive circuits and filters** – Design and characterization of silicon integrated, III-V integrated passive components and filters, including IPDs

7 **Non-planar passive components, filters, and other circuits** – Transmission line components, resonators, filters and multiplexers based on dielectric, waveguide, coaxial, or other non-planar structures

8 **Tunable passive circuits and active filters** – Tunable and active filters, tunable phase shifters and couplers

9 **Microwave acoustic, ferrite, ferroelectric, phase-change, & MEMS components** – Surface and bulk acoustic wave devices including FBAR devices, bulk and thin-film ferrite components, ferroelectric-based devices, and phase change devices and components. RF microelectromechanical and micromachined components and subsystems

10 **Packaging, MCMs, and 3D manufacturing technologies** – Component and subsystem packaging, assembly methods, multi-chip modules, wafer stacking, 3D interconnect, and integrated cooling; package characterization; novel processes related to inkjet printing, 3D printing, or other additive manufacturing techniques

Active Devices and Circuits

11 **Semiconductor device technologies and modeling** – RF to THz devices on III-V, silicon, and other emerging technologies, incl. 2D devices); MMIC and Si RFIC manufacturing, reliability, failure analysis, yield, and cost; linear and nonlinear device modeling (CAD, compact, physics-based, empirical) including characterization, parameter extraction, and validation

12 **HF/VHF/UHF circuits, technologies, and applications** – Advances in passive and active circuits (incl. PAs), components, and systems that operate in the HF, VHF, and UHF frequency ranges ranges (<1 GHz)

13 **Signal generation, modulators, frequency conversion** –CW and pulsed oscillators in silicon and III-V processes including VCOs, DROs, YTOs, PLOs, and frequency synthesizers, frequency conversion ICs in silicon and III-V processes, such as IQ modulators, mixers, frequency multipliers/ dividers

14 **Microwave and millimeter-wave low-noise amplifiers, variable-gain amplifiers, and receivers** – LNAs, VGAs, receivers, detectors, integrated radiometers, and low-noise circuit characterization

15 **Low-power (<10 W) amplifiers, below 30 GHz** – Advances in discrete and IC power amplifier devices and design techniques based on Si and III-V devices, demonstrating improved power, efficiency, and linearity for the microwave band (1-30 GHz)

16 **High-power (>=10 W) RF and microwave amplifiers, below 30 GHz** –Advances in discrete and IC power amplifier devices and design techniques based on III-V and LD-MOS devices, demonstrating improved power, efficiency, and linearity for the microwave band (1-30 GHz); power-combining techniques for SSPA and vacuum electronics

17 **Millimeter-wave and THz power amplifiers** – Advances in IC power amplifier circuits, design techniques, and power combining based on Si and III-V compound semiconductor devices demonstrating improved power, efficiency, and linearity for millimeter-wave and THz bands; vacuum electronics for millimeter-wave

18 **Linearization and transmitter techniques for power amplifiers** – Power amplifier behavioral modeling; linearization and pre-distortion techniques; envelope-tracking, out phasing, and Doherty transmitters for III-V and silicon technologies

19 **Mixed-signal, wireline, and signal shaping circuits** –High-speed mixed-signal components and subsystems, including: PLLs, TDCs, ADCs, DACs, DDSs, and supporting circuits to interface these to the analog world

20 **Integrated transceivers and phased-array chips for beamformers and imaging** – Design and characterization of complex III-V ICs, silicon ICs, heterogenous systems in the RF to mm-wave band including narrowband and wideband designs; innovative circuits and sub-systems for communications, radar, imaging, and sensing applications; Integrated on-chip antennas and on-package antennas

21 **Terahertz and photonic integrated circuits** – Design and characterization of THz active circuits; THz circuits for communications, radar, imaging, and sensing applications; Interaction between microwaves, THz waves, and optical waves for the generation, processing, control, and distribution of microwave, mm-wave, and THz signals; nanophotonics, nanoplasmonics, and nano-optomechanics

Systems and Applications

22 **Wireless power transmission** – Energy harvesting systems and applications, rectifiers, self-biased systems, combined data and power transfer systems

23 **Sensing and RFID systems** – Short range wireless and RFID sensors, gas and fluidic sensors; passive and active tags from HF to millimeter-wave frequencies; RFID systems including wearables and ultra-low-power

24 **Microwave and millimeter-wave wireless subsystems and systems** – Technology advances combining theory and hardware implementation in microwave/millimeter-wave subsystems such as beamformers; microwave and millimeter-wave (<100 GHz) communication systems, incl. 5G – 6G, with hardware implementation for terrestrial, vehicular, and indoor applications, point-to-point links, radio-over-fiber links, cognitive and software-defined radios applied to (massive) MIMO, full-duplex technologies, shared and novel spectrum use, novel modulation schemes, and channel modeling

25 **Radar and imaging systems** – RF, millimeter-wave, and sub-THz radar and imaging systems, automotive radars, sensors for intelligent vehicular highway systems, UWB and broadband radar, remote sensing, radiometers, passive and active imaging systems, radar detection techniques, and related signal processing

26 **Airborne and space systems** – Technologies and systems for remote sensing for earth observation; positioning, navigation, and timing; space exploration, human spaceflight and space transportation; satellite communications including 5G, 6G applications involving aerospace platforms; communication and sensor systems for UAVs, HAPSs, airplanes, and satellites

27 **MHz-to-THz devices, circuits, and systems for biological and health-care applications** – Electromagnetic field interaction at molecular, cellular, tissue and living systems levels; devices, circuits, and systems for characterizations of biological samples; microwave-enhanced chemistry; instrumentation and systems for biomedical diagnostic and therapeutic applications, incl. MRI and microwave imaging; wireless, wearable, and implantable devices for health monitoring

28 **AI/ML for RF to mmWave** – AI/ML algorithms implementations, and demonstrations for: spectrum sensing; mobile edge networking; MIMO and array beam operations and management; design and optimization; in-situ sensing, diagnostics, control, reconfiguration of MHz to THz communication and sensing circuits and systems

Emerging Technologies

29 **Quantum devices, circuits, and systems** – Quantum devices and circuits (incl. cryogenic RF circuits); algorithms, interfaces, and systems for quantum computing and quantum sensing applications

30 **Model-based system engineering** – Applications or demonstrations of model-based system engineering (MBSE) applied to system architecture, behavioral analysis, simulation, performance analysis, and test of RF systems, over the whole product life cycle; applications areas such as aerospace, wireless systems, EMC, and automotive

31 **SubTHz and THz Systems** – SubTHz and THz systems, incl. space and sub-THz architectures for 6G communication systems with hardware implementation

32 **Other innovative MHz-to-THz systems and applications**

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INVITED PAPER

An Enabling Future: The Evolution of GaN for Higher Performance Microwave and mmWave Systems

Pasternack
Irvine, Calif.

In the late 2000s and throughout the 2010s, GaN III/V semiconductor technology was touted as a game-changing technology for RF and power applications. Though GaN technology has yielded impressive power and broadband amplifier solutions (see ***Figure 1***), there have also been many challenges in designing, manufacturing and implementing GaN devices that live up to the hype. Process advancements and R&D efforts continue to whittle away at these challenges and further explore the limits of the technology. These include incredibly wideband amplification, GaN devices operating to hundreds of GHz, new GaN transistors—even GaN-CMOS processes.[2–8]

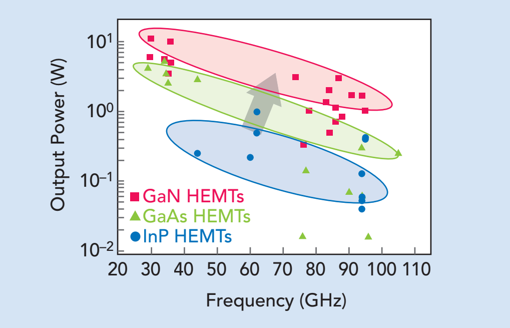

Fig. 1 MMIC PA CW output power, comparing InP, GaAs and GaN technologies.[8]

This article aims to update readers on the state of GaN RF technology, emerging GaN technology/applications and factors enabling the advancement and use of GaN for RF, microwave and mmWave applications.

GAN VARIANTS AND APPLICATIONS

When speaking of GaN devices, the variety of different material and process variants, as well as technology variants, lead to devices better suited for certain applications. In general, when discussing GaN for RF, microwave and mmWave applications, the focus is on GaN HEMTs. However, recent research is seeking to integrate GaN transistors with other processes, such as GaAs and CMOS.

Among the common variants are GaN on insulator combinations such as GaN on SiC and GaN on Si. Less common variants are GaN on GaN and GaN on diamond. In general, the process maturity and cost of GaN

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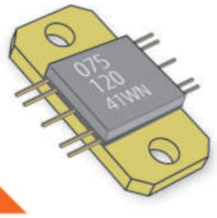
AMCOM's AM030MH4-BI-R is part of the BI series of GaAsHiFETs. The HiFET is a partially matched patented device configuration for high voltage, high power, high linearity, and broadband applications. This part has a total device periphery of 12mm. The AM030MH4-BI-R is designed for high power microwave applications, operating up to 3GHz. The flange at the bottom of the package serves simultaneously as DC ground, RF ground and thermal path. This HiFET is RoHS compliant.

AMCOM's AM005MH2-BI-R is a part of the BI series ofGaAs HiFETs. The HiFET is a partially matched patented device configuration for high voltage, high power and broadband applications. This part has a total device periphery of 1mm. The AM005MH2-BI-R is designed for high power microwave applications, operating up to 6 Ghz. It is also an ideal driver for larger power devices. The flange at the bottom of the package serves simultaneously as DC ground, RF ground, and thermal path. This part is RoHS compliant.

AMCOM's AM032MH4-BI-R is part of the BI series of GaAs HiFETs. The HiFET is a partially matched patented device configuration for high voltage, high power and broadband applications. This part has a total device periphery of 12.8mm. The AM032MH4-BI-R is designed for high power microwave applications, operating up to 6GHz. The flange at the bottom of the package serves simultaneously as DC ground, RF ground and thermal path. This HiFET is RoHS compliant.

AMCOM's AM030WX-BI-R is a discrete GaAs pHEMT that has a total gate width of 3.0mm. It is in a ceramic BI package for operating up to 10 GHz.The BI package uses a specially designed ceramic package with bent (BI-G) or straight (BI) leads in a drop-in mounting style. The flange at the bottom of the package serves simultaneously as DC ground, RF ground, and thermal path. This part is RoHS compliant. For more information on this product or any other AMCOM product visit our website at www.amcomusa.com.

GaN MMIC Amplifiers



The AM07512041WN-SN-R is in a ceramic package with a flange and straight RF and DC leads for drop-in assembly. It has 27dB gain, and 41dBm output power over the 8.25 to 11.75 GHz band. Because of high DC power dissipation, good heat sinking is required.

Model	Freq(GHz)	Freq(GHz)	Gain(db)	Psat(dBm)	Eff(%)	Vd(V)	ECCN
AM003042WN-XX-R	0.05	3	23	42	33	40 / -2	EAR99
AM003042WN-00-R	0.05	3	24	42	35	40 / -2	EAR99
AM206041WN-SN-R	1.8	6.5	30	41	23	+28 / -1.8	EAR99
AM206041WN-00-R	1.8	6.5	32	42	27	+28 / -1.8	EAR99
AM408041WN-SN-R	3.75	8.25	31	41	23	+28 / -1.8	3A001.b.2.b
AM408041WN-00-R	3.75	8.25	33	42	27	+28 / -1.8	3A001.b.2.b
AM00010037WN-SN-R	DC	10	13	37	23	+28 / -1.8	EAR99
AM00010037WN-00-R	DC	10	13	37	25	+28 / -1.8	EAR99
AM00010037WN-QN6-R NEW	DC	10	13	36	25	+28 / -2.0	EAR99
AM08012041WN-SN-R	7.5	12	21	41	20	+28 / -1.9	3A001.b.2.b
AM08012041WN-00-R	7.5	12	22	42	20	+28 / -1.9	3A001.b.2.b
AM07512041WN-SN-R	7.75	12.25	27	41	22	+28 / -1.8	3A001.b.2.b
AM07512041WN-00-R	7.75	12.25	28	42	27	+28 / -1.8	3A001.b.2.b

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on SiC and GaN on Si are why the GaN on insulator variants are the most common. These are also the best for a range of current and emerging applications, such as high frequency power amplifiers (PAs), wideband amplifiers and 5G/6G telecommunications systems at mmWave.

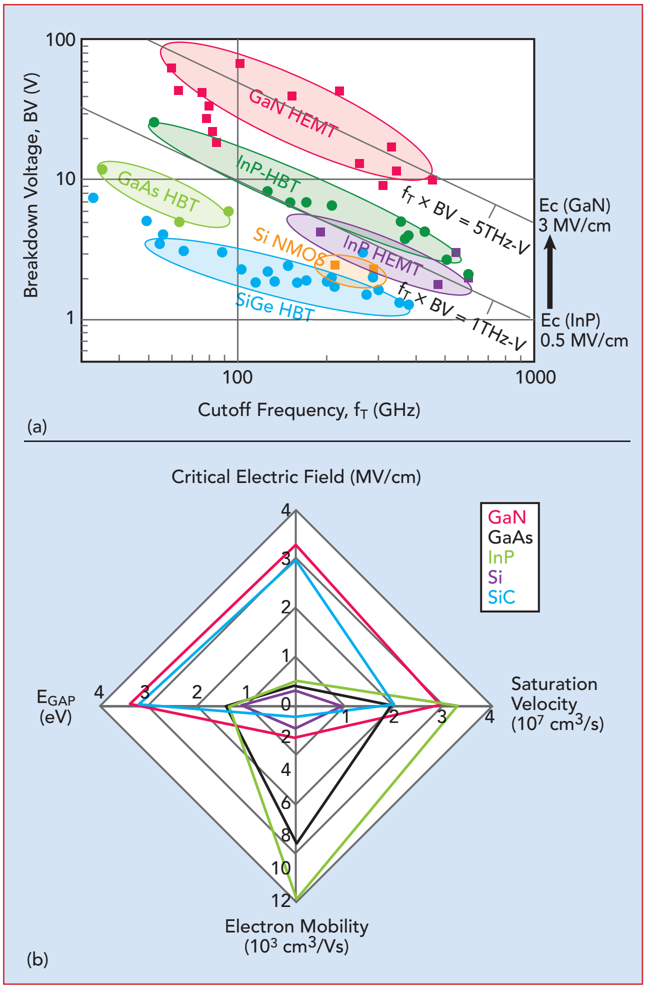

Fig. 2 Comparison of semiconductor technology breakdown voltage, BV, cutoff frequency, f_T, (a) and material properties (b).[4]

Power Amplification

GaN transistors generally yield better PA characteristics than Si, SiC, InP, SiGe and GaAs devices (see ***Figure 2***). The main reasons are GaN's higher breakdown voltage and higher power-added-efficiency (PAE) at a higher power than Si or GaAs devices. GaN on SiC outperforms GaN on Si, although GaN on Si devices tend to cost less per device than GaN on SiC devices operating in the same frequency range. Higher epitaxial defects and lower thermal conductivity of the Si substrate are the main reasons why GaN on Si is generally inferior to GaN on SiC for PAs. Another beneficial aspect is GaN's wide operating temperature range, beyond that of SiC, making it suitable for aerospace, defense and space applications.[9] GaN HEMTs also exhibit higher mechanical robustness than other class III/V semiconductors.

These capabilities led to GaN PAs with extremely high-power densities and good PAE, even to mmWave frequencies. The ruggedness and operating temperature capabilities enable GaN HEMTs to be used in virtually any application where its costs support system goals.

Broadband Amplification

These same factors have led GaN HEMTs being used in broadband amplifiers. Many instrumentation and communication systems operating over a wide band are constrained by cost and size. Combining several lower bandwidth transmitters with a matrix of switches and multiplexers to cover the wider bandwidth adds system complexity and generally increases system size and cost. In addition to the expense, combining adds loss, reduces efficiency and degrades performance compared to using a single wideband PA. A single GaN PA offers performance advantages at likely lower cost compared to combining multiple GaAs, Si, SiGe or SiC PAs. Design innovations have extended the bandwidth of GaN amplifiers, such as on-chip traveling-wave power combiner circuits and non-uniform distributed PA (NDPA) designs.[1]

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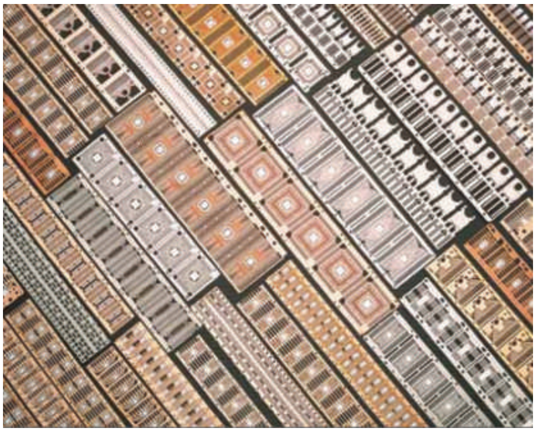

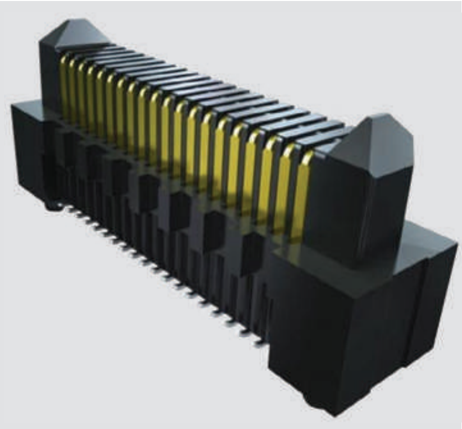

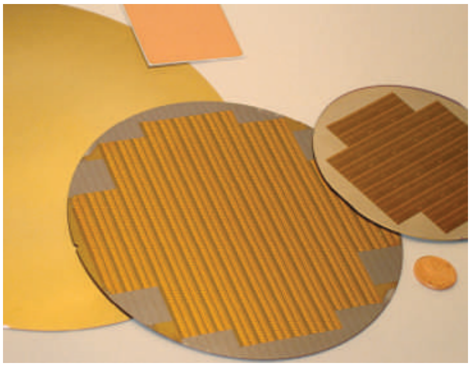

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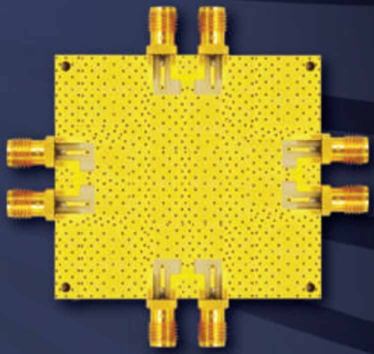

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Low Noise Amplification

Though previously considered a niche application in defense and aerospace systems, high survivability low noise amplifiers (LNAs) are gaining interest in applications that need to handle high-power interference signals. GaAs and InP LNAs typically have a limited maximum signal input before becoming desensitized or being damaged. To protect sensitive LNAs, limiters and other protection, such as variable attenuators, have been used at the input to the LNAs to protect them. However, these protective devices including ESD protection, add insertion loss and degrade the noise figure, limiting the sensitivity of the receiver. Because GaN transistors have a much higher breakdown voltage and power handling before damage, a GaN LNA may eliminate the need for a limiter or other front-end protection circuitry. Though current GaN LNAs may not have a noise figure as low as GaAs LNAs, eliminating the loss of the receiver protection circuitry may yield close to the same system noise figure.

Switching

GaN FETs and PIN diodes are now being used as switching elements. The latest GaN switches have relatively low on resistance and off-state capacitance, and GaN switches benefit from the high breakdown voltage, which enables the switch to have much higher power handling than GaAs switches—tens of watts compared to a few watts or less.

GaN switches may reduce the complexity of the signal chain and greater system efficiency. As GaN operates at much higher temperatures than GaAs or InP, GaN switches may be suitable for applications with higher ambient temperature or greater power levels than other III-V semiconductor options.

5G & 6G PAs

The dynamic network performance of 5G and future 6G systems presents challenges for RF hardware designers attempting to achieve the highest output power and efficiency. 5G and 6G systems will push operating frequencies to higher mmWave and sub-THz bands with wide modulation bandwidths to reach the desired data rates. System complexity will increase dramatically with the adoption of MIMO and beamforming antennas that require a matrix of transceivers to achieve the power levels for acceptable link ranges and multiple simultaneous users. In many cases, these complex base stations, each with an array of antennas and transceivers, will operate in harsh environments, whether outdoors, industrial settings or aerospace and defense systems—all requiring compact, rugged hardware.

This is where GaN HEMTs offer promising advantages. For the same output power, GaN PAs enable fewer elements in the array than GaAs PAs. As GaN HEMTs can operate at higher temperatures more efficiently than GaAs, a comparable—even higher performance—active antenna system can be built with GaN than GaAs, yielding a smaller system for possibly lower cost.

TECHNOLOGY ADVANCEMENT

GaN technologies have been in development for several decades, with early GaN HEMTs available commercially for nearly a decade. Commercialization has enabled GaN to make inroads into a variety of applications, which has sparked interest in using GaN for higher frequency and more challenging performance applications. Technology developments have turned to integrating GaN devices in modules with other semiconductors, such as CMOS-compatible GaN processes.

Multi-Chip Modules (MCMs)

Though on-chip integration of CMOS and GaN or GaAs may be futuristic, current advancements have enabled MCM integration of GaN and GaAs.[10,11] Where GaN is better suited to power and broadband amplification, GaAs LNAs, switches, mixers and other active circuit functions are well established and available at desirable prices. MCMs combining GaN and GaAs devices can enable transceivers that use the best commercially available process for each semiconductor while minimizing the size, weight and interconnect complexity if such a circuit function were implemented using discrete components assembled on a printed circuit board.

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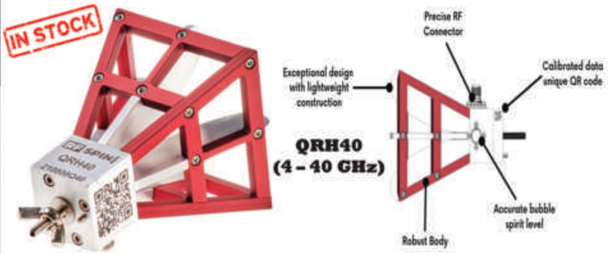

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Figure 2 shows that GaN has a much higher critical electric field and energy gap—roughly 3x that of GaAs, Si and InP—and it has a saturation velocity nearly that of InP. These indicate GaN should be well-suited to fabricating high-power and high voltage mmWave devices, as the higher critical electric field and energy gap enable higher breakdown voltage and, thus, operating voltage. The higher saturation velocity leads to the maximum current density the semiconductor can handle.

These factors and GaN's ability to withstand a wide temperature gradient and many thermal cycles supports its suitability for mmWave applications, where intrinsic device losses are higher and heat is generated during amplification and switching. As GaN's thermal conductivity (~1 to 3 W/cm K) is greater than the conductivity of GaAs and InP, GaN devices are inherently better at heat dissipation at high-power levels.

For the same output power, a GaN device will be a fraction of the size of GaAs and InP devices. Substantially reducing device size reduces on-chip routing and combining losses when multiple transistors are integrated on the same die. GaN's size and power advantages are dramatic (see ***Figure 3***).

Vertical Transistors

Typically, GaN devices have been fabricated as lateral heterojunction AlGaN/GaN HEMTs on Si or SiC substrates. Lateral GaN technologies are becoming mature and potentially reaching their voltage and power limits. At high voltage and power, lateral devices require substantially more chip area than vertical devices. Generally, vertical devices can provide higher power from a smaller area, as vertical devices withstand higher blocking voltage in the vertical direction into the bulk material.[4,12] Other arguments for vertical devices are potential benefits from current spreading and thermal management.

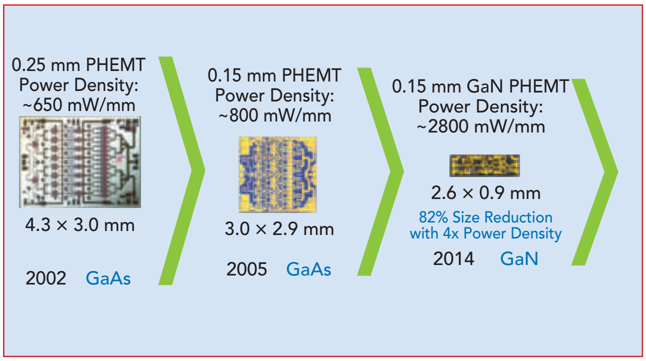

Fig. 3 MMIC PA evolution from PHEMT to GaN.[8]

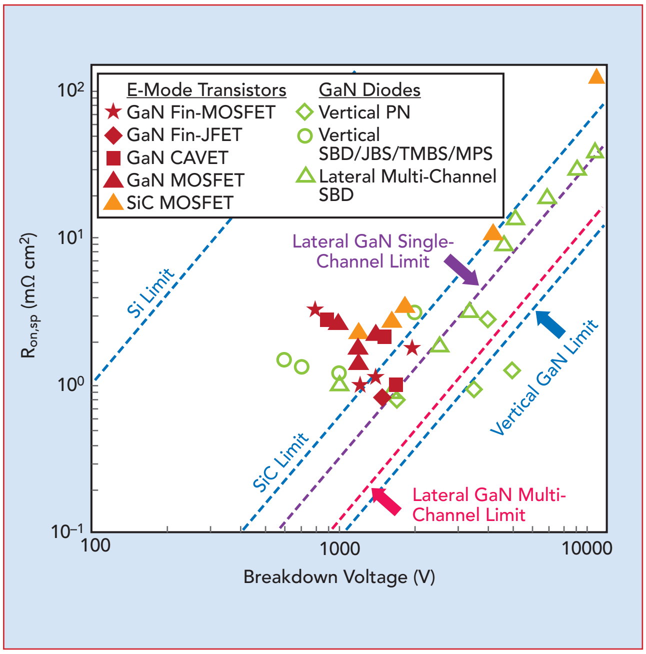

Fig. 4 R_{on} vs. breakdown voltage of state-of-the-art vertical and lateral GaN diodes and transistors.[12]

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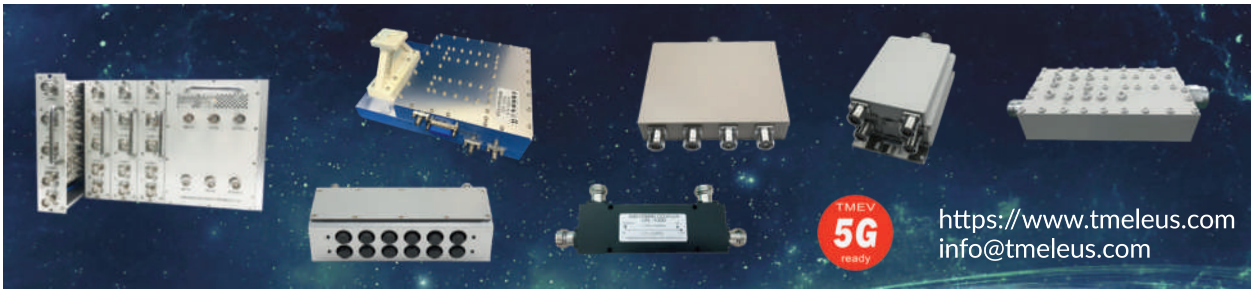

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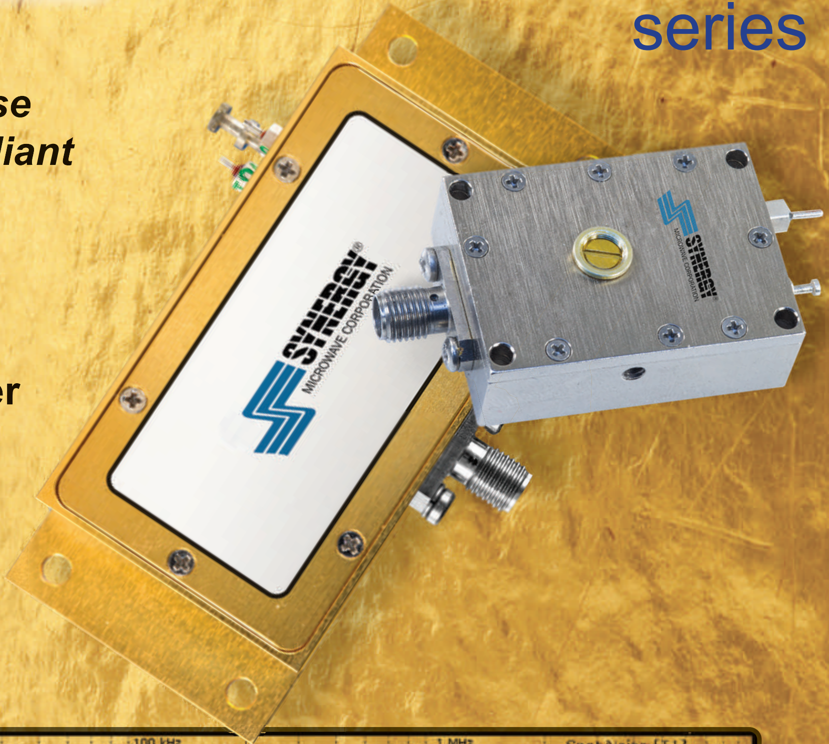

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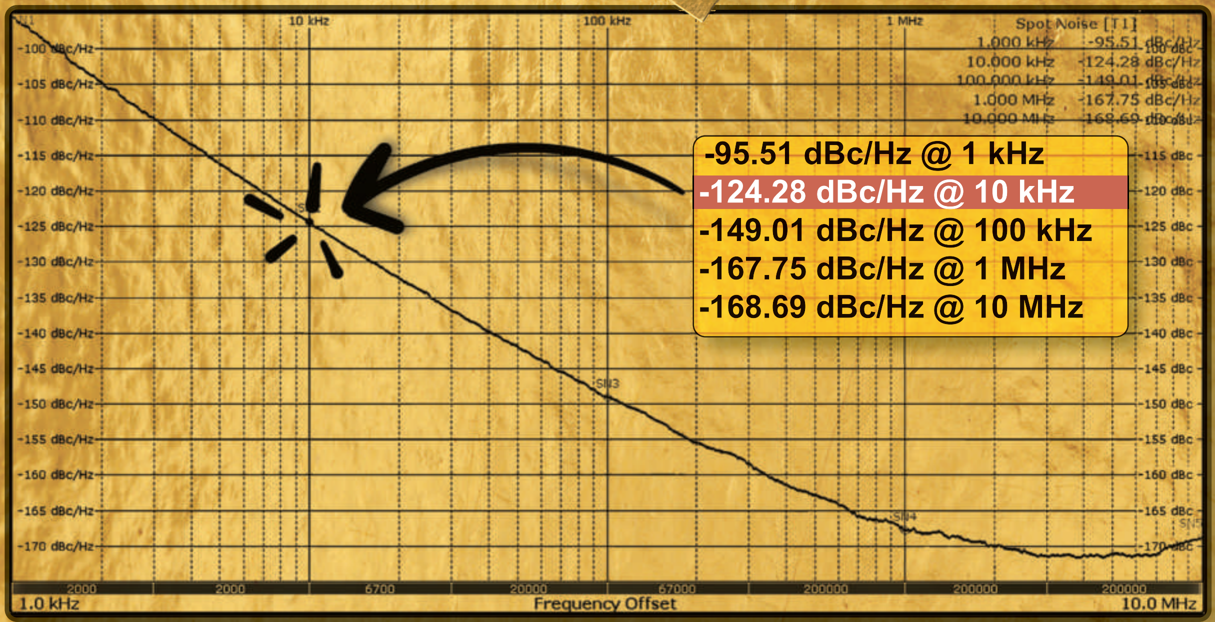

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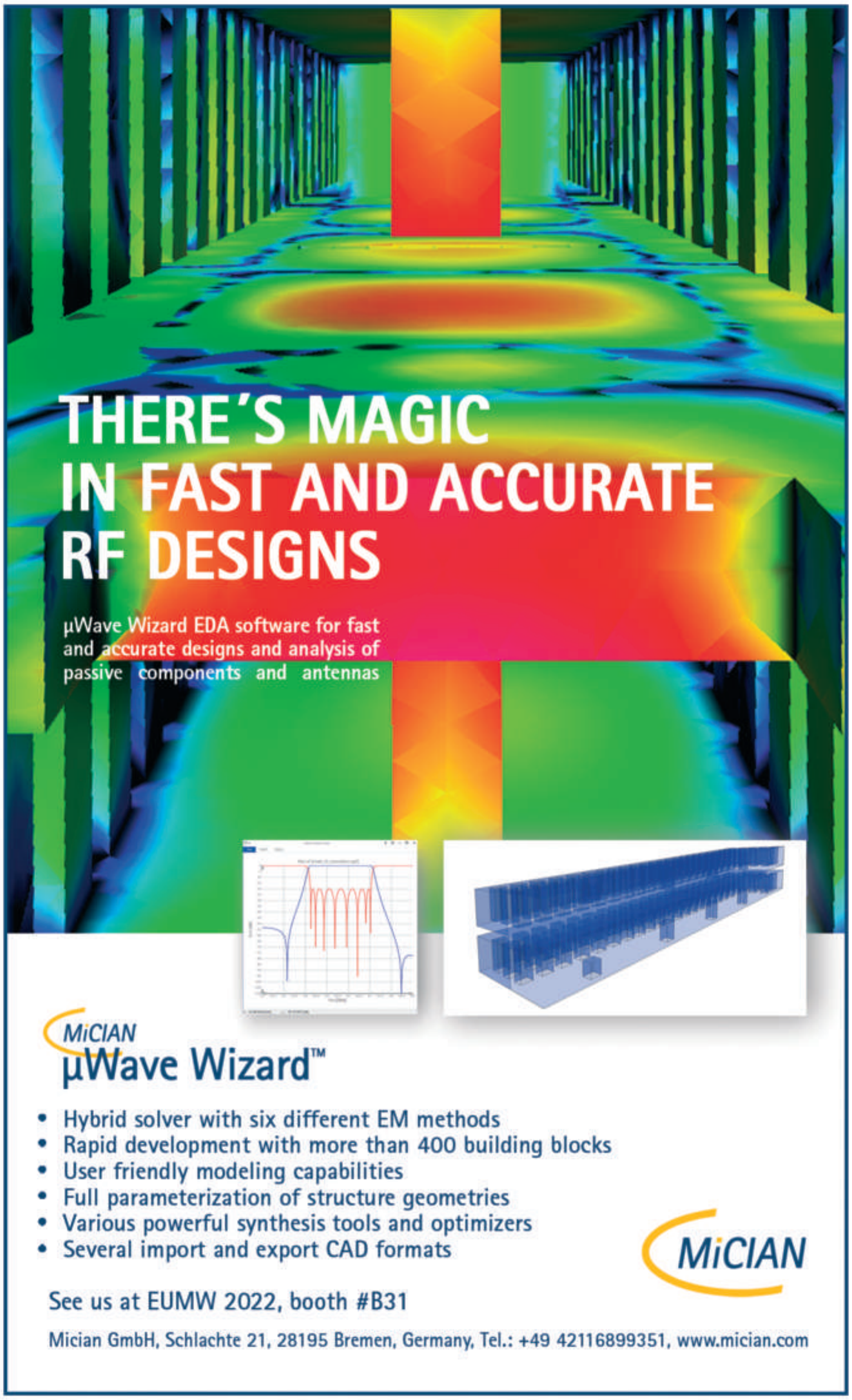
Vertical GaN transistors are early in the development lifecycle. A vertical transistor technology would likely be GaN on GaN[12] because GaN on GaN homoepitaxial layers have lower dislocation densities than GaN on Si or GaN on SiC. Though GaN on GaN wafers have historically been expensive, the cost has steadily declined over the last several years and larger wafer sizes are becoming available. Vertical GaN transistors have achieved breakdown voltages greater than 1 kV and current handling near 100 A.[12] The evolutions of high voltage GaN transistors will likely require development of enhancement mode devices, which could be GaN trench MOSFETs or even FinFETS (see ***Figure 4***). The figure shows the R_{on} and breakdown voltage performance of vertical and lateral GaN diodes and transistors, as well as the performance of 1D unipolar Si and SiC devices.



GaN & CMOS Compatibility

Significant R&D is underway to develop a GaN process that is compatible with CMOS.[5,13–18] GaN epitaxy on Si substrates has rapidly developed and will enable a GaN-CMOS process in the near future. The process replaces GaN's Au ohmic contact metal with an alternative, as Au metallization is incompatible with CMOS processes. Possible alternatives are Ti, Al, Ni or a TiN combination instead of the typical Ti/Al/Ni/Au ohmic contact metal stack.[13] A TiN diffusion barrier/Schottky metal with a Cu or Al conductor layer could replace the metal gate, rather than the typical Ni Schottky gate with an Au conductor layer.[14]

CMOS-compatible GaN could enable GaN on Si high frequency and high-power devices to be integrated on the same IC as the digital, memory, signal processing, analog-to-digital and digital-to-analog circuits fabricated in CMOS. This capability would enable an entire transceiver containing the RF front-end, modulation, demodulation, beamforming, MIMO, signal processing and other communication or sensing features to be integrated. This could lead to pairing several GaN transceiver channels with a high performance FPGA core, enabling a single chip solution for a phased array antenna.

SUMMARY

As GaN technology brings performance and system benefits to a variety of RF applications, costs will continue to reduce, feeding an investment cycle to develop better GaN-based technologies and the development of a GaN-CMOS process. Devices capable of mmWave and sub-THz performance combined with higher power and operating voltage will open even more doors for GaN. ■

References

1. K. Harrouche and F. Medjdoub, "GaN-based HEMTs for mm-wave Applications," *Nitride Semiconductor Technology: Power Electronics and Optoelectronic Devices*, 2020, Web: hal.archives-ouvertes.fr/hal-03287288.

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2. "Gallium Nitride Semiconductor Devices Market Report, 2030," *Grand View Research*, Web: www.grandviewresearch.com/industry-analysis/gan-gallium-nitride-semiconductor-devices-market.
3. "GaN RF MARKET APPLICATIONS, PLAYERS, TECHNOLOGY, SUBSTRATES - MARKET UPDATE 2021," *Yole Développement*, Web: www.yole.fr/GaN_RF_Market_Update_2021.aspx.
4. "Monolithic Microwave IC Market Size - Growth Trends 2028," *Global Market Insights Inc.*, Web: www.gminsights.com/industry-analysis/monolithic-microwave-ic-market.
5. A.-C. Liu et al., "The Evolution of Manufacturing Technology for GaN Electronic Devices," *Micromachines*, Vol. 12, No. 7, Article No. 7, July 2021.
6. T. M. Research, "GaN on Silicon Technology Market Growth, Trends and Forecasts | 2019 – 2027," *Digital Journal*, Web: www.digitaljournal.com/pr/gan-on-silicon-technology-market-growth-trends-and-forecasts-2019-2027.
7. "GaN on Silicon Technology Market," *Transparency Market Research*, Web: www.transparencymarketresearch.com/gan-on-silicon-technology-market.html.
8. "Heterogeneous Integration Roadmap 2021 Edition, Chapter 12: 5G Communication," Nov. 2021, Web: eps.ieee.org/images/files/HIR_2021/ch12_5G.pdf.
9. R. Chen and F. F. Wang, "SiC and GaN Devices With Cryogenic Cooling," *IEEE Open J. Power Electron*, Vol. 2, 2021, pp. 315–326.
10. "Qorvo Wins U.S. Government Project to Create Advanced, State-of-the-Art, RF Semiconductor Packaging Center," *Microwave Journal*, Nov. 2020, Web: www.microwavejournal.com/articles/34910-qorvo-wins-us-government-project-to-create-advanced-state-of-the-art-rf-semiconductor-packaging-center.
11. J. McHale, "GaN in Space, Military RF trends - Military Embedded Systems," *O. Media*, June 2021, Web: dev007.militaryembedded.com/from-the-editor/gan-in-space-military-rf-trends.
12. K. Hoo Teo et al., "Emerging GaN Technologies for Power, RF, Digital, and Quantum Computing Applications: Recent Advances and Prospects," *J. Appl. Phys.*, Vol. 130, No. 16, Oct. 2021, pp. 160902.
13. X. Li, S. Gao, Q. Zhou, X. Liu, W. Hu and H. Wang, "Fabrication and Performance of Ti/Al/Ni/TiN Au-Free Ohmic Contacts for Undoped AlGaN/GaN HEMT," *IEEE Trans. Electron Devices*, Vol. 67, No. 5, May 2020, pp. 1959–1964.
14. T. Kawanago et al., "Advantage of TiN Schottky Gate Over Conventional Ni for Improved Electrical Characteristics in AlGaN/GaN HEMT," *2013 Proceedings of the European Solid-State Device Research Conference (ESSDERC)*, Sept. 2013, pp. 107–110.
15. M. Ho Kwan et al., "CMOS-Compatible GaN-on-Si Field-Effect Transistors for High Voltage Power Applications." *IEEE International Electron Devices Meeting*, 2014, Web: ieeexplore.ieee.org/document/7047073.
16. K. Y. Wong et al., "A Next Generation CMOS-compatible GaN-on-Si Transistors for High Efficiency Energy Systems," *IEEE Int. Electron Devices Meet, IEDM*, 2015.
17. L.-H. Hsu et al., "Development of GaN HEMTs Fabricated on Silicon, Silicon-on-Insulator, and Engineered Substrates and the Heterogeneous Integration," *Micromachines*, Vol. 12, No. 10, Oct. 2021.
18. U. Peralagu et al., "CMOS-compatible GaN-based Devices on 200mm-Si for RF Applications: Integration and Performance," in *2019 IEEE International Electron Devices Meeting (IEDM)*, Dec. 2019, pp. 17.2.1-17.2.4.

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- European Microwave Integrated Circuits Conference (EuMIC) 26th - 27th September 2022
- European Microwave Conference (EuMC) 27th - 29th September 2022
- European Radar Conference (EuRAD) 28th - 30th September 2022
- Plus Workshops and Short Courses (From 25th September 2022)
- In addition, EuMW 2022 will include the Defence, Security and Space Forum, the Automotive Forum and the 5G and Beyond Forum

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Registration opening times:

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1 Conference	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.
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EuMIC	€ 400	€ 130	€ 560	€ 190	€ 560	€ 190	€ 780	€ 260
EuRAD	€ 360	€ 120	€ 500	€ 170	€ 500	€ 170	€ 700	€ 240
2 Conferences	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.
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EuMC + EuRAD	€ 700	€ 260	€ 980	€ 370	€ 980	€ 370	€ 1,380	€ 520
EuMIC + EuRAD	€ 610	€ 250	€ 850	€ 360	€ 850	€ 360	€ 1,190	€ 500
3 Conferences	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.
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	Date	Delegates*	All Others**	Delegates*	All Others**
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5G and Beyond Forum	29th September 2022	€ 60	€ 90	€ 80	€ 100
Defence, Security & Space Forum	28th September 2022	€ 30	€ 60	€ 30	€ 60
Tom Brazil Doctoral School: Build a Frequency -Modulated Continuous Wave Radar in 1-day	25th September 2022	€ 40	€ 40	€ 40	€ 40
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Despite the organiser's best efforts to ensure the availability of all listed workshops and short courses, the list below may be subject to change. Also workshop numbering is subject to change. Please refer to www.eumweek.com at the time of registration for final workshop availability and numbering.

Sunday 25th September 2022			
SC1	EuMIC	Full Day	Fundamentals of Microwave PA Design
WS1	EuMIC	Full Day	140GHz: Where radar meets 6G
WS2	EuMC/EuMIC	Full Day	Latest Digital Predistortion Solutions for 5G and Beyond: from Handsets to MIMO Arrays.
WS3	EuMC/EuMIC	Full Day	Millimeter-Wave GaN Power Amplifiers
WS4	EuMC	Half Day	New On-Chip and Scalable RF Packaging Solutions with Integrated Antennas for 5G mmWave and 6G Applications
WS5	EuMIC	Half Day	RF and mmW reliable ICs: characterization, test and security challenges
WS6	EuMC/EuMIC	Full Day	Technological needs for future SatCom connectivity
WS7	EuMC	Full Day	Microwave Design and Metrology for Quantum Computing
WS8	EuMC	Full Day	Reconfigurable radiofrequency circuits based on ferroelectric materials
WS9	EuMC	Half Day	Advances in Nonlinear Component Modeling and Digital Predistortion under Modulated Signal Conditions
WS10	EuMC	Half Day	Electromagnetic Waves in Daily Life: Research Insights from Young Professionals
WS11	EuMC	Full Day	Additive Manufacturing Technologies for Microwave and Millimeter-Wave Applications

Monday 26th September 2022			
WM1	EuMC	Half Day	Recent Advances in Topologies, Technologies and Practical Realizations of Microwave Sensors dedicated to biomedical applications
WM2	EuMC	Full Day	Cryogenic RF-mmW Technology and circuit platforms: a path toward Quantum-Computing
WM3	EuMC	Full Day	mmWave Front Ends: Challenges and Advances
WM4	EuMC	Full Day	Wireless Power Transmission
WM5	EuMC	Full Day	Substrate Integration Technologies for High-Density Hybrid and Monolithic Integrated Circuits, Antennas and Systems
WM6	EuMC	Full Day	Reconfigurable intelligent surfaces for smart electromagnetic environment: an integrated vision towards industrial applications
WM7	EuMC	Full Day	Recent developments in millimetre-wave measurement: S-parameters and material properties
WM8	EuMC	Full Day	New techniques and foundations for microwave and mm-wave RF filtering devices for emerging communication systems
WM9	EuMC	Full Day	Nanoparticles in medicine: from diagnosis to treatment
WM10	EuMC	Half Day	RF Reliability Status and Challenges for 5G mmWave and 6G Applications

Friday 30th September 2022			
WF1	EuRAD	Half Day	Ubiquitous Radar
WF2	EuRAD	Half Day	Future individual mobility based on automotive radar sensors and more ...
WF3	EuMC	Half Day	Design and optimization of mmWave wideband radios for 5G and Satcom
WF4	EuMC/EuRAD	Half Day	Metasurfaces
WF5	EuRAD	Full Day	Applications for advanced passive radar systems
WF6	EuRAD	Full Day	Radar for Medical and Biological Applications and Bioinspired Radar
WF7	EuMC	Half Day	Dosimetry and microdosimetry applied to emerging wireless technologies: from human to cell level
WF8	EuRAD	Full Day	Integrated Sensing and Communications for 6G Systems
WF9	EuMC	Full Day	Reconfigurable Intelligent Surfaces and Smart Skins for B5G/6G Communications: Recent Advances, Current Trends and Vision

WORKSHOPS AND SHORT COURSES	IN COMBINATION WITH CONFERENCE REGISTRATION				WITHOUT CONFERENCE REGISTRATION			
	Society Member		Non-Member		Society Member		Non-Member	
	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.	Standard	Student/Sr.
Half Day	€ 110	€ 80	€ 140	€ 110	€ 140	€ 110	€ 190	€ 140
Full Day	€ 150	€ 110	€ 200	€ 150	€ 200	€ 150	€ 270	€ 200

Filter Design Platform Generates 3D Coaxial Cavity and Waveguide Filter Models in HFSS

SynMatrix Technologies, Inc.
Toronto, Canada

The growth in high frequency applications, driven by satcom, 5G and aerospace and defense, continues to challenge the design engineering community. Challenging RF filter designs continue to escalate with more stringent specifications coupled with the need to reduce the research and development cycle time, sustain RF performance and maintain manufacturing quality.

One time-consuming operation in RF filter design is creating 3D models. For companies venturing into new design capabilities or with requirements for completely new geometries, their design engineers are faced with a lengthy development process to produce models and simulations from scratch, followed by extensive optimization. Many available tools use templates to ease this process. Once designers have created a library of designs, this resource is sufficient to support the business for the near future. However, as applications expand to higher frequencies and address new market requirements, particularly at mmWave frequencies, this practice can be hard to scale.

SynMatrix, the RF filter design platform, has released several functions and features during the past two years to help designers accelerate the RF/microwave filter design process. This year, SynMatrix released a significant upgrade to the platform: launching a function that automatically creates 3D RF filter models in Ansys HFSS. This automatic 3D modeling feature supports coaxial cavity filters, rectangular waveguide filters and cylindrical waveguide filters.

One of the highlights of this new function is the design approach, which uses first principle design to build a flexible and highly customizable workflow for any filter application using a specific 3D geometry. This enables the designer to produce and simulate designs in an accelerated workflow.

WORKFLOW FEATURES

The user-guided workflow provides the following features:

Mode chart analysis for waveguide — Waveguide modes describe the field patterns for the waveguide structure. SynMatrix analyzes the transverse hybrid modes, either TE or TM, to determine the widest range of dimensions that will meet the desired operating bands. Through this mode chart analysis tool, users can quickly retrieve the correct waveguide dimension to obtain the widest spurious-free window (see ***Figure 1***).

Single resonator design and analysis — The design workflow begins with a single resonator. SynMatrix supports various coaxial resonators with different shapes. It also handles frequency and Q analysis; dimension synthesis; mode chart analysis for waveguide, including tools to help define the best dimension; temperature drift analysis; and single click auto simulation and modeling. Users can edit the HFSS simulation setup, including refining the mesh.

Coupling design and analysis — SynMatrix features a flexible coupling scheme definition to help customize the coupling structure. For coaxial cavities, SynMatrix supports four major coupling schemes

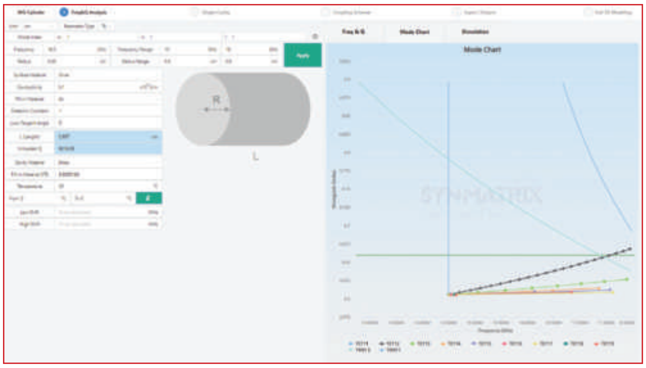

Fig. 1 **Mode chart for a cylindrical waveguide resonator.**

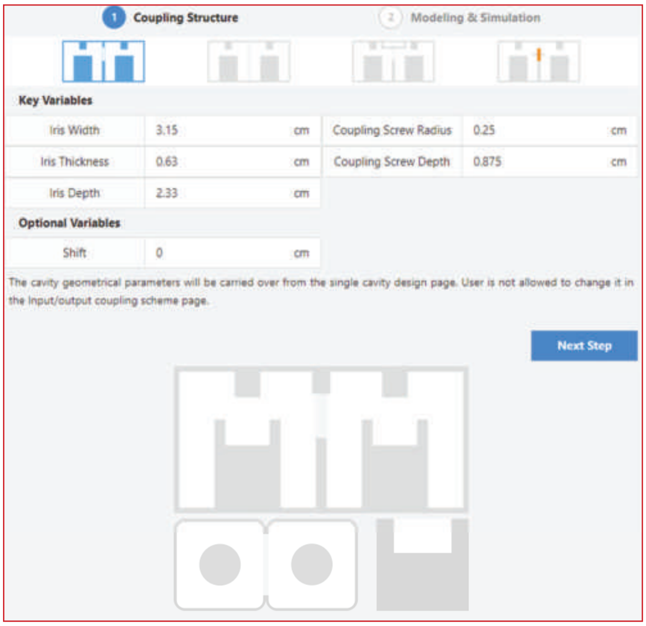

Fig. 2 **Interface for defining the coupling structure.**

and up to 42 different geometries. It also supports key variable parametric analysis to analyze the coupling coefficient (see ***Figure 2***).

Input/output design — For waveguide filters, SynMatrix offers different waveguide sizes to customize the port interface. For coaxial cavities, the platform supports three major coupling schemes and up to nine different geometries. Like the previous steps in the workflow, parametric study analysis for the key variables is available (see ***Figure 3***).

Full 3D modeling generation — The latest version of SynMatrix introduces a click-and-drag graphical interface to help users fully customize a topology. Unlike other platforms in the market, which use template-based methods, SynMatrix gives users full command and control to build and modify the design. This feature supports generic modeling with different rotation angles. Another highlight, the 3D model generated in Ansys HFSS is fully parameterized. Users can edit the design easily after the model is generated (see ***Figure 4***).

Fast optimization — Once the 3D model is created and simulated using this workflow, users can use the powerful optimization tools available in SynMatrix. The initial performance can be quickly tuned using computer-aided tuning tools and then optimized with SynMatrix's intelligent optimization suite, which includes automatic AI optimization, space mapping algorithms and the perturbation system.

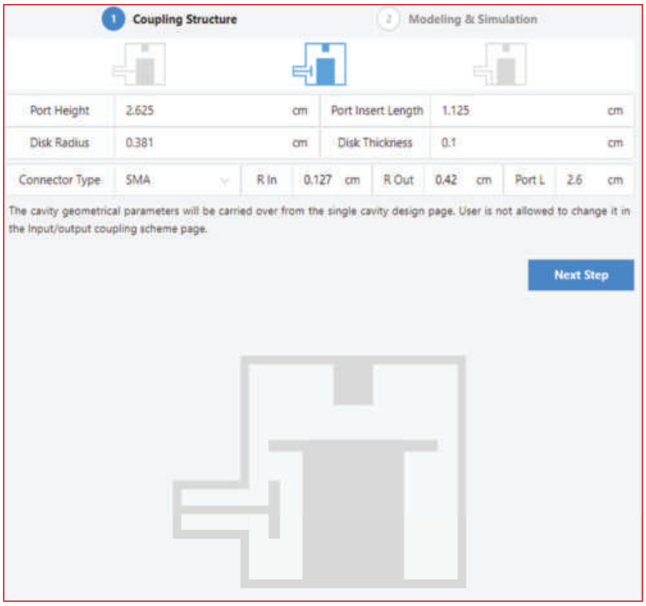

Fig. 3 **Interface for defining the input/output port.**

Fig. 4 **3D modeling screen.**

For Ansys HFSS users, SynMatrix is the only platform that offers a powerful tool for 3D RF filter creation. Other tools in the market use template-based methods to build 3D models, which reduces the flexibility and customization when designing new RF filters. Simplifying the creation and simulation of a 3D RF filter model from scratch can help startups and system companies add new capabilities, build new products and create revenue opportunities. Other benefits include reducing filter component costs, shortening the design cycle time, increasing the design flexibility and efficiency and eliminating dependence on third-party suppliers, which can add risk to a project or solution proposal response. Because the design approach used by SynMatrix is based on first principles, the tool is "future proof" for evolving design requirements. Users can use the workflow knowing the investment will pay back for many years.

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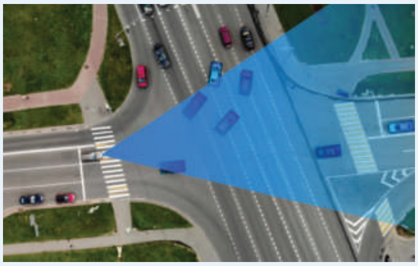

Ultra-High-Resolution RF Chipset for Automotive Imaging Radar

Arbe Robotics has released its final RF chipset for production. The new transmit (Tx) and receive (Rx) RFICs increase radar sensitivity and range, reduces power consumption and combine design flexibility with ultra-high-resolution for excellent image quality. To achieve high resolution, the radar uses 48 Tx and 48 Rx antennas to create a 2304 virtual channel array, natively providing high dynamic range and avoiding angular ambiguities and phantom objects. This resolution enables the system to track moving objects, map the environment and detect stationary obstacles, generating free-space mapping for path planning while providing accurate localization. This 48 x 48 architecture has 12x the MIMO channels as the current most advanced 12 x 16 radars, which have lower resolution and higher sidelobes.

Arbe's Tx RFIC provides 12.5 dBm output power from a single channel, high enough to detect a car at > 300 m using a single beam. It can also transmit multiple channels simultaneously, which can extend vehicle detection to 800 m, 350 m for pedestrians and two wheelers. The radar's waveform can be tailored to optimize performance for a specific application, like trucks and other commercial vehicles. The Tx RFIC's power consumption is 50 percent that of the prior generation.

The Rx RFIC has 11 dB noise figure, which Arbe says is the best in the industry, and 50 percent lower power consumption compared to the previous generation. Rx and Tx performance uses auto calibration to be stable across the automotive temperature range of −40°C to +125°C.

Arbe's proprietary chipset uses the latest RF processing technology to achieve this level of RF performance and the lowest cost per channel. The chipset meets ASIL-B, AEC-Q100 and Automotive Grade 2 and is Grade 1 ready.

Arbe Robotics
Tel Aviv-Yafo, Israel
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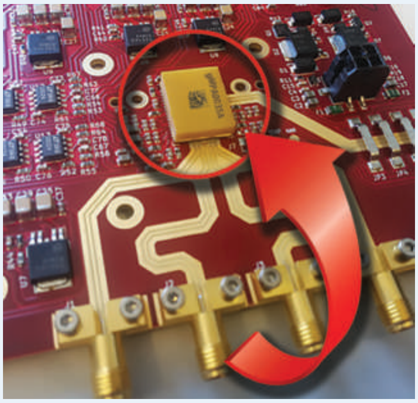

Packaged MMIC Components Aid mmWave Development

The high cost of entry has made mmWave a barrier for many companies seeking growth opportunities, such as point-to-point radio, vehicle radar, metrology or other markets. Typically, a company considering whether to develop mmWave components or systems must establish an end-to-end capability, beginning with design expertise and extending to prototyping and manufacturing. Prototyping and manufacturing require an investment in equipment for die handling, pick-and-place, die attach and wire bonding, with a clean room to house assembly and test.

To help companies minimize this investment and get to market faster, HASCO offers system in package (SiP) components developed by gotMiC. The SiPs integrate GaAs MMIC die and other chip components into individual packages that enable companies to use conventional handling and storage systems, eliminating the investment in specialized and expensive assembly equipment. These SiPs are compatible with surface-mount pick-and-place and reflow processes, which simplifies the assembly of mmWave components on conventional PCBs. Integrating an RF front-end into a SiP reduces the number of RF transitions, which improves performance.

HASCO's SiP components are available for all of gotMiC's broadband, D-, E-, G-, V- and W-Band, including mixers, multipliers, amplifiers and transmit/receive front-ends. The SiPs have matched ports that are optimized to launch directly into waveguide. All of HASCO's die products manufactured by gotMiC can be packaged in a SiP to replace traditional split-block packaging. These new mmWave SiPs, produced by gotMiC, expand HASCO's line of mmWave MMIC die to PCB-level components, making mmWave accessible to new companies seeking growth opportunities.

VENDORVIEW

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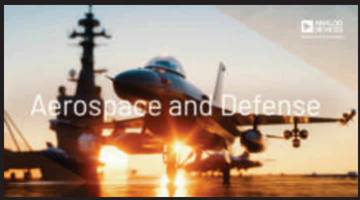
Moorpark, Calif.
www.hasco-inc.com/SIP



Analog Devices' Signal Processing and System Solutions: A 50-Year Success Story

Analog Devices has a clear mission: to solve today's and tomorrow's aerospace and defense challenges with industry leading integrated solutions.

Analog Devices
www.analog.com/en/applications/markets/aerospace-and-defense-pavilion-home.html

Integrated Circuits (ICs) & Component EMC Testing

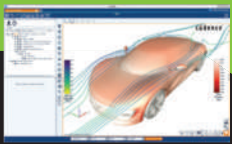
Read "Integrated Circuits (ICs) & Component EMC Testing," to learn more about today's advancing technology and the components they're built with.

AR RF/Microwave Instrumentation
https://bit.ly/3zqHyJa

What's New in the Latest Release of Cadence Fidelity CFD

Cadence released Fidelity CFD version 2022.1, with many new features to speed up and streamline your workflow for highly accurate performance simulation of multiphysics systems.

Cadence
https://bit.ly/3zskA4i



All Things 5G: The 6G Vision for Verticals

A new episode of the All Things 5G podcast dives deep into network digital twins with Rajive Bagrodia, a pioneer in the field and the founder of Scalable Network Technologies.

Keysight Technologies Inc.
https://bit.ly/3NrNx40

ALL THINGS 5G
PODCAST

eVNA-63+ Vector Network Analyzer Video Series

This tutorial series introduces you to Mini-Circuits' eVNA-63+ vector network analyzer, including getting started/setting up, SOLT calibration and S-parameter measurement.

Mini-Circuits
https://bit.ly/3zkIPkT

NOFFZ Technologies Recognized for International Reach

NOFFZ Technologies was one of three companies honored by NI, beating out more than 1000 system integrators in the partner network. The specialists received the award as "Global Premier" for their outstanding performance.

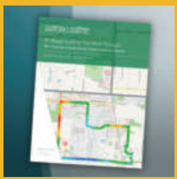
NOFFZ Technologies GmbH
https://noffz.com/en/

New Video from RF Industries

TruField's superior RF and mmWave transparency is truly revolutionary, it can be configured to fit any small cell or current mmWave radio.

RF Industries
https://vimeo.com/709508567

RF Mapping Feature Now Available in Spike



Download the RF mapping White Paper which details the steps of performing a drive test using these features in Signal Hound's Spike, spectrum analyzer software.

Signal Hound
https://signalhound.com/rf-mapping-guide

SMP/SMPM Spring Loaded RF Bullets

SV Microwave's SMP and SMPM spring bullets guarantee maximum RF performance by eliminating gaps between the bullet and shroud during gang mating. Additionally, these spring loaded bullets have been designed for repeatable VSWR performance under all states of compression by solving radial misalignment issues when fully mated.

SV Microwave
https://youtu.be/GbKeEjMKaEE

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COMPONENTS

Ultra-Wideband Cavity Filter

3H Model number CC2235-X930-12AA (Zo = 50 Ω) has an ultra-wide bandwidth of 930 MHz with a passband of 1770 to 2700 MHz with insertion loss of < 0.6 dB in the entire bandwidth while achieving rejections > 30 dB from DC to 1600 MHz and > 40 dB from 3600 to 8000 MHz. This filter can handle up to 100 W of average power in the small form factor of only 3.937" × 0.894" × 1.02" with weight only 4.3 oz. (122 g).

3H Communication Systems
www.3hcommunicationsystems.com

Directional Coupler

Electro-Photonics LLC has released a new broadband surface mount (SMT) directional coupler: Q10HG-3850R. Its new Q10HG-3850R, directional coupler operates from 2 to 4 GHz, dissipates 150 W and offers low insertion loss and high directivity for the most critical applications. This coupler has a very small package of 0.560 × 0.350 inches (14.22 mm x 8.89 mm). The Q10HG-3850R is manufactured in the U.S. and is RoHS compliant.

Electro-Photonics LLC
www.electro-photonics.com

Detector Discerns G-Band Signals

VENDORVIEW

Measuring frequencies from 140 to 220 GHz, model SFD-144224-05SF-P1 is a G-Band amplitude detector with typical sensitivity of 200 mV/mW. Sensitivity flatness is ±2.0 dB. The maximum input signal strength for square-law detection is -20 dBm. Maximum allowable input power is +17 dBm. The video output is provided through an SMA connector. The zero-bias detector has video bandwidth that spans DC to 10 MHz. The WR-05 waveguide input includes a UG-387/U-M anti-cocking flange.

Eravant
www.eravant.com

High-Power Directional & Dual-Directional Couplers

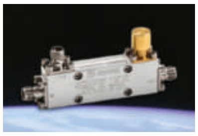
VENDORVIEW

MIcable 0.5 to 6 GHz 30 dB high-power directional/dual-directional couplers have DC pass capability, 30 ±0.7 dB coupling, 0.6 dB maximum insertion loss, ±1/1.2 dB flatness, 1.3:1 maximum input/output VSWR and 15 dB minimum directivity. It can handle 250 W CW power. The price is $1378/$1818 each, delivery stock to four weeks FOB Fuzhou China factory.

Fujian MIcable Electronic Technology Group Co. Ltd.
www.micable.cn

Directional Coupler

VENDORVIEW



Model 101040010SQ offers superior performance ratings including nominal coupling (with respect to output) of 10 dB, ±1.0 dB and frequency sensitivity of ±1.52 dB. The directional coupler exhibits insertion loss (including coupled power) of less than 1.3 dB (1 to 20 GHz) and 1.7 dB (20 to 40 GHz). The directional coupler comes with industry-standard 2.4 mm female connectors. The compact package measures just 2 (L) × 0.4 (W) × 0.65 in. (H) and weighs only 1.3 oz.

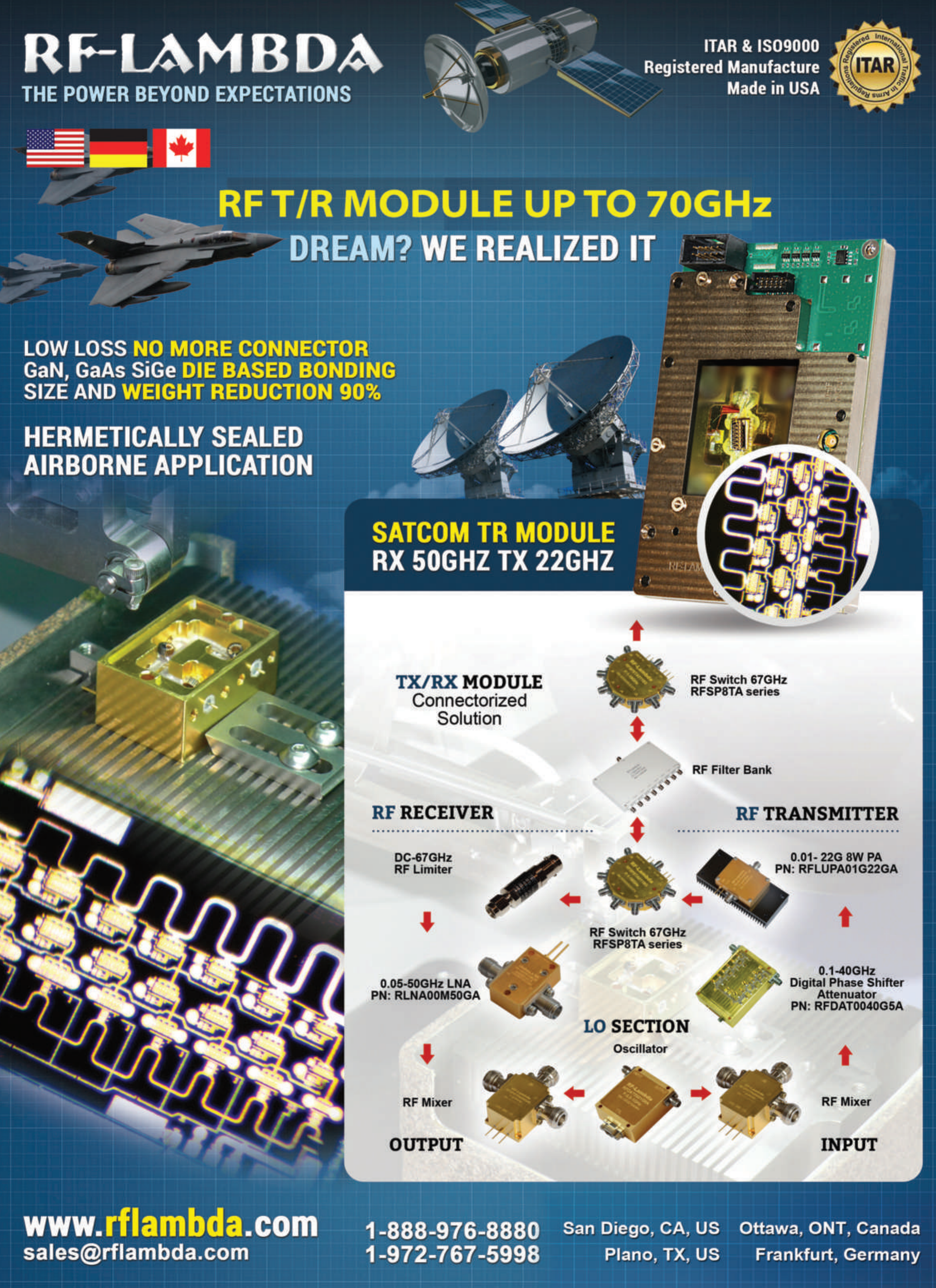
Krytar
www.krytar.com

SP4T Switch

VENDORVIEW

The QPC8013Q is a low loss, high isolation SP4T switch with performance optimized for LTE and diversity applications. The QPC8013Q is packaged in an ultra-compact 1.1 x 1.9 x 0.44 mm, 13-pin module package which allows for the smallest solution size with no need for external DC blocking capacitors (when no external DC is applied to the device ports).

Qorvo
www.qorvo.com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PTRAN-100M18G-SDLVA-2SFB-3UVPX-P4-MAH fits a 3U open VPX form factor utilizing high speed VITA 67 connector. Up-converts 100 MHz to 4 GHz transmit signal to 2 to 18 GHz; down-converts 100 MHz to 18 GHz received signal to the 100 MHz to 4 GHz IF for analog-digital conversion; equipped with an integrated CW immune logarithmic amplifier offering 70 dB dynamic range.

Quantic PMI
www.pmi-rf.com

"Weightless Filter" Series

RLC Electronics introduced the "Weightless Filter" series. Founded on high Q cavities and engineered to provide premium RF performance, these new miniaturized filters boast low insertion loss (typically 0.6 dB maximum over operating temperature) and excellent power handling capabilities, up to 60 W cW. The filter pictured measures 0.8"× 0.46"× 0.46", utilizing GPO connectors to save space and eliminate the need for cables at the system level. This particular filter is used in a family of antennas that is part of a radar system.

RLC Electronics
www.rlcelectronics.com

AMPLIFIERS

GaN SSPAs

Engineered specifically to meet the stringent requirements imposed by many modern system designs, CTT's GaN power amplifiers, built in the U.S., perform a wide range of functions making them ideal for applications in cutting-edge multi-function electronic warfare systems. Three models include: AGM/060-5056, 2 to 6 GHz, 100 W power out; AGX/0218-3946, 2 to 18 GHz, 8 W power out; AGX/0318-4656, 3 to 18 GHz, 40 W power out. TTL on/off options and rack-mount configurations are also available.

CTT Inc.
www.cttinc.com

6 KW Extended Band Pulse Amp

VENDORVIEW

Exodus AMP2068P-LC-6KW is a robust 500 MHz to 2.0 GHz, 6 KW pulse amplifier for pulse/HIRF, EMC/EMI Mil-Std 461/464 and radar applications. Up to 100 usec pulse widths, up to 6 percent duty cycle with a minimum 68 dB gain. Providing superb pulse fidelity, excellent rise/fall times, monitoring parameters for forward/reflected power in watts and dBm, VSWR, voltage, current, temperature sensing for unprecedented reliability and ruggedness, 13U high, nominally 250 lbs.

Exodus Advanced Communications
www.exoduscomm.com

Low Noise Amplifier

VENDORVIEW

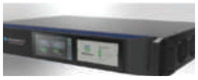
Mini-Circuits' model ZVA-71863LNX+ is a coaxial amplifier with low noise figure

and high, flat gain from 71 to 86 GHz. It provides 37 dB typical gain with ±1.75 dB gain flatness and 5.5 dB or better typical full-band noise figure. Well matched to 50 Ω with 1.60:1 typical input/output VSWR, the amplifier includes 1 mm female connectors. It runs on a single supply from +10 to +15 VDC and is a powerful asset for automotive, 5G and radar test applications.

Mini-Circuits
www.minicircuits.com

SYSTEMS

Repeater



WilsonPro's Enterprise 1337R is the first repeater engineered to extend C-Band

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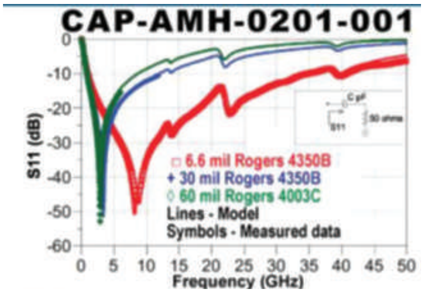
frequencies and amplify 5G in buildings. The Verizon and AT&T-compatible repeater operates at 3.7 to 3.8 GHz. With time-division duplex technology, it automatically syncs to the carrier network ensuring reliable coverage. The ideal repeater for amplifying C-Band, the Enterprise 1337R requires no additional backhaul, data plan or recurring fees, and includes secure remote management.
WilsonPro
www.wilsonpro.com

SOFTWARE

Microwave Global Model™

VENDORVIEW



Modelithics has developed a new Microwave Global Model™ for the Amotech A60Z capacitor series, available in the Modelithics Complete Library™ for many of today's EDA software tools. The model is validated up to 50 GHz and is part-value scalable, covering the capacitance range of 0.1 to 10 pF. This part-value scalability makes the model well suited for tuning or optimization. The model also scales with respect to substrates and solder pads. Thanks to substrate scalability, desired substrates can be used, and the model will then scale accordingly.
Modelithics
www.modelithics.com

ANTENNAS

Omnidirectional Antennas

VENDORVIEW

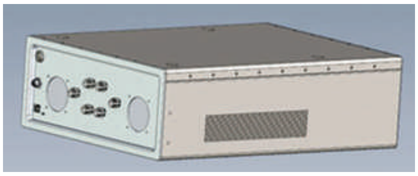
Fairview Microwave Inc., an Infinite Electronics brand and a provider of on-demand RF, microwave and mmWave components, has just released a new series of 5G outdoor-rated omnidirectional antennas that cover 4G, 5G, LTE and CBRS bands. These small form factor omni antennas are the perfect solution when broad coverage is required but traditional base station antennas are too bulky or expensive. They support 6, 7, 8 and 10 dBi gain and are also offered with fiberglass radomes (PRO series).
Fairview Microwave Inc.
www.fairviewmicrowave.com

Dual Linear Polarized Scalar Feed Horn Antenna

Anteral's Dual Linear Polarized Scalar Feed Horn Antenna (DLPSFHA) is an integrated system composed of an orthomode transducer that provides high isolation and cross-polarization cancellation and a broadband scalar feed horn antenna that provides high gain, low VSWR and low side-lobes, with minimum size. This type of horns is especially suitable for laboratory test measurements, electromagnetic measurements and gain calibration. Moreover, custom bands and gain values can be requested.
Impulse Technologies
www.impulse-tech.com

TEST & MEASUREMENT

Harmonic Tuner

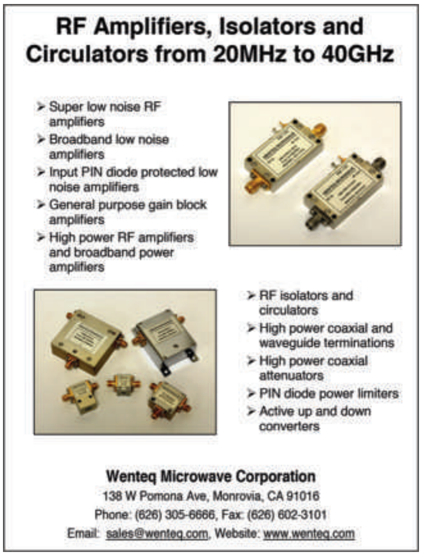


Focus Microwaves launches a new family of very low frequency (500 kHz to 10 MHz) high-power harmonic impedance (load-pull) tuners. Based on the over 15-year-old proven and patented technology of the company's low frequency tuner (10 to 150 MHz), the new modular tuners allow handling up to three independent harmonic frequency tuning and several kW RF power with a typical tuning accuracy of 40 dB or higher. The new tuners are available in fundamental mode ultra-low frequency-wideband (ULFT) and ultra-low frequency-harmonic-wideband (ULFHT).
Focus Microwaves Inc.
www.focus-microwaves.com

Spectrum Analyzer

Signal Hound's SM435B, a high performance spectrum analyzer and monitoring receiver, will expand your reach into mmWave spectrum analysis at an affordable price point. Tuning from 100 kHz to 43.5 GHz, this next-generation SM-series analyzer has 160 MHz of instantaneous bandwidth, 110 dB of dynamic range, 1 THz/sec sweep speed at 30 kHz RBW (using Nuttall windowing), ultra-low phase noise and PC-connection via USB 3.0. The SM435B continues the Signal Hound tradition of unrivaled value. Available now.
Signal Hound
www.signalhound.com

MICRO-ADS



Review by: Brian Rautio

Bookend

Introduction to LabVIEW™ FPGA for RF, Radar and Electronic Warfare Applications

Terry Stratoudakis

Working in a high-technology field, we're accustomed to novelty. New materials, new techniques, new software; whether we seek contributions to the scientific record or better products, we're hungry for something ground-breaking. However, sometimes we miss what already exists; novelty doesn't have to be new science, merely science new to us.

Stratoudakis makes a solid argument that FPGAs—easily reconfigurable integrated circuits—can be just that to microwave engineers. Accessible to a wide audience, his new book not only explains the concepts to program an FPGA using block diagrams with LabVIEW, it also explains why you would want to do so. In a word, latency. Both for the design cycle—programming an FPGA with a graphical tool should require well less investment than an ASIC—and for circuit delay; for the multitude of RF and microwave sensor applications out there, FPGAs offer a much-needed determinism that conventional CPUs cannot manage.

So, this isn't a book for memorizing, it's a book for accomplishing. Already know a bit about FPGAs and LabView? No problem, skip the introductions and there's plenty of detail and many interesting references to explore. It also reviews many examples, citing an example browser as well as an online code repository. Without built-in questions and assignments, these seem to be geared for launching practical projects more than textbook use.

While Stratoudakis does spend time discussing other methods for programming FPGAs, the titular LabView is clearly his favorite. He's quite passionate about it, so much so that on occasion the book toes the line with promotion. I will note that someone with a strong background in digital design or computer science may prefer a text-based method like Verilog, however it is still a cogent argument that the microwave field can benefit from the shorter learning curve of LabView's graphical environment. In fact, given the hardware nature of FPGAs, I came out of this book seeing programming in LabView as a natural extension of design—we increase the order of layouts with schematics, so why not increase the order of schematics with block diagrams?

In summary, this is a well thought-out, clear and concise book that makes a strong case to use LabView to program FPGAs for microwaves design and research. Anyone curious about doing so will thoroughly enjoy this book, and anyone who intends to will absolutely love it. 4.5/5.

ISBN: 9781630817930 • 270 pp
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Hardcover: $139

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High-Throughput Satellites

Hector Fenech

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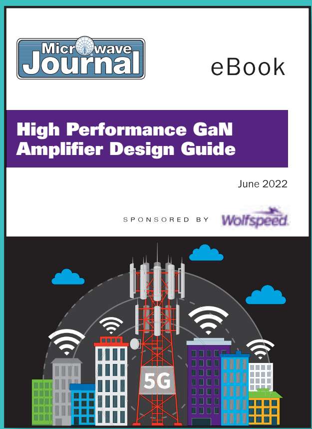

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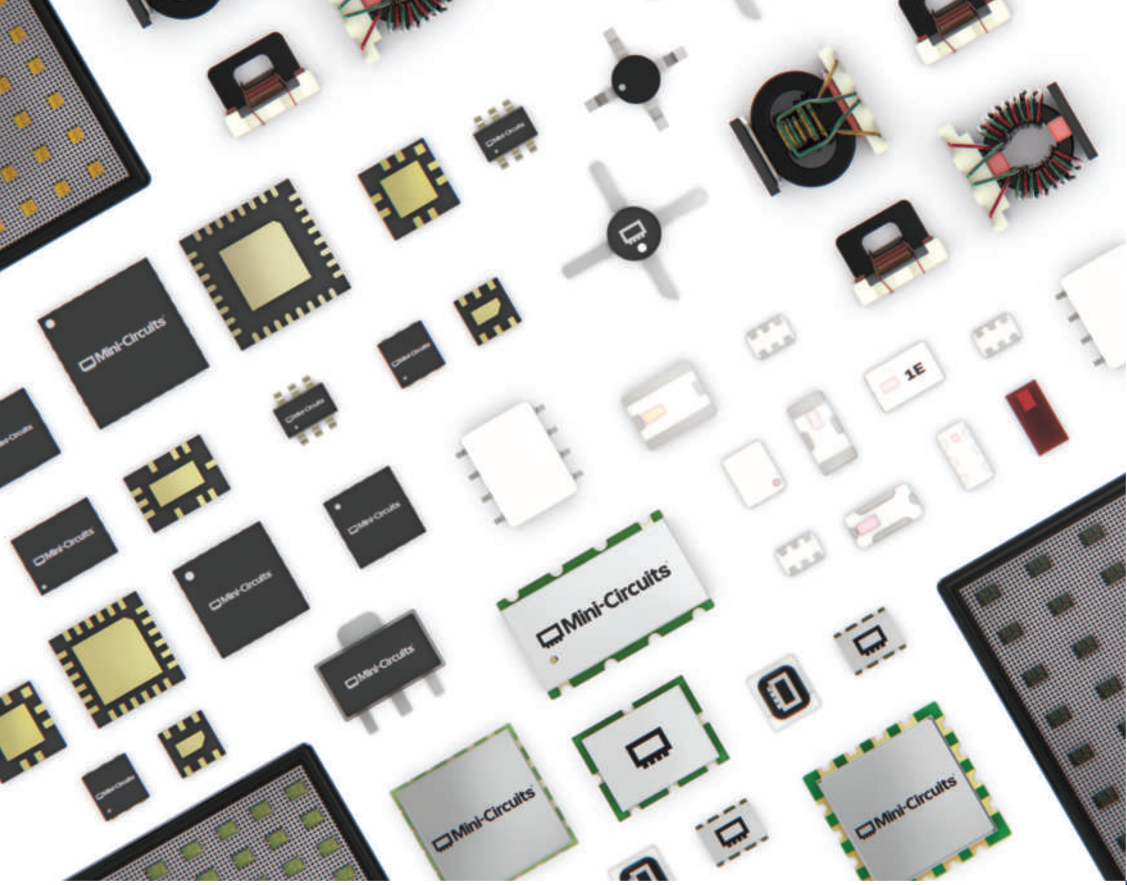

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CesiumAstro: Developing Plug and Play Phased Arrays for Satellite Communications





CesiumAstro is a great example of the renaissance of the space industry enabled by affordable rocket launches. Shey Sabripour, who started his career at Lockheed Martin Space Systems, realized that affordable launches of small satellites in low Earth orbit (LEO) would lead to a myriad of space-based communications, imaging, scientific and military applications. Orbiting the globe every 90 minutes, LEO satellites need antennas with agile beams to focus service and capacity where it's needed as they orbit—the perfect application for an active electronically steered array (AESA).

Seeing an opportunity, Sabripour founded CesiumAstro to provide "plug and play" AESAs for satellites and airborne systems. CesiumAstro provides the "full stack": antenna, RF front-end, up-/down-converters, software-defined radio, computer and power conditioning. The AESA only requires power and Ethernet from the satellite and includes application software to control the array and manage the link.

With seed funding and a small team, CesiumAstro started designing the modules, each the size of a credit card. The team also designed a Ka-Band AESA for the NASA and 5G non-terrestrial network spectrum. To ensure the high reliability needed for space, the designs use "careful COTS" ICs, meaning automotive grade and either radiation tolerant or radiation hardened. These standard modules qualified for space are manufactured and assembled into a complete AESA payload, reducing the development risk and cost while improving time to market for new platforms.

CesiumAstro plans to develop modules for all satellite bands from L- through V-Band and has developed multiple flight payload architectures using its modular approach. Nightingale provides a high data rate, time-division duplex satellite link covering 24.5 to 29.5 GHz. Comprised of the phased array antenna and digital back-end, it generates a single, steerable (±60 degrees) beam. Another payload, VIREO, provides multiple beams with fast beam hopping, beam sequencing and storage of beam weights to support multi-user connectivity from LEO.

Since its founding in 2017, CesiumAstro has raised nearly $90 million—most recently in its $60 million Series B round from investors including Airbus Ventures and L3Harris Technologies—to bolster in-house engineering, manufacturing and test. A 10,000 square-foot facility in Austin houses CesiumAstro's new product introduction (NPI) line, consisting of end-to-end surface-mount assembly, machined parts fabrication, module and mechanical assembly, electrical/RF/antenna testing and environmental testing, with a home-grown automated test software architecture capable of controlling instrumentation across multiple locations and labs. Testing capabilities include a near-field anechoic antenna test range, EMI chamber and the pyroshock, vibration, thermal vacuum and thermal cycling test systems required for space. The NPI line is designed for rapid prototyping and low volume production. High volume production is supported by a network of tier-1 AS91000 contract manufacturers.

CesiumAstro recently announced an extension of its business model for companies that need a complete satellite in addition to the AESA payload. A new division in Broomfield, Colo., will integrate the AESA in a 150 kg satellite ready for launch. This will aid customers without the capability to integrate a phased array on their own satellite bus.

Having grown to a staff of more than 100, CesiumAstro is poised to achieve its vision of supplying the best AESAs circling the planet. Several launches have been announced that will feature CesiumAstro payload modules, and their own satellite is planned to fly in early 2024. Sabripour says, "It's the perfect timing for this technology."

www.cesiumastro.com

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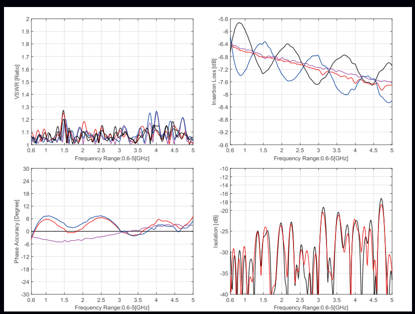
SA-07-4B006050	4x4	0.617~0.821	1.4	8.2	±1.1	±0.8	±10	16
		0.832~0.96	1.4	8.2	±1.1	±0.7	±9	16
		1.427~1.71	1.5	8.3	±0.9	±0.7	±9	15
		1.71~2.2	1.5	8.5	±0.9	±0.8	±10	14
		2.496~2.69	1.5	8.7	±0.9	±0.7	±9	13
		3.3~4.2	1.6	8.9	±1	±0.7	±12	13
		4.4~5	1.6	9.2	±1	±0.8	±12	13
SA-07-4B020080	4x4	2.4~2.5	1.4	7.3	±0.5	±0.3	±4	14
		5.18~5.83	1.5	7.7	±0.6	±0.4	±5	13
		5.9~7.25	1.5	7.8	±0.7	±0.5	±6	13
SA-07-8B020080	8x8	2.4~2.5	1.5	11.2	±0.6	±0.4	±8	13
		5.18~5.83	1.5	11.6	±0.8	±0.5	±10	12
		5.9~7.25	1.55	11.8	±0.9	±0.7	±12	12
SA-07-4B240430	4x4	24~43	2.0	12.4	±1.2	±2.0	±15	10

*Theoretical 6dB Included

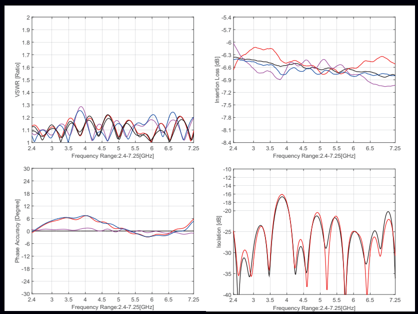
Note: The connected components are available from MIcable which include the phase matched assemblies & low loss high isolation phase matched switches.

Typical Test Curve**

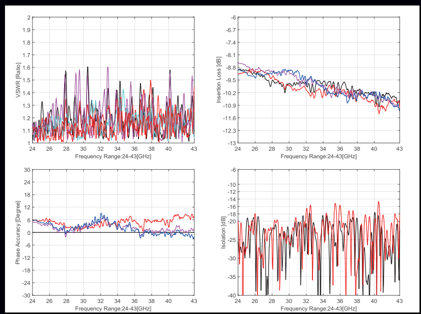
SA-07-4B006050



SA-07-4B020080



SA-07-4B240430



**Corresponding Channels: A1B1、A1B2、A1B3、A1B4

More Information-
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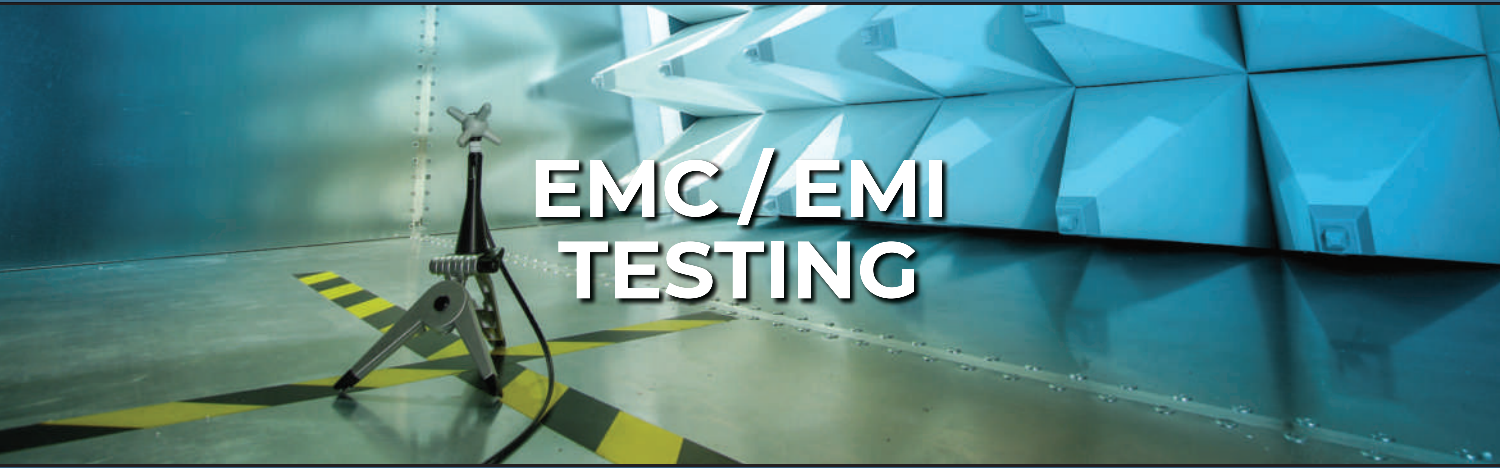
WERLATONE®

HIGH POWER DIRECTIONAL COUPLERS



Up to 1000:1 Bandwidth ✦ Low Insertion Loss ✦ *Mismatch Tolerant*® Designs

Model	Type	Frequency (MHz)	Power (W CW)	Coupling (dB)	Insertion Loss (dB)	Connectors	Size (inches)
C8730	Dual	0.009-250	500	40	0.40	N-Female	10.5 x 3.0 x 2.0
C8731	Dual	0.009-250	1000	40	0.40	N-Female	10.5 x 3.0 x 2.0
C11462	Dual	0.009-400	500	40	0.45	N-Female	6.7 x 2.28 x 1.69
C8510	Dual	0.009-1000	500	40	0.45	N-Female	6.7 x 2.28 x 1.69
C5047	Dual	0.01-100	4,000	50	0.15	7/16-Female	10.0 x 4.16 x 3.5
C1979	Dual	0.01-100	10,000	60	0.10	LC-Female	2.0 x 6.0 x 4.5
C5086	Dual	0.01-250	250	40	0.50	N-Female	5.2 x 2.67 x 1.69
C5100	Dual	0.01-250	500	40	0.40	N-Female	10.5 x 3.0 x 2.0
C5960	Dual	0.01-250	1,000	50	0.40	N-Female	10.5 x 3.0 x 2.0
C1460	Dual	0.01-250	2,000	50	0.15	N-Female	10.0 x 3.0 x 2.0
C4080	Dual	0.01-250	3,500	50	0.20	N-Female	10.0 x 4.6 x 3.5
C11026	Dual	0.01-220	5,000	60	0.10	LC-Female	12.0 x 6.0 x 4.5
C8390	Dual	0.01-250	10,000	60	0.10	LC-Female	12.0 x 6.0 x 4.5
C5339	Dual	0.01-400	200	40	0.50	N-Female	5.2 x 2.67 x 1.69
C6047	Dual	0.01-400	500	40	0.50	N-Female	5.2 x 2.67 x 1.69
C2630	Dual	0.01-1000	100	40	0.60	N-Female	5.0 x 2.0 x 1.51
C6021	Dual	0.01-1000	500	40	0.45	N-Female	6.7 x 2.28 x 1.69
C6277	Dual	0.01-1000	500	50	0.45	N-Female	6.7 x 2.28 x 1.69
C11146	Dual	0.01-1000	500	43	0.45	SC-Female	6.7 x 2.63 x 2.20
C11047	Dual	0.01-1000	1,000	43	0.45	SC-Female	6.7 x 2.63 x 2.20
C11161	Dual	0.01-1000	1,000	50	0.45	SC-Female	6.7 x 2.63 x 2.20
C1795	Dual	0.1-1000	100	40	0.50	N-Female	5.0 x 2.0 x 1.51
C5725	Dual	0.1-1000	500	40	0.50	N-Female	5.2 x 2.28 x 1.69
C11077	Dual	0.1-1000	1,000	43	0.45	SC-Female	6.7 x 2.28 x 1.69
C3910	Dual	80-1000	200	40	0.20	N-Female	3.0 x 3.0 x 1.09
C5982	Dual	80-1000	500	40	0.20	N-Female	3.0 x 3.0 x 1.09
C3908	Dual	80-1000	1,500	50	0.10	7/16-Female	3.0 x 3.0 x 1.59
C6796	Dual	80-1000	5,000	60	0.20	1 5/8" EIA	6.0" Line Section
C8060	Bi	200-6000	200	20	0.40	SMA-Female	1.8 x 1.0 x 0.56
C8000	Bi	600-6000	100	30	1.10	SMA-Female	4.8 x 0.88 x 0.50
C10117	Dual	700-6000	250	40	0.20	N-Female	2.0 x 2.0 x 1.06
C10364	Dual	700-6000	500	50	0.20	7/16-Female	2.15 x 2.0 x 1.36
C10996	Dual	700-6000	700	50	0.20	7/16-Female	2.15 x 2.0 x 1.36
C11555	Dual	700-6000	1,000	50	0.20	7/16-Female	2.15 x 2.0 x 1.36
C10695	Dual	700-6500	500	50	0.20	7/16-Female	2.15 x 2.0 x 1.36

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