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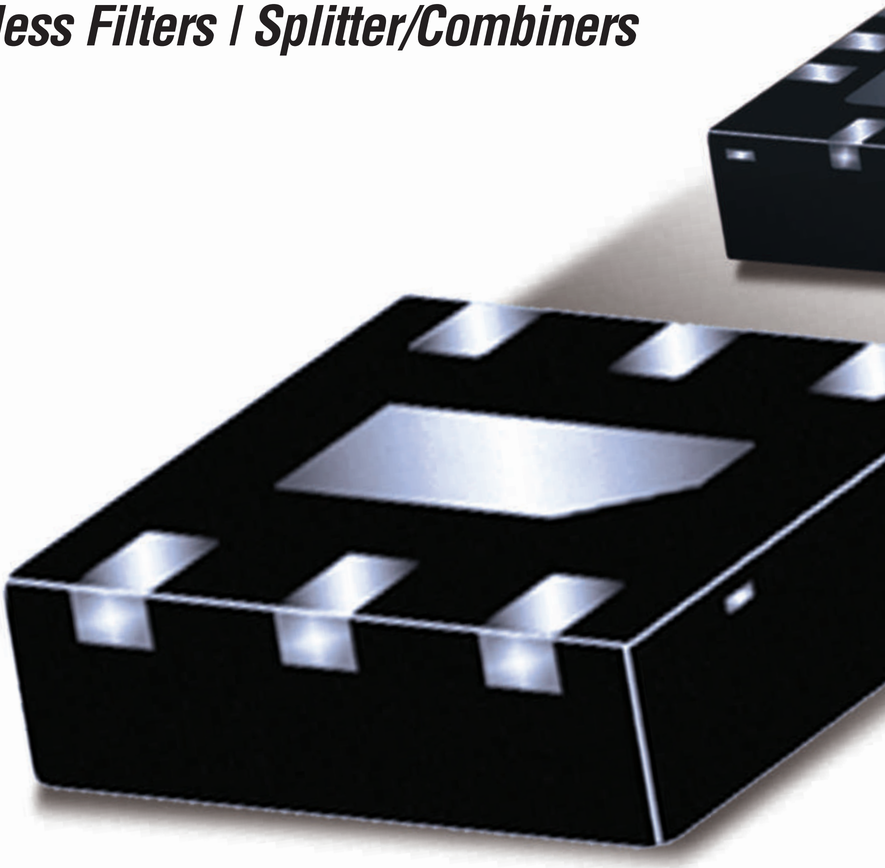

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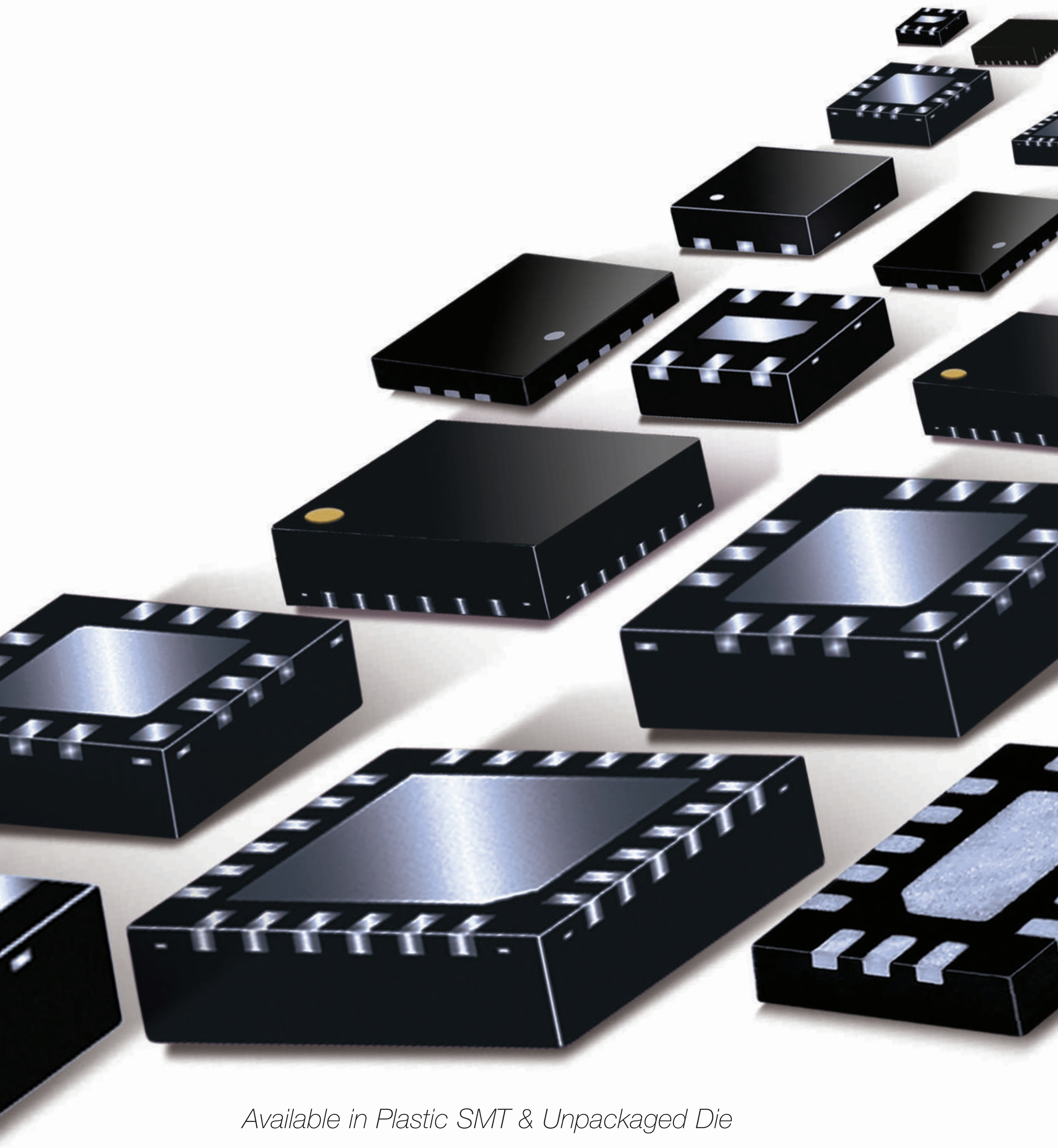

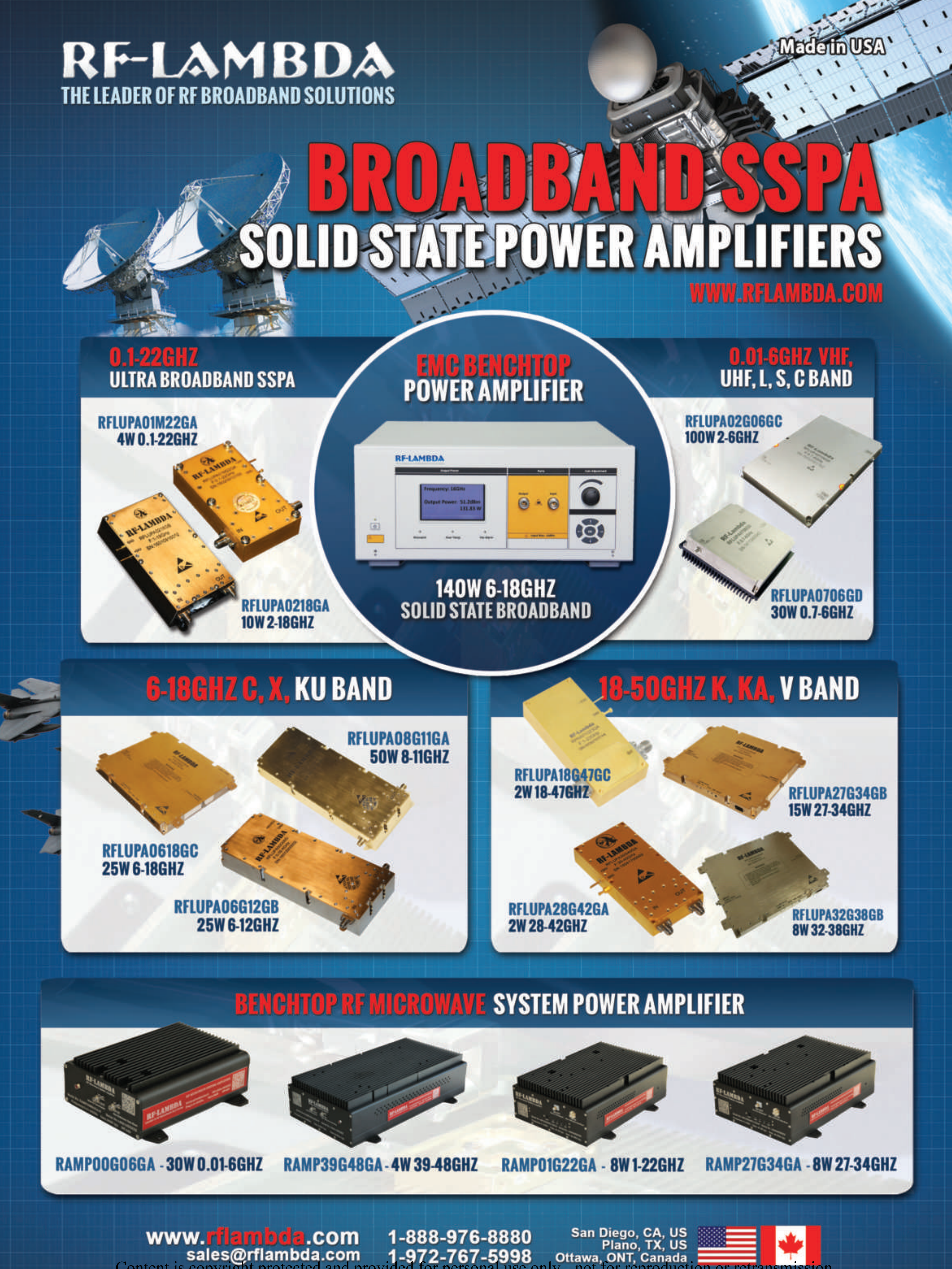

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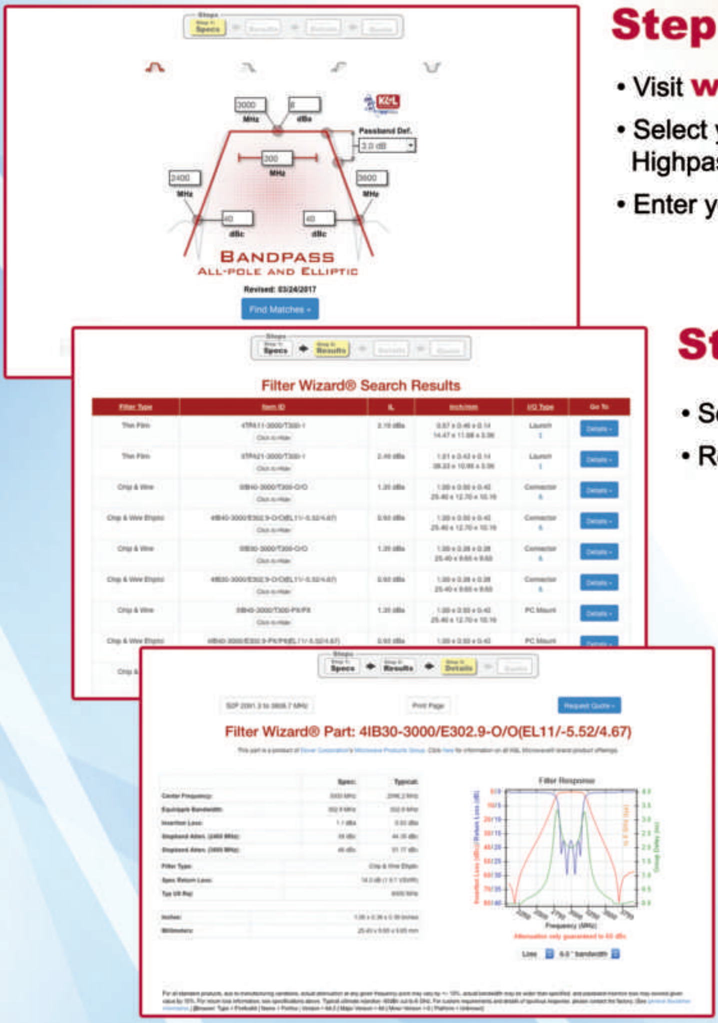

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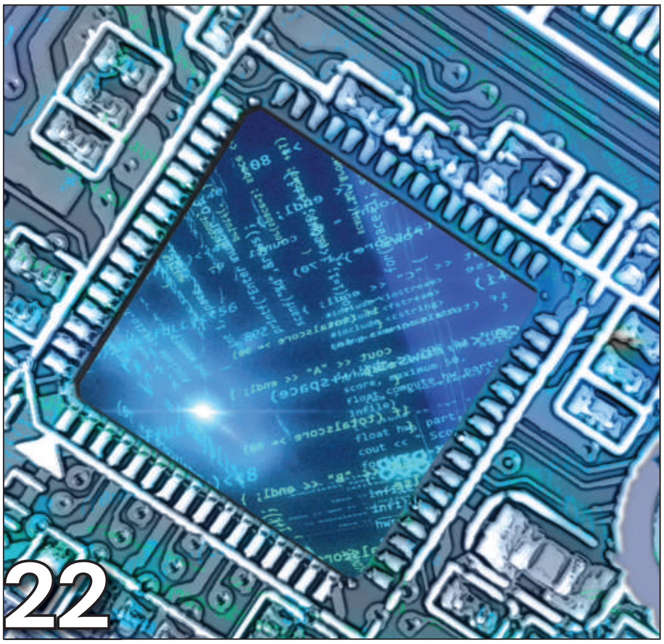

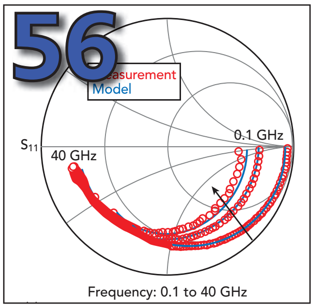

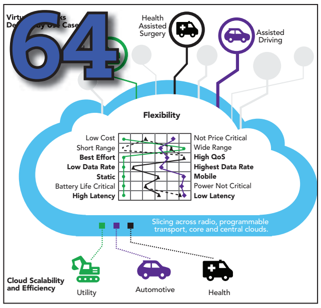

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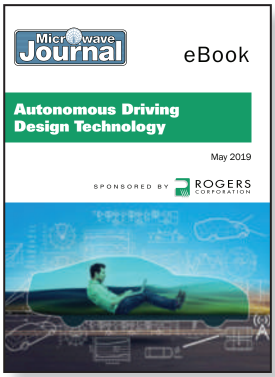

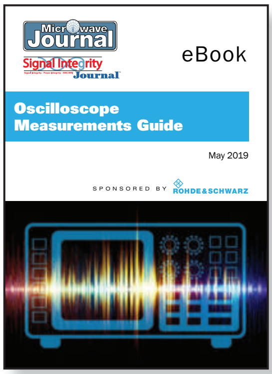

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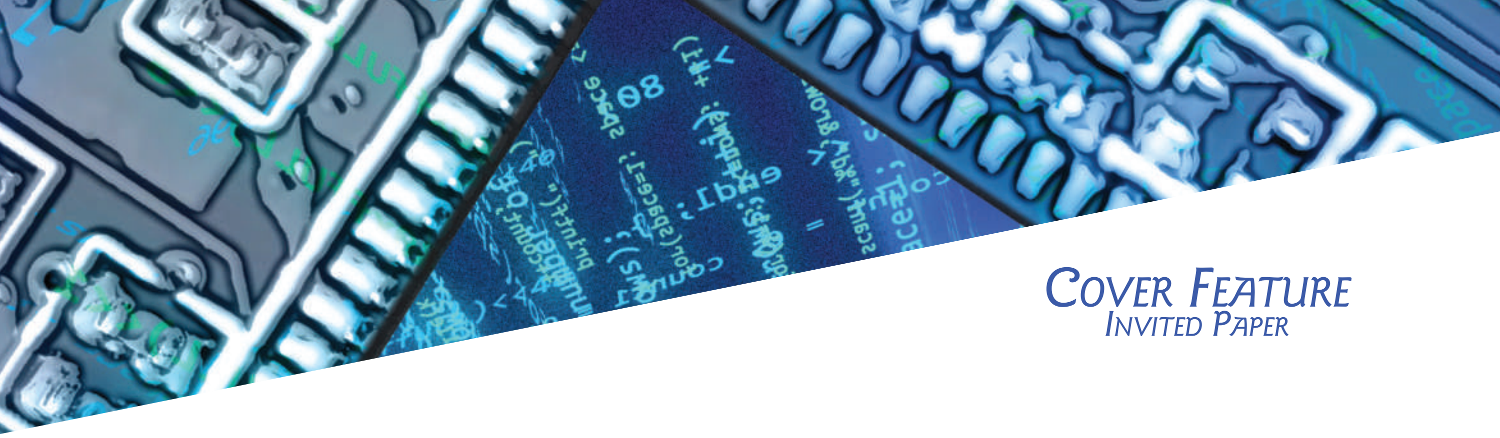


5G Power Amplifier Design and Modeling for mmWave GaN Devices

Valeria Brunel and Eric Leclerc
UMS, France

David Vye
AWR Group, National Instruments, El Segundo, Calif.

Advanced semiconductor technology plays an important role in evolving RF and microwave applications for 5G and SATCOM where the next generation of systems is moving towards mmWave frequencies. Support of design flows and model availability for these semiconductor technologies is critical to designers for successful product development. In response, EDA software vendors offering MMIC and RFIC design solutions must work closely with leading foundries to ensure their products provide increased integration and higher performance while lowering cost and size requirements.

This article highlights techniques supporting device modeling of III-V wide bandgap semiconductor technology, specifically the United Monolithic Semiconductors (UMS) GH25 (0.25 µm gate length), GaN on SiC process for mmWave power amplifiers (PA) targeting new communication and defense systems. Model accuracy is validated through simulation and measurements of multiple designs that were developed using the GH25 process design kit (PDK), serving as a development framework that will guide future work in support of evolving process node technologies like the GH15, 0.15 µm GaN on SiC process currently in the qualification phase. Processes such as this are well suited for 5G applications as demonstrated by a 10 W Ka-Band (29.5 to 36 GHz) PA and a 2 W front-end module (24 to 30 GHz) that integrate the GaN on SiC PA with other RF functions implemented with a GaAs process.

GaN TECHNOLOGY AND MODELING CHALLENGES

Short gate-length GaN devices have demonstrated excellent performance for mmWave PAs. Offering higher operating voltages and reduced device parasitics, these GaN transistors provide higher output power densities, wider bandwidths and improved DC-to-RF efficiencies than their GaAs counterparts. In order to take advantage of this enhanced performance, designers need a scalable model that accurately captures the complex behaviors of the device during circuit simulation. The behavior of the trapping and thermal phenomena in GaN devices represents a real challenge for transistor modeling.

Devices can be represented in simulation by various methods, including compact, physics-based or behavioral models. Physics-based models incorporate physical aspects of the device to predict performance but are too complex for circuit simulation. Behavioral models are generally used in system simulations to represent an entire radio block but do not provide the necessary detail to support the actual amplifier design effort.

Compact models, based upon

curve fitting, use functions and parameter values that produce the best fit to measured data, such as pulsed I/V and S-parameters. It is critical for the model to accurately replicate the transistor response over its entire range of operation in order to produce reliable circuit simulations. Parameters in these empirical models have no fundamental basis, but the physical consistency of the model equations is necessary to guarantee a good model extrapolation for designs lying outside the model characterization range.

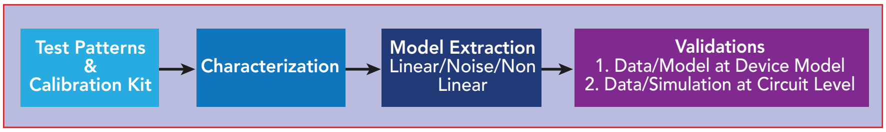
There has to be a strong connection between technology/device development and the device modeling effort. The characterization and modeling methods implemented need to be validated through a well-established process/model qualification procedure that has been proven to yield reliable device models for the foundry's family of semiconductor processes (see ***Figure 1***). For GaN devices, the know-how and background from developing GaAs technologies have guided the current model development efforts in many cases. Established lower frequency GaN processes have also helped advance the state of device modeling for the latest short-gate devices. Nonlinear models are extracted taking into account traps phenomena[1] and transistor self-heating. In addition to electrical characterization, the UMS modeling team performs a comprehensive study of the thermal device behavior and other non-stationary effects to improve the quality of their nonlinear device modeling.

This fitting process and characterization data supports the development of transistor models used by software design tools, such as the NI AWR Design Environment platform, to predict the overall MMIC behavior when these devices are embedded in a matching/biasing network and excited by RF signals. Models are organized into PDKs supported in Microwave Office circuit design software with electrical and physical layout information to enable the design of MMICs using the GaN or GaAs process.

MODEL/PDK DEVELOPMENT

Characterizing the active device to develop a scalable transistor model is the most important step in developing a process design kit. A scalable model allows the designer to vary the device periphery (gate width and number of gate fingers) for desired performance. One challenge is developing models accurately over the desired range of gate peripheries and operating conditions.

A device modeling procedure



▲ Fig. 1 Main steps to active device modeling incorporating measurements, model extraction and validation.

based on device characterization through measurement, model extraction via empirical fitting, and validation through device- and circuit-level simulation as illustrated in Figure 1 has been implemented here. The foundry also provides a family of models dedicated to multiple uses. For example, considering quarter micron technology, scalable linear models supporting low-noise amplifier (LNA) designs include noise characterization over a 10 to 20 V drain bias. A hot, nonlinear model for high power applications is scalable with medium to large gate peripheries, offering electrothermal model accuracy over a 10 to 30 V drain bias. A cold nonlinear model dedicated to switch applications is available for 2 topologies (serial and parallel) with model accuracy for various gate voltages.

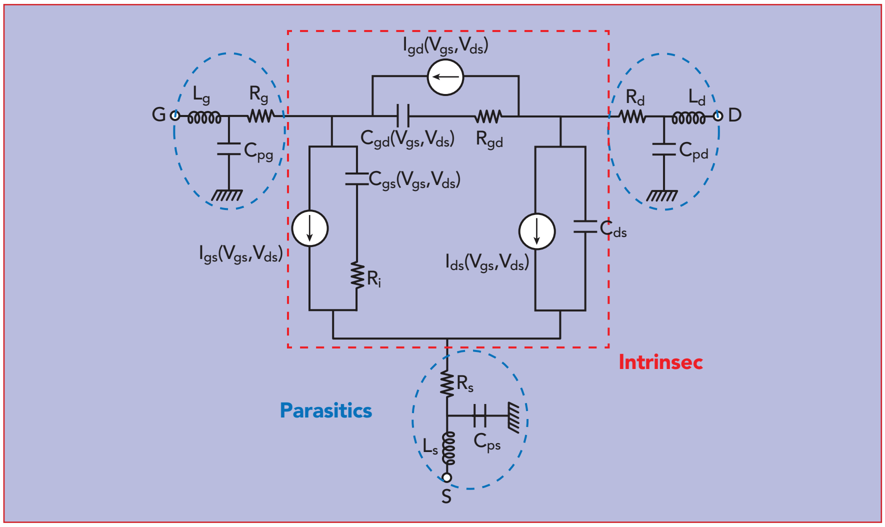


Fig. 2 Nonlinear sources in equivalent circuit model with extrinsic parasitics.

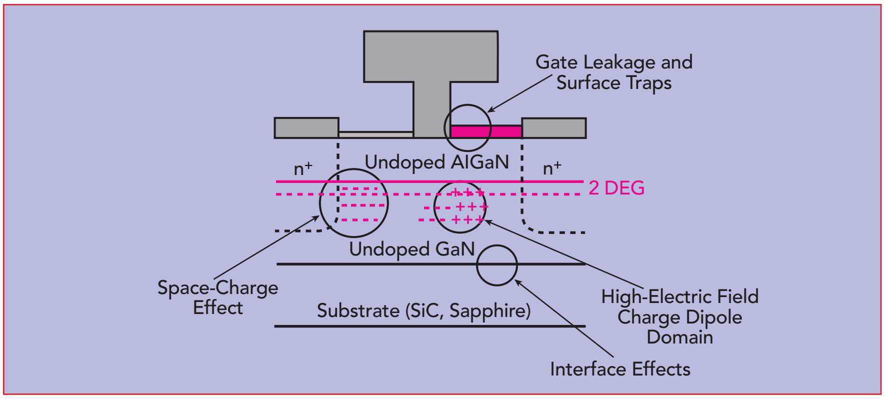


Fig. 3 Locations of trapping centers in wide bandgap semiconductors.

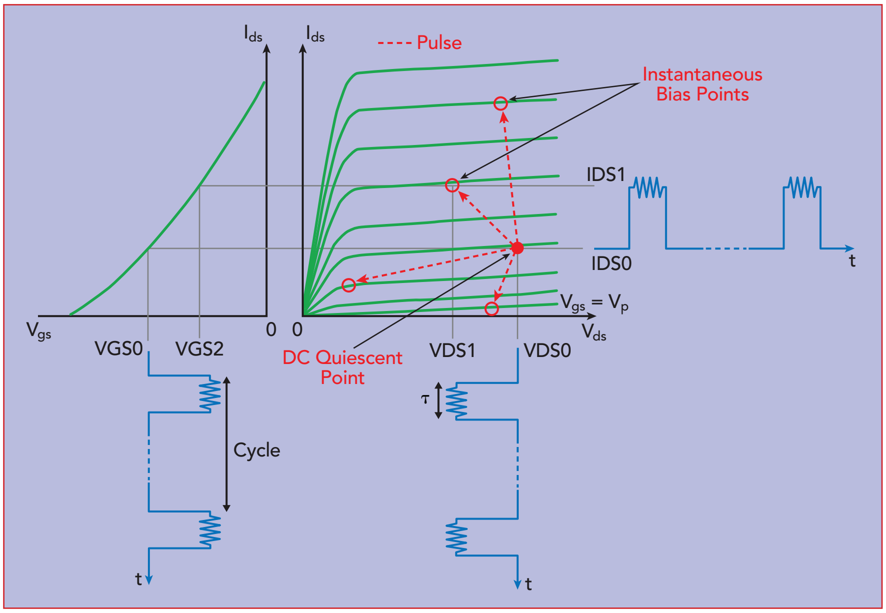


Fig. 4 Pulsed technique for device characterization.

MODEL EXTRACTION

The typical equivalent circuit of a compact transistor model is shown in ***Figure 2***. This model includes extrinsic linear elements and intrinsic nonlinear elements. Firstly, the transistor's extrinsic parasitic elements (R, L and C) are extracted in order to de-embed the S-parameter data to the intrinsic reference plane and to extract the intrinsic parameters (C_{gs}, C_{gd}, G_m, G_d, C_{ds}, R_i, T_{au}, R_{gd}) using explicit equations. The accurate extraction of the parasitic elements is based on both cold field-effect transistor (F_{ET}) S-parameter measurements ($V_{ds} = 0$) and electromagnetic (EM) simulations of the device feed manifold.

The next step is to determine the value of the intrinsic elements. For GaN devices, the main nonlinearities are the drain-to-source current and the gate-to-source and gate-to-drain capacitor, as well as the input Schottky diode behavior.

The high-electron mobility-transistor (HEMT) is affected by trapping phenomena. Traps are locations within a semiconductor that limit the movement of holes, mostly due to crystalline imperfections in the GaN material like impurities in the crystal lattice and dangling bonds on the surface or at interfaces, as shown in ***Figure 3***. These imperfections generate trap centers within the bandgap of a semiconductor.[2] The parasitic charge of the traps affects the density of the two-dimensional electron gas channel[3] in GaN-based transistors.

A variety of trapping effects in aluminum GaN (AlGaN)/GaN HEMTs have been observed, including transconductance frequency dispersion, current collapse, gate- and drain-lag transients and restricted microwave power output. The dominant drain lag effect depends on both the voltage bias and the

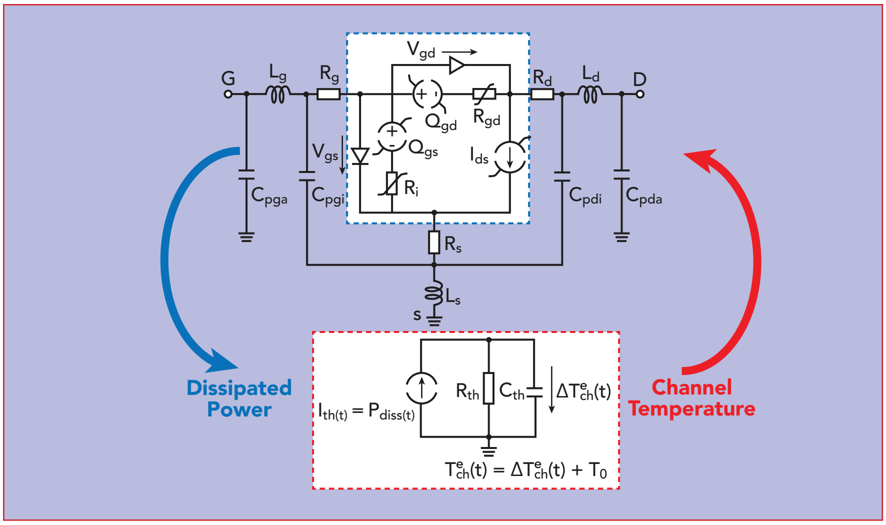


Fig. 5 Electrical description of the thermal behavior of the device contained in the model.

channel temperature, and it is traditionally taken into account by using quasi-isothermal pulsed I/V and pulsed S-parameter data instead of continuous wave (CW) measurements. The pulsed I/V S-parameters technique measures the S-parameters during the on-cycle of a fast pulse with a low-duty cycle. Instantaneous gate and drain biases are moved from a chosen steady quiescent bias to another point on the I/V plane to better replicate operational behavior where the thermal and trap conditions are set by the quiescent bias conditions (see ***Figure 4***). Pulse widths are kept short enough to avoid a strong temperature variation during the pulse duration, so that the transistor's pulsed I/V measurements are obtained under quasi-isothermal conditions.

The data obtained with this measurement protocol is then used to fit the parameters of in-house equations, developed for improved accuracy of the source current derivatives (G_m/G_d) over large values of V_{gs} and V_{ds}. Similarly, UMS gate charge equations improve the description of the capacitors variation over the gate and drain voltages.

Nevertheless, the pulsed I/V and S-parameter characterization are not sufficient for describing the drain lag in GaN transistors. Indeed, the trapping phenomena in GaN HEMTs present several time constants, some of them shorter than the shortest pulse duration available for test. The charge of these traps directly depends on the voltage pick across the device under RF dynamic operations, this is taken into account in the model by a dedicated module based on envelope detection.[4]

THERMAL MODELING

The thermal behavior of high-power GaN devices must be taken into account. The thermal impedance is determined with the use of 3D finite-element method (FEM) simulation and introduced into the model using an electrical description in order to automatically calculate the junction temperature during the electrical simulation, as described in reference 4 (see ***Figure 5***). The model is valid over a backside temperature from −40°C to 120°C. This electro-thermal model enables design at different temperatures and simulation of the junction temperature in both CW and pulsed operations.

MODEL VALIDATION

The resulting model is validated by comparing simulation results for a range of operating conditions and gate peripheries (from 2 × 30 μm to 10 × 300 μm for this quarter micron process). Load-pull measurements are used to validate the model's ability to predict device performance for different load impedances. For validation, the model is used for a fixed device periphery at various bias conditions, input power levels and excitation frequencies. Load-pull simulations in Microwave Office software can be readily compared to measured results obtained in the test lab. Measured figures of

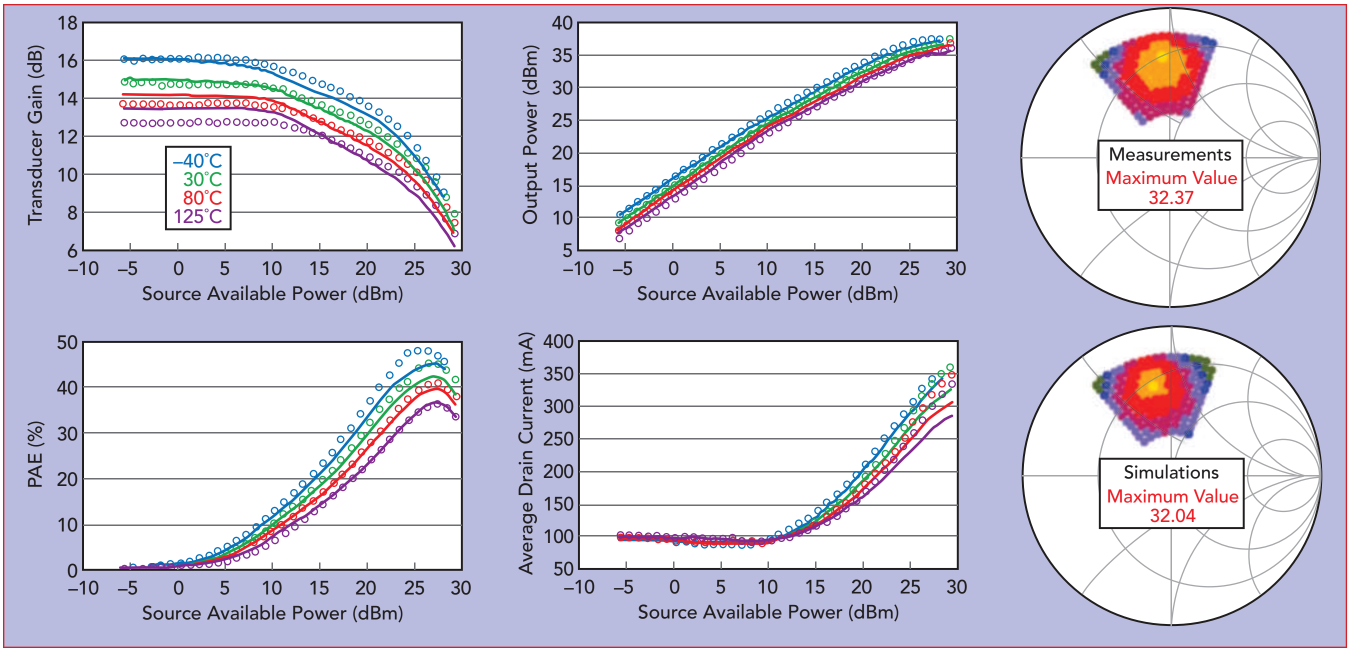


Fig. 6 GH25-10 heterostructure FET (HFET) model validation at 10 GHz on 8 × 125 µm transistor: line = model, circles = measurements.

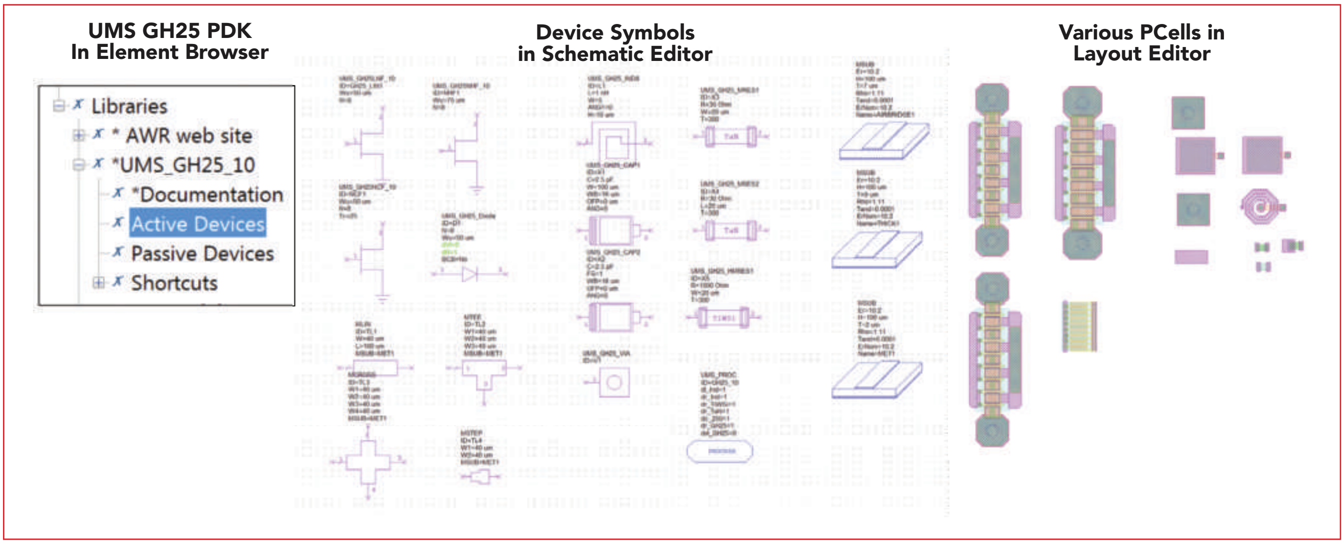


Fig. 7 Various components from UMS GH25 PDK in NI AWR Design Environment software.

merit, such as gain, output power, power-added efficiency (PAE) and drain current, are captured in ***Figure 6*** for a 1 mm device operating at 10 GHz, and show excellent agreement with the simulation results at several backside temperatures sweeping from –40°C to 125°C. The load positions for optimum power, PAE or linearity are also well-simulated as demonstrated in Figure 6 by the output power contour load pull.

PDKs FOR CIRCUIT SIMULATION

Active device models and passive on-chip components, along with their parametric layout cells (PCells) are organized into PDKs to support MMIC development using these technologies. These PDKs provide simulation-ready device models to design ICs and generate layout masks for fabrication. The PDKs for Microwave Office

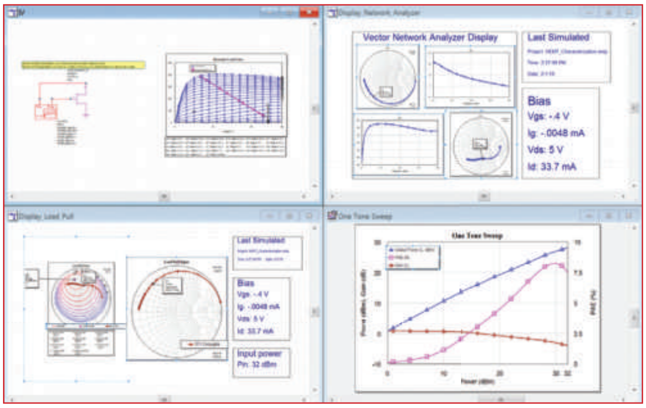


Fig. 8 Simulation results for a single (8 x 75 µm) 0.25 µm GaN HEMT device, characterized for DC, small- and large-signal RF performance.

software are available directly from UMS and include a layout process file (LPF), which defines the material stackup and metallization layers for EM simulation. Designers can adjust the parameters of the active and passive device models, such as gate width/number of fingers or capacitor/inductor values. In addition to a parameterized PCell, models come with a symbol representation for schematic editing. ***Figure 7*** shows components from the GH25 PDK placed in a Microwave Office schematic. A similar PDK will be developed for the GH15 and GH10 process nodes as the finalized models are qualified at UMS.

Microwave Office software offers a pre-configured example project for FET characterization that designers can use to investigate basic functioning of the transistor model before beginning their design. The default device can be replaced with a nonlinear hot FET model and simulations to observe the device DC and RF performance can immediately be performed. After adding the UMS PDK to the process library, the project layout browser will be populated with the UMS LPF file. The PDK models will appear in the elements browser for user placement in the schematic design window. The FET characterization project is configured to simulate standard device measurements, including DC I/V curves, S-parameters, single- and two-tone swept power such as gain, output power and PAE and power-dependent output load-pull contours (see ***Figure 8***).

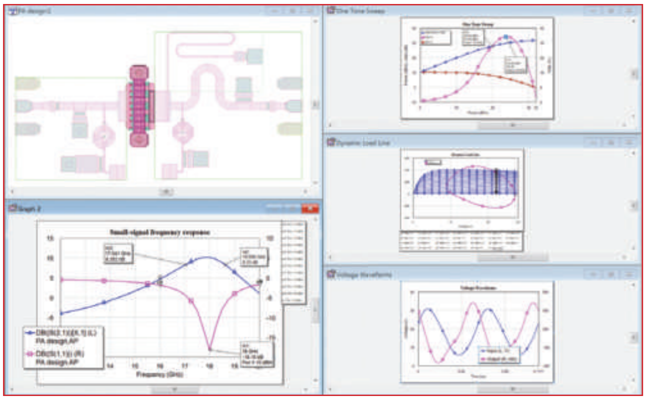


Fig. 9 Simulation results for an 18 GHz PA based on a single (8 x 75 μm) 0.25 μm GaN HEMT device.

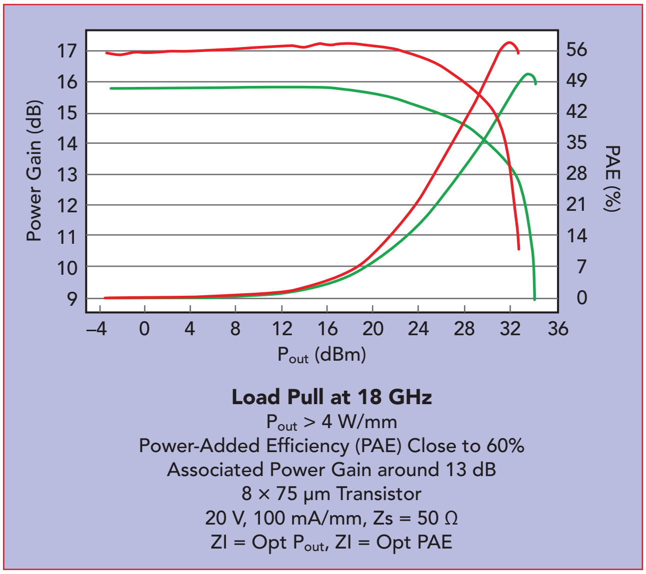


Fig. 10 Typical performance of an 8 x 75 μm 0.15 μm transistor at 18 GHz with the output impedance set for optimum P_{out} and PAE using load-pull measurements.

With the 0.25 μm PDK installed, the designer is able to apply a combination of linear/nonlinear and load-pull analyses. The recently introduced network synthesis feature in Microwave Office software supports the development of the bias and matching networks from frequency response (S-parameters) or load-pull analysis to achieve optimum power, linearity and/or efficiency performance. This capability was used to determine the appropriate source/load impedance for an 8 × 75 μm (0.25 μm) GaN device operating at 18 GHz, shown in ***Figure 9***. An approximate short circuit was presented to the output of the device at the second harmonic (36 GHz) via a shunt capacitor to improve the peak PAE (~36 percent).

Isola Pioneers New Quick-turn PCB Facility To Support the Innovative US PCB Market

Sean Mirshafiei
Chief Sales & Marketing Officer
Isola Group

isola

The PCB industry has been increasing in pace in the past several years as technologies take root and new technologies begin to emerge. Emerging applications, such as electric/autonomous vehicles, smart home/building, building automation, 4G LTE/5G, fiber optics, high-speed digital, enhanced computing power, high power density semiconductors, and mm-Wave communications and tactical technologies have been a result of unleashed US innovation that relies on fast time-to-market and reduced prototyping cycles to succeed. A major need for these, and other emerging technologies, is the accessibility of a high quality and high performance quick-turn PCB services near enough to the action to minimize transportation delays.

Recognizing the trend of the US PCB industry shifting demand from large-scale manufacturing to quick-turn prototyping of high quality copper-clad laminates and dielectric prepreg materials, Isola is planning a new and state-of-the-art facility for 2020 that will meet this need head-on. The new quick-turn PCB fabrication facility in the Chandler AZ area will be specifically geared to offering Isola's customers with greatly reduced lead times, even with Isola's most advanced materials.

Moreover, the new facility in Chandler AZ, along with Isola's South Carolina facility, will help Isola offer its customers coast-to-coast access to Isola's latest technologies, without delays.

A modular cell-based manufacturing process will be one of the keys of Isola's new facility, and this capability will enable quick delivery of small batches of product, ideal for early stage production and product prototyping. Though this new manufacturing process will be focused on speed, quality will not be sacrificed. The new facility quality features include a new generation of Lamination Press Control systems that use bar code programming. This method offers unmatched performance in environments under high-to-low and varying vacuum, pressure, and temperature conditions.

The upcoming quick-turn facility will also leverage new clean room construction practices employing HEPA filtration in all material processing areas. Furthermore, the facility will be equipped with a 3-point laser thickness measurement system that will automatically measure and capture data for every master sheet processed. Additionally, an augmented data management system will further enable monitoring and data analysis of all critical process control equipment, which aids to ensure quality control is maintained.

What's more, is that the future Chandler AZ facility will be using the latest and most precise quick-turn technologies, such as the latest drill capability for delivering the highest prepreg hole and slot accuracy. These technologies also include automated lay up systems that provide better yields of copper, Caul plate, and b-stage prepreg alignment for over-size panels and an elimination of copper errors using laser copper weight measurements. On top of that, Isola technicians will be using programmed automatic slitter blade size changes and achieving repeatable dimensions and prepreg accuracy of +/- 1 mm for all panel widths and lengths.

Isola's new facility will have two independent laminate finishing lines that will employ completely automated material handling from roll storage to laminate panel cutting. The results of this new tooling will empower Isola to deliver a throughput increase of 20% in lamination and CPP capacity over the previous Chandler AZ facility. Ultimately, OEMs offering products in a wide array of markets can look forward to Isola's evolving capabilities and the potential to bring new products to market with greater speed and higher quality than ever before.

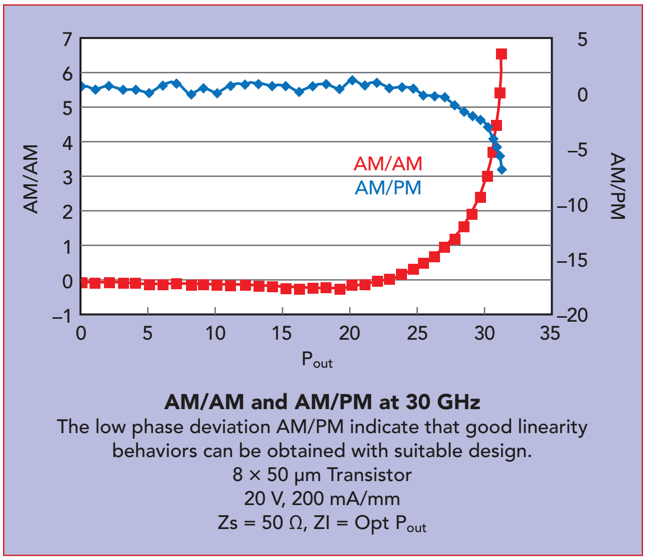


Fig. 11 AM/AM and AM/PM performance of a 8 x 50 µm 0.15 µm transistor at 30 GHz exhibits low phase deviation indicating good linearity.

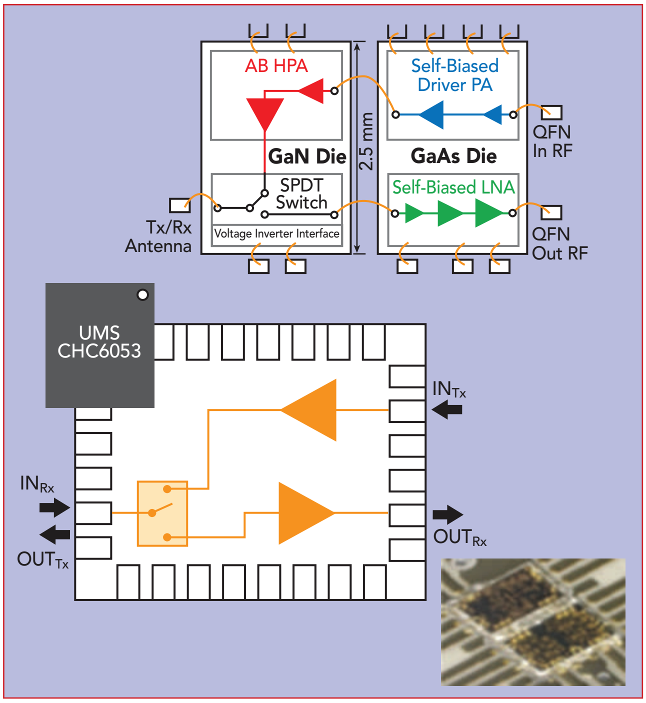


Fig. 12 Example of a 5G 2 W high-power front-end operating from 24 to 31 GHz.

GaN TECHNOLOGY FOR 5G APPLICATIONS

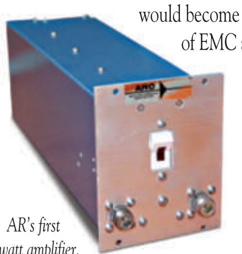
The GH15 technology[5] is fabricated on a 4 in. AlGaN/GaN on 70 µm thick SiC substrate wafer. The source-terminated field-plate transistors offer more than 3 W per mm power density at 30 GHz for high-PA (HPA) designs. The process also supports dedicated transistor topologies for cold FET applications such as the switches needed in a front-end module. The typical performance for an 8 × 75 µm GH15 device at 18 GHz is shown in ***Figure 10***. Using load pull to provide the optimum impedance termination for output power and PAE, the transistor exhibits 4 W/mm output power, 13 dB associated power gain (with the Z_{source} = 50 Ω) and a maximum PAE of nearly 60 percent.

Good transistor linearity is important, especially for telecom applications. A measure of the device's potential linearity can be obtained through the CW measurements of the transistor's AM/AM and AM/PM performance as a function of output power. Sweeping the input power driving a 0.15 micron transistor at 30 GHz, which is terminated with a load for maximum power, the device demonstrates low-phase deviation indicating good linearity (see ***Figure 11***).

A 2 W front-end module operating at 24 to 31 GHz covering the 28 GHz 5G band was developed to demonstrate the performance capabilities of the 0.15 micron AlGaN/GaN on SiC technology for mmWave frequencies.[6] Two technologies were combined into a plastic package. The module shown in ***Figure 12*** includes the PA and switch realized with 0.15 micron GaN technol-

AR RF/Microwave Instrumentation Celebrates 50th Anniversary

50 years ago Don "Shep" Shepherd began designing power amplifiers in the basement of his home, and selling them from the trunk of his car. He and his partner didn't realize it at the time, but they were laying the groundwork for a company that would become a global leader. AR would forever change the world of EMC and RF testing, and positively affect the development of innumerable products in multiple industries.



AR's first 1 watt amplifier.

"My basement was a great place to start," Shep says, "because the only place to go from there was up."

No one envisioned the heights that AR would reach. Within three years, AR was selling amplifiers across the United States and into Europe.

The small company moved to a rented storefront in 1970, then to new headquarters just three years later. As AR grew, it began creating high power RF and microwave amplifiers with capabilities that no one had ever seen before. New innovations changed the industry, and made developing and testing new products much faster, more accurate, and more practical.

First AR storefront property.

Some innovations that catapulted AR to international success include:

- 1976 - Introduction of first 10,000 watt tube amplifier spanning the 10 kHz to 100 MHz frequency range
- 1988 – First 100 watt solid-state, 100 to 1000 MHz linear instantaneous bandwidth amplifier
- 1992 - 500 watt solid-state amplifier that covers 80 to 1,000 MHz
- 2003 - 10,000 watt Class A, 100 kHz to 250 MHz solid-state amplifier
- 2007 - 10-to-20 GHz 5-watt instantaneous bandwidth amplifier

Introduction of first 10,000 watt tube amplifier.

- 2012 - First production 16,000 watt linear solid-state amplifier to 225 MHz
- 2014 - 3,000 watt 1 – 2.5 GHz "S" Series solid-state Class A amplifier
- 2015 – First 50,000 watt Solid-state linear amplifier produced
- 2015 – First production high power linear amplifier capable of covering an instantaneous bandwidth of 0.7 – 6 GHz using microelectronics technology
- 2016 - First production 10,000 watt solid-state amplifier to 1,000 MHz

First 100 watt solid-state, 100-1000 MHz instantaneous bandwidth amplifier built.

Along the way, AR expanded it capabilities to include amplifier modules with the acquisition of Kalmus, now AR Modular RF. It then added Carnel Labs which designed EMI receivers and was eventually called AR Receiver Systems. In 2008 AR Europe was launched to better serve clients throughout the U.K., France, Benelux, and Germany. AR later acquired Sunol Sciences Corporation, now providing positioning equipment and antennas for EMC and Wireless Testing as SunAR RF Motion.

AR Europe is launched with AR United Kingdom, AR France, AR Benelux and now AR GmbH.

In 2017 and again in 2018 AR was awarded the EMC Product of the Year. Even as it enters its 50th year, AR continues to blaze new trails and set higher standards.

Mr. Shepherd sums it up like this: "With the combined resources of all the AR companies, we simply have more options, more solutions and more innovations. Our customers get the benefit of it all when they connect with any AR company."

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AR acquisition of Kalmus, now AR Modular RF.

sunar rf motion

AR acquires Sunol Sciences Corporation, now SunAR RF Motion.

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ogy and the 0.15 micron GaAs receiver. This device is for telecommunications applications such as high-throughput fixed-access wireless, time-division duplex (TDD) and phased-array antennas.

CW measured power results of the transmit path demonstrate a maximum output power higher than 2 W (33.5 dBm) with 24 percent PAE and 36 dB of insertion gain in the transmit path over the

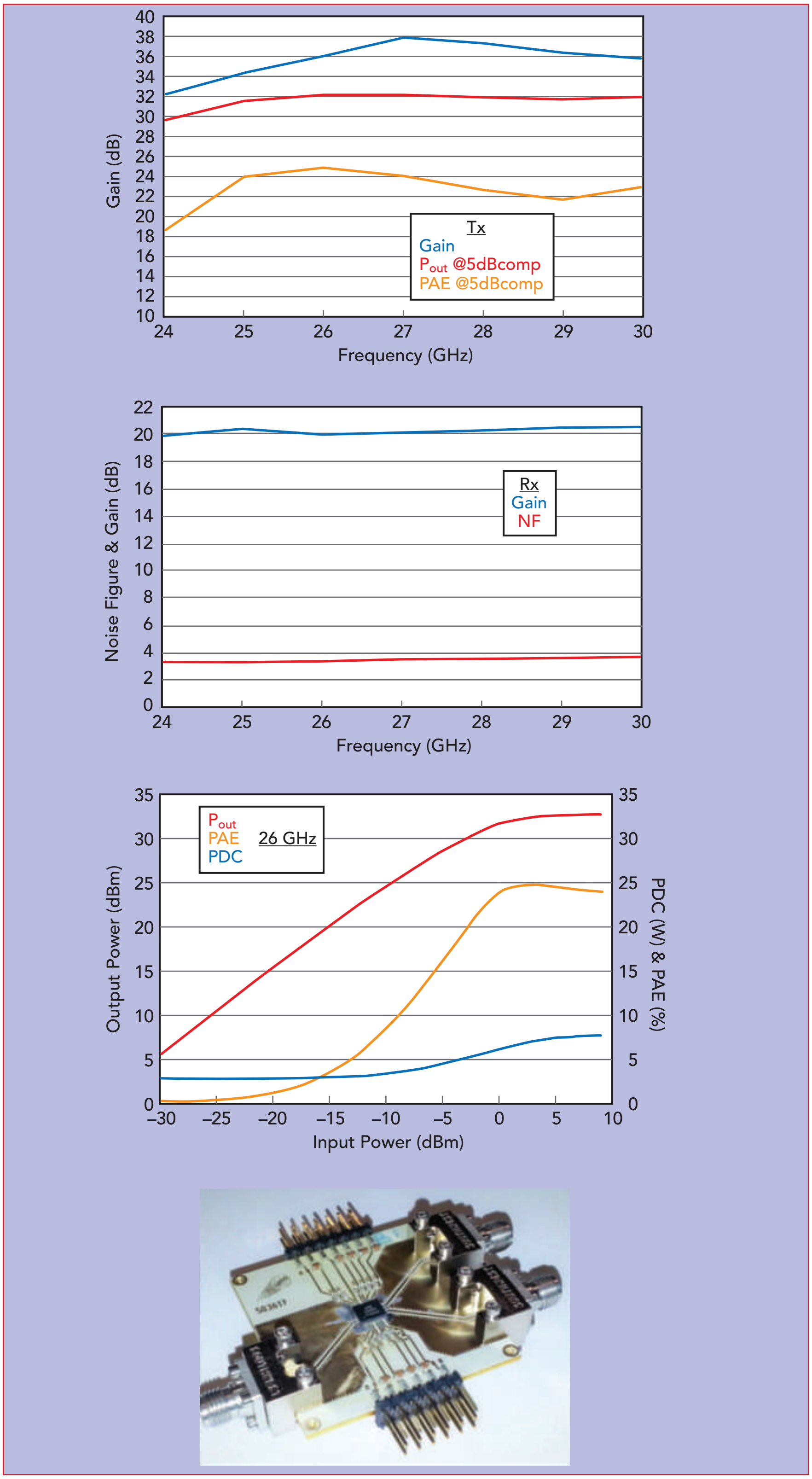

Fig. 13 Simulation results for the 5G 2 W HPFE.

5G Technology – 600 MHz & 3500 MHz PIM Test Analyzers

For future 5G technology Rosenberger introduces low-PIM components as well as PIM test solutions for all applications – new rack and portable desktop analyzers, and band filter units for 600 MHz & 3500 MHz measurements.

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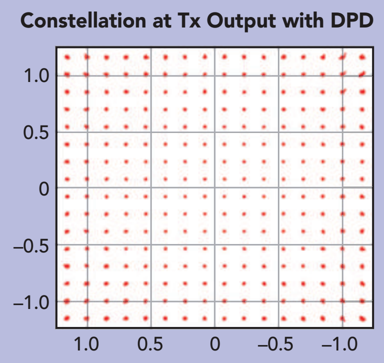
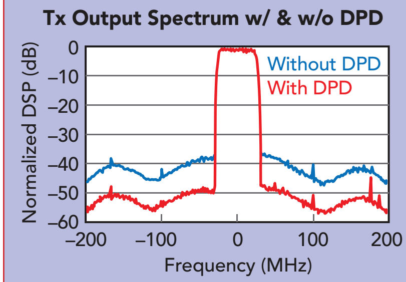


Parameter	Without DPD	With DPD
ACLR1 (dB)	–38	–48
MSE (dB)	–34	–45



256-QAM Signal Modulated	
Channel Spacing	56 MHz
RF Frequency	28 GHz
$P_{OUT, AVERAGE}$	23 dBm
PAPR	9 dB

Fig. 14 Large-signal modulated Tx results showing adjacent channel regrowth with and without DPD.

24 to 31 GHz spectrum. The receiver path provides a noise figure (NF) of 3.6 dB with an associated gain of 20 dB with maximum output power of 30 mW (15.5 dBm). The high-power front-end (HPFE)/Tx linearity has been investigated with several M-quadrature amplitude modulation (M-QAM) signals with 25/50 and 100 MHz channel spacing and using digital predistortion (DPD) leading to 48 dBc adjacent-channel leakage-ratio (ACLR) and 40 dB mean-squared error (MSE) for average output powers ranging from 17 dBm to 25 dBm. The linearity performances have been compared to the ones obtained with two other linear GaAs amplifiers dedicated to point-to-point telecommunications applications: the HPFE presents similar linearity performances associated with a higher efficiency.

An optimized tradeoff in terms of integration, electrical performance and cost was achieved using the mixed-technologies approach, shown in ***Figure 13***. The frequency response of the transmit path shows a gain between 34 to 36 dB over the band, with an output power close to 32 dBm (at 5 dB compression). The PAE varies in the band between 22 to 24 percent (at 5 dB compression). The receive path shows 20 dB gain with a typical NF from 3 to a maximum of 4 dB.

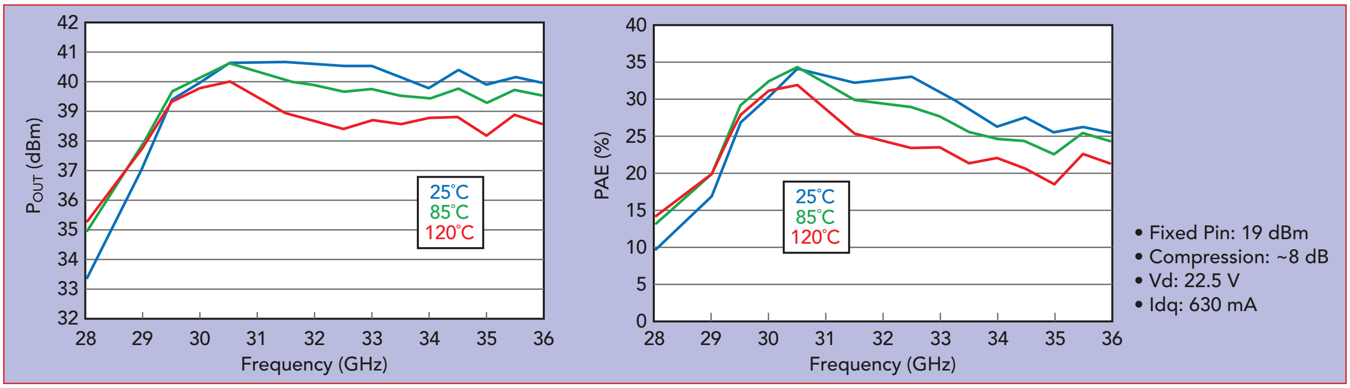
Figure 14 is the large-signal modulated results including ACLR for the transmitter with and without the polynomial DPD. The 256-QAM modulated signal specifications are shown in the lower bottom table, with channel spacing of 56 MHz, RF frequency of 28 GHz, average output power of 23 dBm and peak-to-average power ratio (PAPR) of 9 dB. The top constellation diagram of the Tx output with DPD shows the relevance of a full characterization.

Another example of a GaN Ka-band PA also demonstrates the performance of this process at 29.5 to 36 GHz, in the vicinity of the 5G upper mmWave spectrum (37 to 43.5 GHz) (see ***Figure 15***). The measured performance (CW and 25°C) shows a peak output power greater than 10 W, PAE greater than 25 percent and power gain at P_{sat} greater than 21 dB. The next step at the product level will be to extend the frequency band of this amplifier family to cover the 37 to 40 GHz band for 5G.

CONCLUSION

This article has described emerging GaN on SiC semiconductor technology targeting mmWave frequencies for applications such as 5G. The performance of MMICs designed with this GaN process was demonstrated with two examples: a 10 W Ka-Band (29.5 to 36 GHz) PA and a 2 W integrated front end for 24 to 30 GHz combining a GaN PA with other GaAs functions in a plastic package for 5G applications.

The success of the circuit design was guaranteed by the use of accurate, nonlinear FET models, in-



▲ **Fig. 15** **Output power and PAE over temperature from 25°C to 120°C.**

clusive of trapping and thermal effects and based on measurements. Load-pull measurements were compared with simulated results to validate model accuracy. The resulting models were organized into a PDK, along with the corresponding layout PCells for use in designing MMICs in a simulator such as Microwave Office software. Along with the UMS PDKs currently available for Microwave Office software, the foundry will fully release the 0.15 micron process in 2019 and is also developing a 0.1 micron GaN process.■

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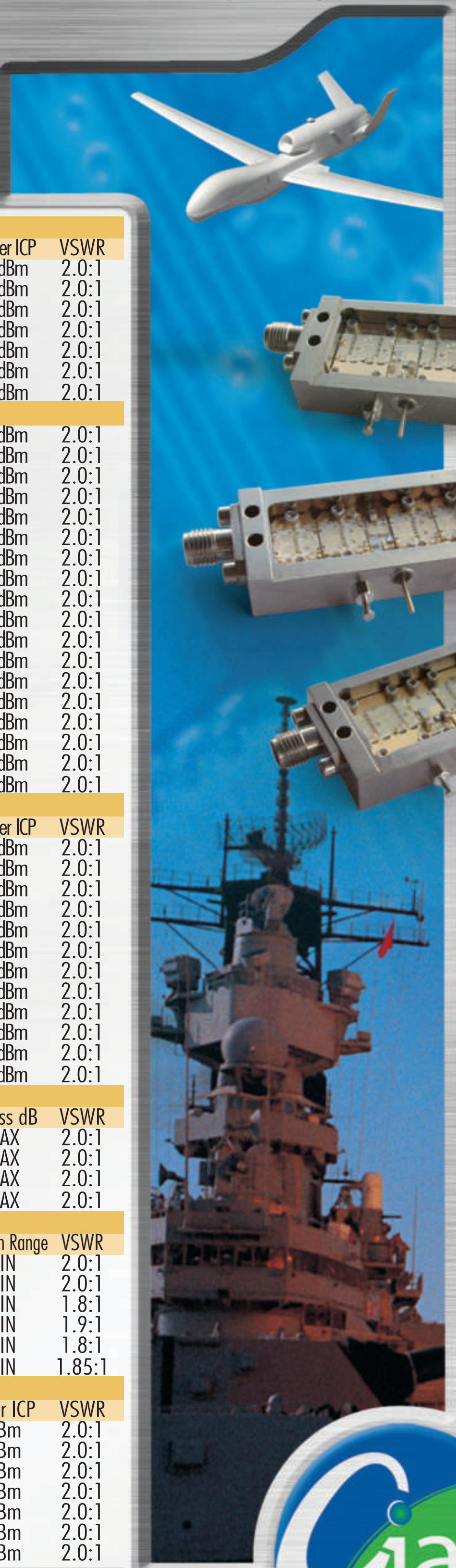

OCTAVE BAND LOW NOISE AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2110	0.5-1.0	28	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
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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DefenseNews

Cliff Drubin, Associate Technical Editor

Revolutionary Electronic Protection System

HENSOLDT has introduced a new radar warning system "Kalaetron RWR" (Radar Warning Receiver) to the market, which revolutionizes the protection of aircraft and helicopters from radar-guided weapons.

"With the help of the latest artificial intelligence (AI) and digital signal processing methods, our Kalaetron RWR detects radar-based threats early and reliably," explained Celia Pelaz, head of the Spectrum Dominance/Airborne Solutions Division. "Our new product thus increases the assertiveness of aircraft and helicopters and their survivability, especially in view of the increasingly dense signal spectrum and the growing threat posed by highly integrated air defence systems."

Kalaetron Radar Warning Receiver (Source: HENSOLDT)

Due to its fully digital design, the new system detects and identifies threats quickly and with a very low false alarm rate, over an extremely wide frequency range. The Kalaetron RWR uses AI techniques to detect new threat patterns from a huge amount of collected raw data. This is especially important to identify the latest air defence radar systems that cover an extremely wide bandwidth or which hop between particular frequencies in fractions of a second. Kalaetron thus enables fighter or transport aircraft to be protected even against upcoming anti-aircraft weapons and integrated air defence systems, while also offering adaptability to cope with future threats.

Global SATCOM for USSOCOM

Leonardo DRS Inc. recently announced a contract award by the Defense Information Technology Contracting Organization, to provide the U.S. Special Operations Command (USSOCOM) worldwide SATCOM and support for its headquarters, components and major subordinate units operating around the world.

USSOCOM requires an integrated satellite and terrestrial telecom system to support the dissemination of command, control, communications computers and intelligence information between USSOCOM, its components and their major subordinate units as well as selected U.S. government agencies and activities directly associated with the special operations community. Network connectivity includes satellite transmission and terrestrial services, which connect communication hubs to deployed communication nodes located in the continental U.S. and outside the continental U.S. in support of deployed Special Operations Forces.

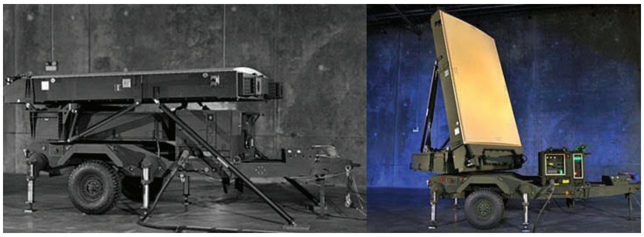
Global SATCOM (Source: Leonardo DRS)

Under the Blanket Purchase Agreement contract, the work can extend up to eight years and services can be requested by the customer that will not exceed $977 million. Leonardo DRS will provide USSOCOM's Global Access Network (GAN) system, an end-to-end custom-engineered, global commercial SATCOM (COMSATCOM) solution, engineered to meet USSOCOM's unique COMSATCOM needs.

G/ATOR Passes Initial Operational Test and Evaluation

Northrop Grumman Corp. (NGC), in partnership with the U.S. Marine Corps, recently passed a successful Initial Operational Test and Evaluation (IOT&E) for the AN/TPS-80 Ground/Air Task-Oriented Radar (G/ATOR) Blocks 1 and 2. NGC's AN/TPS-80 G/ATOR is an advanced, multi-mission active electronically scanned array (AESA) radar that provides comprehensive real-time, 360-degree situational awareness.

IOT&E is a rigorous phase of testing that a new system undergoes to determine that it is operationally effective and suitable for fleet introduction. The milestone demonstrates viability and suitability of the system, and completion indicates the Marine Corps is ready to operate and field G/ATOR Blocks 1 and 2 in their current configuration. The commitment of both the Marine Corps and G/ATOR team to deliver an operationally effective, 360-degree AESA radar system will ensure warfighters can detect—and take action against—complex, modern threats.



G/ATOR (Source: ASD News)

For More Information

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To date, eight production systems have been delivered to the Marine Corps. In early 2017, NGC delivered six low rate initial production systems. The first GaN systems were delivered ahead of schedule in July 2018 and were used for development test 1E1, 1E2 and IOT&E.

Space Surveillance Radar to Protect Military Satellites

The economy, security and defense of countries depends more and more on services provided from space, which makes satellites strategic assets and clear objectives in the event of conflict. Communications, air and maritime transport, logistics and meteorological information depend on space assets functioning correctly.

The Indra space surveillance radar developed for the Spanish surveillance and space monitoring system (S3T) provides the ability to protect satellites and space assets from unintentional threats, such as spatial debris, and deliberate threats, such as enemy missiles or satellites.

Installed at Morón Air Base in Seville, it is one of the most powerful radars in Europe and the world, with the capacity to detect objects at altitudes of 2,000 km. Its

Indra Radar (Source: ASD News)

dual nature, civil and military, enables the protection of military satellites in low orbits, providing an alert in the event that a hostile satellite approaches to damage, interfere with or spy on space assets. It also monitors the trajectory of intelligence satellites in other countries and it will be able to track ballistic missiles.

The radar has already demonstrated its high accuracy in the detection and calculation of the trajectories of objects that orbit out of control in low orbits. The information collected reduces the risk that the International Space Station and satellites in operation might suffer an impact and increases the safety of new launches.

This radar technology is one component of S3T, which is integrated together with other sensors and the data processing center. Indra leads the development of the complete S3T system under technical supervision of the Center for the Development of Industrial Technology (CDTI), under the Ministry of Science, Innovation and Universities, through a contract managed by the European Space Agency (ESA).

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FCC Announces Winners of 24 and 28 GHz Auctions

The FCC announced the winners of the 28 and 24 GHz Spectrum Frontiers auctions, known as auctions 101 and 102, on June 3. Not surprisingly, Verizon took most of the 28 GHz licenses. At 24 GHz, AT&T and T-Mobile fought for the best position.

28 GHz Licenses

At 28 GHz, Verizon won 1,066 licenses in 863 markets, paying $506 million, which is 72 percent of the total raised. The second highest bidder, U.S. Cellular, won 408 licenses in 362 markets, spending $129 million or 18 percent of the total. T-Mobile netted 865 licenses in 864 markets for $39.3 million and—a distant fourth—Windstream Services won 106 licenses in 106 markets, paying $6.2 million.

The total net bids were some $700 million, from 33 bidders chasing 2,965 licenses.

Company	Licenses	Markets	Net ($M)	% Total $
Verizon	1,066	863	505.7	72%
U.S. Cellular	408	362	129.4	18%
T-Mobile	865	864	39.3	5.6%
Windstream	106	106	6.2	0.9%
All Other	520		20	2.8%
Total	**2,965**		**$700.3**	

24 GHz Licenses

At 24 GHz, AT&T and T-Mobile bid 89 percent of the total funds raised for 75 percent of the licenses. T-Mobile won more licenses than AT&T—1,346 vs. 831—yet spent less—$803 million vs. $982 million. The rationale for that outcome is to be found in the partial economic areas (PEA) where each company's licenses are located.

U.S. Cellular and Starry, a wireless internet service provider, took 282 and 104 of the 24 GHz licenses, respectively. The 24 and 28 GHz auctions added 690 licenses to U.S. Cellular, a regional carrier and the fifth largest cellular operator in the U.S.

Company	Licenses	PEAs	Net ($M)	% Total $
AT&T	831	383	982.5	49%
T-Mobile	1,346	400	803.2	40%
U.S. Cellular	282	102	126.6	6.3%
Starry	104	51	48.5	2.4%
All Other	341		62	3.1%
Total	**2,904**		**$2,022.7**	

IoT Solutions in Agriculture to Connect Crops and Livestock

A new report from ABI Research unveils the opportunity for the IoT within the agricultural market, specifically connected agriculture in field crops, tree crops and livestock. For field and tree crops, the primary driver for the introduction of connectivity and the IoT is not only to irrigate sufficiently, but also to limit excess water application for usage efficiency and to align with government regulation. For livestock, it is about collecting data relating to the health of the animals, including birthing activities, as well as knowledge of their whereabouts. Across all agriculture sectors, the benefits are improved yields, a higher quality product and greater insight for farmers to more efficiently manage their operations.

"Hi-tech systems involving drones are sometimes referenced when discussing the future of farming, but a drone's primary function is to provide high-level aerial imagery, including strategic analysis of large areas to provide analytics on indices like chlorophyll content. While this is useful, it is time-consuming and can lack granular information. Ground-based sensor-based systems are more insightful and cost-effective for focusing solely on monitoring soil under the crops and animal behavior. This is exactly the information farmers need to map out their plan of action to secure the optimum yield," explains Harriet Sumnall, research analyst, ABI Research.

The technologies that will power IoT in connected agriculture will rely heavily on gateways and low-power wide-area products. LoRa is increasing finding preference in supplier solutions, particularly for sensor-to-node connections. The cost of connected agriculture system depends upon the number of sensors, with vendor pricing strategies ranging from a single upfront fee and an inclusive subscription to a data management platform, to a zero upfront cost but a data subscription-only model.

"The reasons for adopting IoT in agriculture are universal—cost reduction, improved productivity and better profit margins—but the specific prompts in terms of readiness to adopt can be more pragmatic and localized. For example, in North America, the political climate is proving challenging for the immigrant workforce required by the agricultural sector, and more automation could make up for this lack of manual labor. In Europe, farmers are notably younger than elsewhere in the world and are more naturally receptive to adopting new technology. In general, however, there is a lack of education among farmers about the benefits of connected agriculture—a vital issue that vendors must continue to be active in remedying," Sumnall concluded.

For More Information

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Simultaneous Indoor/Outdoor Location Technologies

The growing need for seamless indoor/outdoor integration and supply chain visibility is expected to force more companies at the lower layers of the technology supply chain to create more flexible technology offerings.

Computing the position of a person or asset outdoors is usually done via GNSS technology; although in some cases, auxiliary technologies like cellular networks or to lesser extent LPWAN solutions may also be used at lower tracking accuracy. However, for indoors, GNSS signals do not penetrate well and suffer from interference issues. For this environment, infrastructures based on short-range wireless anchor points are the best option for tracking end-devices in the vicinity. These anchor points can use a variety of location technologies including BLE, UWB, RFID or Wi-Fi.

"Offering seamless tracking between indoor/outdoor environments raises the possibility of having unprecedented visibility into the supply chain, as any item can be tracked end-to-end between factories, warehouses and retailers up to the point-of-sale," remarked Henrique Rocha, research analyst, ABI Research.

Yet, 63 percent of location companies in ABI Research's research are involved with indoor solutions only. Indoor tracking is still more demanding than outdoor tracking in the industrial and logistics spaces as it often requires high accuracy and real-time tracking capabilities of individual assets, as well as on-site dedicated infrastructure. With a consolidating location ecosystem, however, it is expected that more companies will turn to offering full supply chain visibility solutions, which require seamless indoor/outdoor tracking. While several companies offer both indoor and outdoor location solutions separately, only few have managed to offer a single end-to-end solution providing seamless indoor/outdoor tracking capabilities. One of the most common combinations for seamless asset tracking involves BLE communication for indoor and GNSS for outdoor, with an LPWAN like LTE-M used to relay location data.

"Manufacturing and warehousing verticals are some of the most technologically demanding in the asset tracking space. In this ecosystem, companies stand out only through scalable business models. One way of achieving scale is by implementing seamless indoor/outdoor tracking. By this time next year, we anticipate an approximate 30 percent growth in the number of companies offering indoor/outdoor location services," Rocha concluded.

Around the **Circuit**

Barbara Walsh, Multimedia Staff Editor

MERGERS & ACQUISITIONS

Carlisle Interconnect Technologies (CIT) announced the acquisition of **MicroConnex Corp.**, a privately held manufacturer of highly engineered microminiature flex circuits for the medical and test & measurement markets. MicroConnex will operate under CIT's Medical Technologies Business Unit known as Carlisle Medical Technologies (CMT). This acquisition aligns with CMT's focus on expanding its platform of advanced technology capabilities to further enable highly-integrated devices that support critical and cost-effective performance requirements.

Infineon Technologies AG and **Cypress Semiconductor Corp.** announced that the companies have signed a definitive agreement under which Infineon will acquire Cypress for USD$23.85 per share in cash, corresponding to an enterprise value of €9 billion. With the addition of Cypress, Infineon will consequently strengthen its focus on structural growth drivers and serve a broader range of applications. This will accelerate the company's path of profitable growth of recent years. Cypress has a differentiated portfolio of microcontrollers as well as software and connectivity components that are highly complementary to Infineon's leading power semiconductors, sensors and security solutions. Combining these technology assets will enable comprehensive advanced solutions for high-growth applications such as electric drives, battery-powered devices and power supplies.

NXP Semiconductors N.V. announced that its wholly owned subsidiary has entered into a definitive agreement with **Marvell**, under which NXP will acquire Marvell's Wireless Connectivity portfolio in an all-cash, asset transaction valued at $1.76 billion. The acquisition encompasses Marvell's Wi-Fi Connectivity Business Unit, Bluetooth technology portfolio and related assets. The acquisition will enable NXP to deliver complete, scalable processing and connectivity solutions to its customers across its focus end markets. The acquisition includes approximately 550 people worldwide. NXP expects the acquisition to create new revenue opportunities in its target end markets.

TPC Wire & Cable Corp., a portfolio company of Audax Private Equity, announced that it has completed the acquisition of **EZ Form Cable Corp.**, an AS9100D certified provider of coaxial cable based in Hamden, Conn. EZ Form is a leading provider of RF/microwave interconnect products for specialized applications common in defense, space, wireless communications and medical instrumentation. This acquisition strengthens TPC's position as a diversified supplier of high performance wire and cable solutions to specialized, high cost-of-failure environments.

Raytheon and **United Technologies** are merging in an all-stock deal that the two companies say is a merger of equals. The new company's name will be **Raytheon Technologies Corp.** and is expected to have nearly $74 billion in annual sales. By annual revenue, the size of the merged defense and aerospace company will be second only to Boeing in the U.S., according to the latest Forbes 500 ranking. On that list, Boeing had more than $101 billion in revenue, while rival Lockheed Martin racked up $53.7 billion, according to Forbes. The deal brings together two companies that have been integral to U.S. technology during the past century.

COLLABORATIONS

Rohde & Schwarz (R&S) and **UNISOC Technology Co.** have joined efforts to successfully pass RF and radio resource management (RRM) conformance test cases for the new Cat-1bis category for LTE user equipment as defined by the Global Certification Forum (GCF). By opening up this new 3GPP Release 13 feature for certification, both companies are driving the implementation of future IoT scenarios forward. R&S and UNISOC recently conducted the new LTE UE category Cat-1bis conformance test cases. All validated test cases passed successfully on the DUT with the embedded UNISOC IVY series IoT chipset, thus fulfilling the GCF certification entry criteria.

Maury Microwave Corp. and **Vertigo Technologies** announced that they have signed an exclusive development and distribution agreement with regards to Vertigo's mmWave and sub-THz active load pull technology.

RIGOL Technologies and **GradientOne** announce the integration of RIGOL instruments into GradientOne's test automation cloud platform to simplify the day-to-day tasks of test engineers ranging from hobbyists to enterprise users. The continual increases in hardware design complexity demand innovative new approaches to design validation and testing. Trends towards agile development and every day analysis benefit companies by providing better product quality, reduced prototyping costs and faster time-to-market. GradientOne frees test engineers from the high cost of developing and maintaining test data analysis solutions by providing a cloud based platform for remote control, data acquisition, single system of record for test data storage, product quality history and advanced analytics.

NEW STARTS

HUBER+SUHNER has reinforced its commitment to developing products dedicated for solid-state RF energy applications as it became one of eight companies to found the International Microwave Power Institute's (IMPI) new Solid State RF Energy Section. With significant advantages over existing solutions, such as magnetrons, high-power RF applications are on the cusp of

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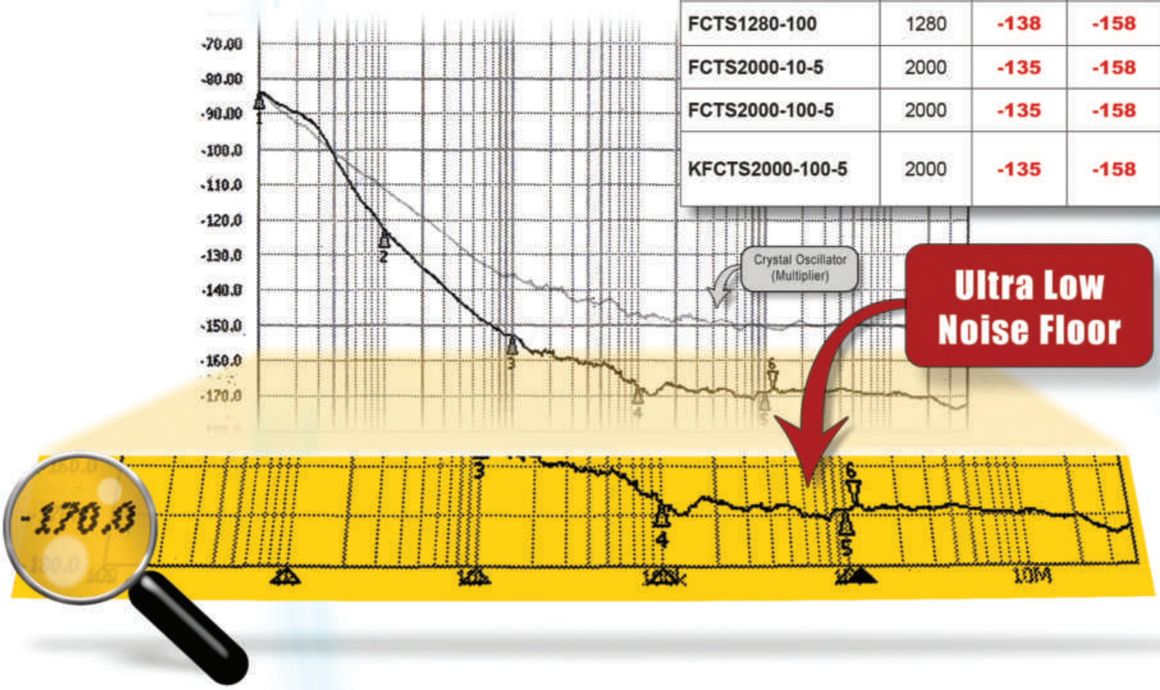
Model	Frequency (MHz)	Phase Noise (dBc/Hz) [Typ.] @10 kHz	Phase Noise (dBc/Hz) [Typ.] @100 kHz	Package
VFCTS128-10	128	-155	-160	
FCTS800-10-5	800	-144	-158	
KFCTS800-10-5	800	-144	-158	
FSA1000-100	1000	-145	-160	
KFSA1000-100	1000	-145	-160	
FXLNS-1000	1000	-149	-154	
KFXLNS-1000	1000	-149	-154	
FCTS1000-10-5	1000	-141	-158	
KFCTS1000-10-5	1000	-141	-158	
FCTS1000-100-5	1000	-141	-158	
FCTS1000-100-5H	1000	-144	-160	
FCTS1040-10-5	1040	-140	-158	
FCTS1280-100	1280	-138	-158	
FCTS2000-10-5	2000	-135	-158	
FCTS2000-100-5	2000	-135	-158	
KFCTS2000-100-5	2000	-135	-158	



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ACHIEVEMENTS

General Atomics Aeronautical Systems Inc. (GA-ASI), an affiliate of General Atomics, in recognition of outstanding quality and delivery performance has awarded **RFMW** with their Supplier of the Year Award at a ceremony held at RFMW's corporate office in San Jose, Calif.

Strand Marketing Inc. is celebrating their 25th year in business with events throughout the year. Located just north of Boston, the agency creates brand identities, custom websites and digital marketing campaigns for high tech and industrial companies worldwide. What began as a marketing consultancy and creative shop in the basement office of founder and owner David Strand's home in 1994, Strand opened its first headquarters in Burlington, Mass. just a few months later. In 2001, they moved into their current location in historic Newburyport, Mass.

Z-Communications Inc. announced that its manufacturing facility located in San Diego, Calif. has successfully achieved the Aerospace Management System AS9100D with ISO 9001:2015 Certification.

Pasternack, an **Infinite Electronics** brand, announced that it has received the Supplier Excellence Award from **Raytheon Integrated Defense Systems (IDS)** for superior supplier performance. Raytheon's IDS business instituted the annual Supplier Excellence Awards program to recognize suppliers who have provided outstanding service and partnership in exceeding customer requirements. Award candidates are judged on certain criteria, including overall quality and on-time delivery. Pasternack was one of 77 companies recognized by Raytheon's IDS business for 4-Star honors.

Keysight Technologies Inc. announced the company's 5G Conformance Toolset was first to submit 5G new radio (NR) non-standalone (NSA) RF test cases for PTCRB validation approval in frequency range 2 (FR2), as well as for 5G NR standalone (SA) protocol test cases in frequency range 1 (FR1), accelerating market introduction of 5G NR mobile devices. Leading mobile operators around the world are deploying 5G technology to deliver fixed wireless access to homes and businesses, as well as to support enhanced mobile broadband (eMBB) applications. Initial 5G deployments in the U.S. will leverage mmWave (FR2).

CONTRACTS

Science Applications International Corp. won a prime contractor spot on the $245 million Marine Air-Ground Task Force Training Systems Support multiple-award IDIQ contract. The company will compete for task orders to support pre-deployment training programs to **Marine Corps** operating forces within the context of Joint and combined environments to improve warfighting skills. The support will include exercise and mission rehearsal support; planning and structuring training; supporting live, virtual, constructive and gaming training scenarios; and executive and technical training support.

Harris Corp. has provided **Lockheed Martin (LM)** with its seventh of 10 advanced navigation payloads contracted for the U.S. Air Force's GPS III satellite program. The new GPS IIIF payload design will further enhance the satellite's capabilities and performance. In September 2018, the U.S. Air Force selected LM in for a fixed-price-type production contract for up to 22 GPS IIIF satellites. Harris is LM's navigation signal partner for GPS IIIF satellites, and, in January, received a $243 million award to provide the navigation signals for the first two GPS IIIF satellites, space vehicles 11 and 12.

Datron World Communications Inc. has been awarded two contracts totaling $9 million for the supply of spares for its tactical HF and VHF radios to customers in Africa and Central Asia. The contracts are a mix of Direct Commercial Sales as well as funds using Datron's IDIQ with the U.S. Army Communications Electronics Command (CECOM). Under these two contracts Datron will deliver spare parts and components that will sustain the end-users ability to continue local repair services, thereby expediting the return of radios to operational readiness. Deliveries of the two contracts are expected within fiscal year 2019.

OSI Systems Inc. announced that its security division was awarded a multi-year U.S. state contract, valued at up to approximately $5 million, to provide comprehensive service and maintenance support for Rapiscan® baggage and parcel checkpoint inspection systems installed at correctional facilities and detention centers. The company operates a global support team 24x7x365 at multiple Customer Experience (CX) Centers worldwide. The CX team delivers OEM technical support, a world-class training portfolio and strategically located factory field service engineers.

Integra Technologies announced it has been awarded a two-year contract by the **U.S. Air Force** to accelerate technology and manufacturing readiness of its patented, thermally-enhanced GaN on SiC technology. Integra's GaN on SiC technology is ideal for high efficiency, solid-state RF power applications including high-power radar systems requiring improved performance, increased range and reduced operating costs. The company has developed its thermally enhanced GaN on SiC to deliver superior power and efficiency while operating at lower temperatures, which is a key enabler of next-generation high performance radar platforms. The company is leveraging its domestic R&D

and manufacturing platform to optimize the GaN epitaxial wafer, device design and package design.

3D Glass Solutions Inc. (3DGS) announced that it has secured an investment from **Lockheed Martin (LM)** as part of its Series B funding. 3DGS provides unique, patented technology that spans the GHz spectrum and allows high performance RF communication essential to both commercial consumer and complex avionics, space and security systems operating at high frequency. Delivering the ability to integrate functionality that has previously been unattainable due to conventional technology limitations, 3DGS' glass-based solutions will enable systems designers to develop and produce state-of-the-art RF components.

Parker Aerospace, a business segment of Parker Hannifin Corp., has been awarded a contract by **The Boeing Co.** to supply flight control tail actuation for the MQ-25 unmanned aerial refueling program. The tail flight control actuator supplied by Parker Aerospace uses the company's proven electrohydraulic servo actuation (EHSA) technology that is flying today on many military, commercial and business aviation platforms. Parker's flight control actuator is supporting Boeing's MQ-25 test asset. The MQ-25 is the U.S. Navy's first operational, carrier-based, unmanned aircraft and is designed to provide a much-needed refueling capability.

PEOPLE

▲ *Alastair Upton*

Anokiwave Inc. announced the latest addition to its executive leadership team with the appointment of **Alastair Upton** to the position of chief strategy officer (CSO), a new position within Anokiwave, effective immediately. Upton will report directly to CEO Robert Donahue. As the Anokiwave CSO, Upton will be responsible for developing and executing Anokiwave's business strategy in all key markets, including responsibility for the strategic marketing organization, driving the company product roadmaps and managing partnership program

▲ *Tony Fattorini*

Altum RF announced its co-founder **Tony Fattorini** as vice president of engineering. Fattorini brings more than 20 years of new product development, technology innovation and design-for-manufacture experience to Altum RF. Fattorini's industry background includes microwave and mmWave circuit design, packaging techniques, thermal analysis and the management of high performing teams. Most recently with MACOM as engineering manager and senior principal engineer, Fattorini had the responsibilities of developing new MMIC products from concept to production release and managing a team of design engineers.

▲ *Fabrizio Montauti*

Akash Systems Inc. has appointed industry veteran **Fabrizio Montauti** as vice president of radios. Montauti brings 30 years of RF communications experience from his work delivering radio technologies to the global space SATCOM market. Montauti's appointment continues the expansion of the Akash Systems' core management team, which has been carefully assembled by co-founders Felix Ejeckam and Ty Mitchell since 2016. Montauti's team of industry-leading engineers expects to deliver its first radio product, a small X/S transceiver, over the next few months to both CubeSat and satellite customers in the Earth observation market, with a Ka/S transceiver shortly thereafter.

▲ *Eric Emley*

NAI has appointed **Eric Emley** to the position of VP of sales, marketing and supply management. The transition of this position from Bill Miller, the company's former VP of sales and marketing, has been planned for a long time, since Miller expressed his desire to retire early last year. Miller remains a strategic advisor to NAI's CEO and an important part of the company. Emley joined NAI in 2017 as VP of global supply management and has achieved outstanding results, including building a highly talented Global Supply Chain Team, which has been an effective participant in enhancing the customer experience at NAI.

REP APPOINTMENTS

Rogers Corp. Advanced Connectivity Solutions (ACS) business unit announced the introduction of a new distribution channel with the addition of **International Electronic Components (IEC)** to their sales and service team in the U.S. and Canada effective immediately. ACS provides global customers with market-leading high performance and high-reliability RF material solutions. IEC comes with over 53 years of sales and service experience in PCB processing and materials distribution. Rogers ACS continued expansion in the U.S., combined with IEC's extensive experience and distribution network, will provide the highest level of support to customers.

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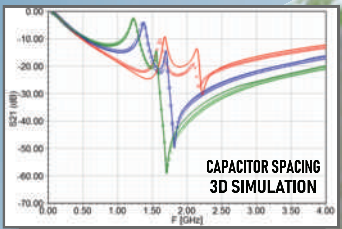
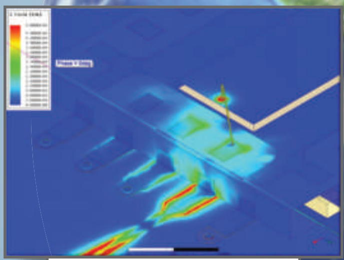
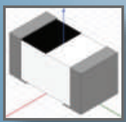
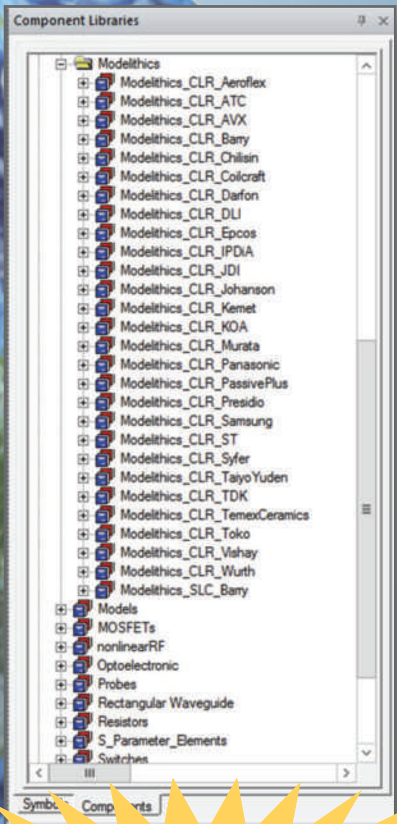


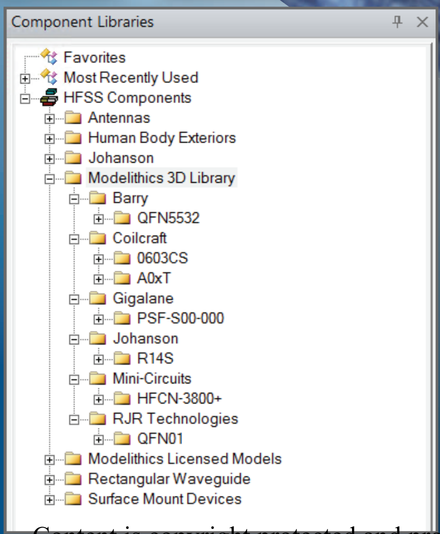
Simulation of 3 shunt capacitors using 3D models at three different spacings. 10 mils (closest), 42 mils (mid), 74 mils (farthest). Solid lines = simulation, Symbols = measurement



E-field visualization using 3D model of a QFN package mounted on 5 mil Alumina. Package pin is wire-bonded to MMIC inside package.







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Modeling of InP HBTs with an Improved Keysight HBT Model

Jincan Zhang, Min Liu, Jinchan Wang, Liwen Zhang and Bo Liu
Henan University of Science and Technology, Luoyang, China

An accurate and flexible large-signal model based on an analysis of the characteristics of InP heterojunction bipolar transistors (HBT) is implemented as a seven-port symbolically defined device (SDD) in Keysight ADS. The model is based on an improved Keysight HBT model formulation, avoiding an erroneous $R_{CI}C_{BC}$ transit time contribution from the intrinsic collector region. The model has been verified by comparing simulated and measured DC and small-signal S-parameters at multiple bias points for a 1 × 15 μm² emitter InP HBT.

InP HBTs in transferred substrate technology have demonstrated excellent high frequency operation, simultaneous with high output power densities.[1-2] Compared with a conventional triple-mesa HBT, the transferred substrate technology allows a reduction of the extrinsic parasitic capacitance between the base and collector semiconductor regions of the device. This leads to HBT devices demonstrating extremely high frequency operation, with the potential for active electronics in the sub-THz frequency range, i.e., 0.1 to 1 THz.

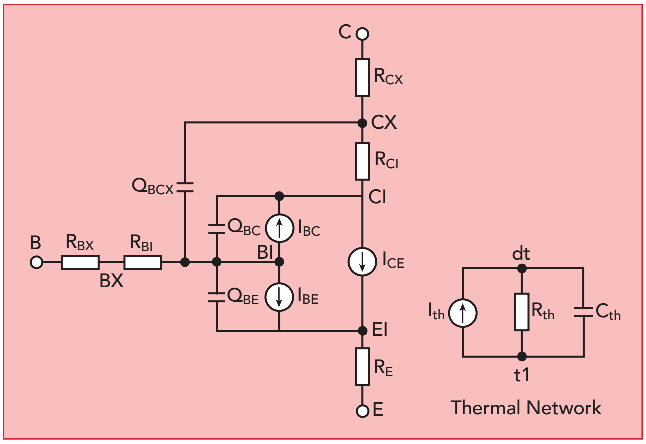

Fig. 1 Large-signal model without the parasitic elements.

There are several available HBT device models (e.g., FBH, University of California San Diego and Keysight) developed specifically for III-V devices.[3-4] The UCSD HBT model implements a physical-based charge-control relation, taking heterojunction effects into account. By using an intrinsic collector resistance (R_{CI}), the UCSD model provides reasonable accuracy for the modeling of the knee region; however, a serious shortcoming of the UCSD model, as well as the Keysight HBT model, is that the intrinsic collector resistance is bias independent. Most modern submicron InP HBTs are designed to reach full depletion of the collector at fairly low collector voltages. In this case, the intrinsic collector resistance should be reduced to zero in the model to avoid an erroneous $R_{CI}C_{BC}$ transit time contribution, where C_{BC} is the intrinsic base-collector capacitance. This can lead to a significant error in the modeling of the transit time of modern submicron InP double HBT (DHBT) devices with cut-off frequencies in the range of several hundreds of GHz.[5]

In this work, the unit finger HBT is modeled with an improved HBT model, which corrects the problem of an erroneous transit time contribution from the intrinsic collector region, keeping the ability to model the


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knee region. Due to improving technology, some new effects occurring in the device can be conveniently added into the SDD in a Keysight ADS simulator. The validity and the accuracy of the large-signal model are assessed by comparing the simulation with the measurement of DC characteristics, small-signal behavior and large-signal operation for a 1 × 15 μm^2 InP DHBT.

MODEL DESCRIPTION

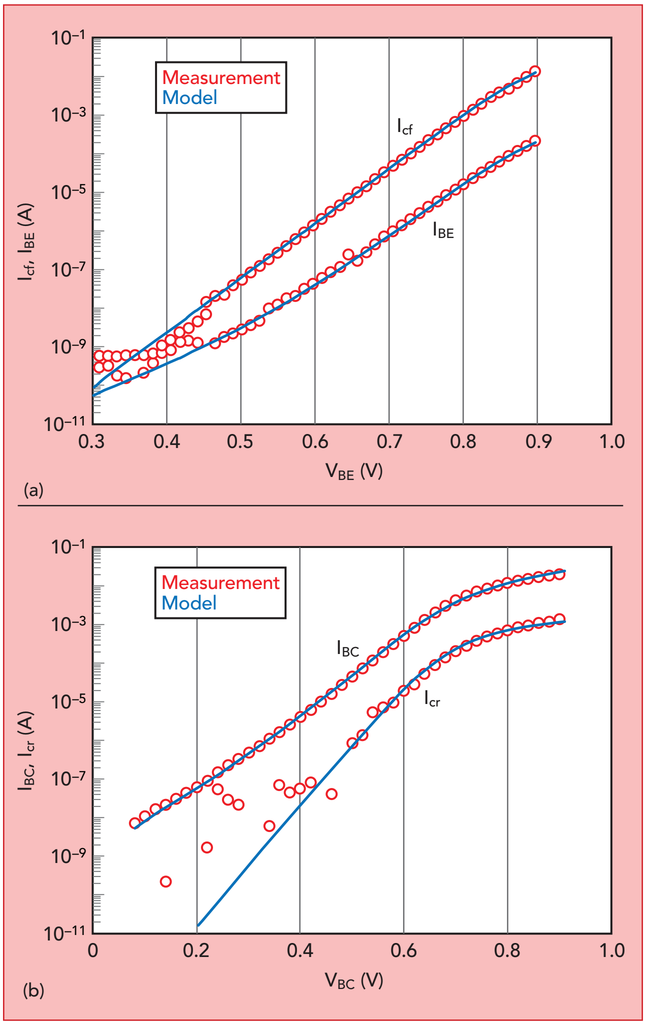
Figure 1 shows the HBT large-signal model, which is based on the Keysight large-signal HBT model. Extrinsic capacitances and inductances are not shown in the figure, as they were removed using electromagnetic de-embedding techniques. I_{CE} is the collector–emitter current, and I_{BE} is the direct base current, representing all recombination processes taking place in the base-emitter junction with forward bias. I_{BC} is the base current in reverse bias, representing hole current injected from the base to the collector, sometimes increased by recombination current in the depletion region. Self-heating is calculated using a simple one-pole RC network, which is commonly used in nonlinear models such as the Keysight, vertical bipolar inter-company (VBIC) and high current (HICUM) models.

The standard collector–emitter current ICE is composed of the forward and reverse currents I_{cf} and I_{cr}:

$$I_{CE} = I_{cf} - I_{cr} \tag{1}$$

$$I_{cf} = \frac{I_S \times \left(\exp\left(\frac{qV_{BEi}}{N_F \times k \times T} \right) - 1 \right)}{DD} \tag{2}$$

$$I_{cr} = \frac{I_{SR} \times \left(\exp\left(\frac{qV_{BCi}}{N_R \times k \times T} \right) - 1 \right)}{DD} \tag{3}$$



▲ **Fig. 2** **Measured vs. modeled forward (a) and reverse (b) Gummel plots.**

I_S is the forward collector saturation current, I_{SR} the reverse collector saturation current, V_{BEi} the inner junction voltage of the base-emitter, V_{BCi} the inner junction voltage of the base-collector and N_F the forward collector current ideality factor. k is Boltzmann's constant, q the magnitude of the electronic charge and T the ambient temperature in Kelvin. The formulation for the modification factor DD is based on the UCSD HBT model; its detailed formulas model the behaviors of the Early effect, the heterojunction effects on the collector current for the base-emitter and base-collector junctions and the high current β roll-off effect of a common-emitter I-V plot.

The base-emitter current and the base-collector current cover the ideal and nonideal (i.e., recombination) behaviors.

$$I_{BE} = I_{BEN}\left(\exp\left(\frac{V_{BEi}}{n_{EN} \cdot V_t} \right) - 1 \right) + I_{BEI}\left(\exp\left(\frac{V_{BEi}}{n_{EI} \cdot V_t} \right) - 1 \right) \tag{4}$$

This includes both an ideal component, which is modeled with a saturation current I_{BEI} and ideality factor n_{EI}, comprising the emitter contact and quasi-neutral region recombination and a nonideal component for the space charge region, which is modeled with a saturation current I_{BEN} and ideality factor n_{EN}. The base-collector component is similarly modeled as

$$I_{BC} = I_{BCN}\left(\exp\left(\frac{V_{BCi}}{n_{CN} \cdot V_t} \right) - 1 \right) + I_{BCI}\left(\exp\left(\frac{V_{BCi}}{n_{CI} \cdot V_t} \right) - 1 \right) \tag{5}$$

To accurately model the DC characteristics, one of the most important physical effects of InP HBTs is the soft knee. The physical reason for this phenomenon is the corresponding injected electron density increases for high level injection, compensating for the collector doping concentration. When the electric field at the base-collector junction is sufficiently reduced, electron transport ceases to be primarily drift current. The rising of the energy band at high current densities blocks electron transport by band energy discontinuity. The effect is equivalent to an increase in the collector resistance, and the voltage drop in the collector resistance causes a reduction of the electric field at the base-collector junction. This resistor is modeled by a bias-dependent collector resistor R_{CI} in this work.[5]

$$R_{CI} = \frac{R_{CI0}}{2}\left(1 + \tanh\left(\frac{V_{BCi} - V_{TR}}{V_{RCi}} \right) \right) \tag{6}$$

where V_{TR}, R_{CI0} and V_{RCi} are three fitting parameters. At the transition voltage, $V_{BCi} = V_{TR}$, the intrinsic collector resistance takes on half of the value R_{CI0} needed to fit the knee region of

the I_C-V_{CE} characteristics. The parameter V_{RCi} controls the steepness of the transition from R_{CI0} to zero.

The high frequency performance is defined by a charge model; therefore, the AC characteristics include depletion charge and diffusion charge. The depletion charge for both the base-emitter and base-collector junctions is based on the Keysight HBT model, where the depletion charge functions for both the base-emitter and base-collector junctions are based on the formulation from HICUM (version 2.1). This formulation and its derivatives are fully continuous for all regions of bias, appropriate for a large-signal computer-aided design model.

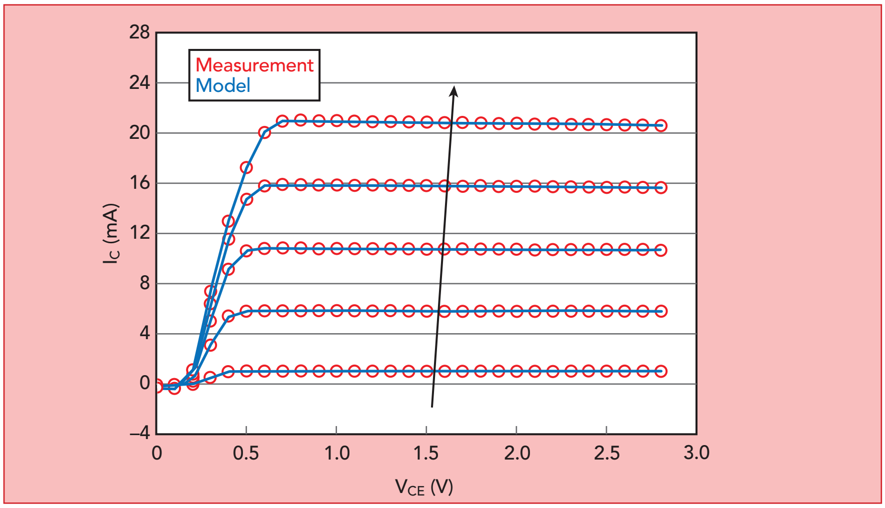


Fig. 3 Modeled vs. measured I_C–V_{CE}. I_B is from 20 to 340 µA in steps of 80 µA.

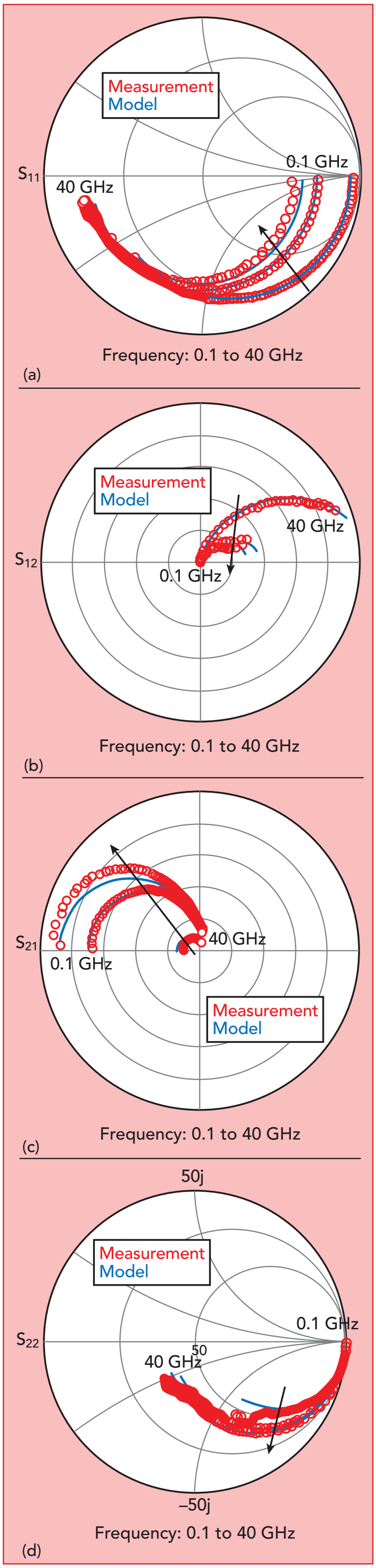


Fig. 4 Modeled vs. measured S_{11} (a), S_{12} (b), S_{21} (c) and S_{22} (d) with I_C = 1, 11 and 21 mA and V_{CE} = 1.7 V.

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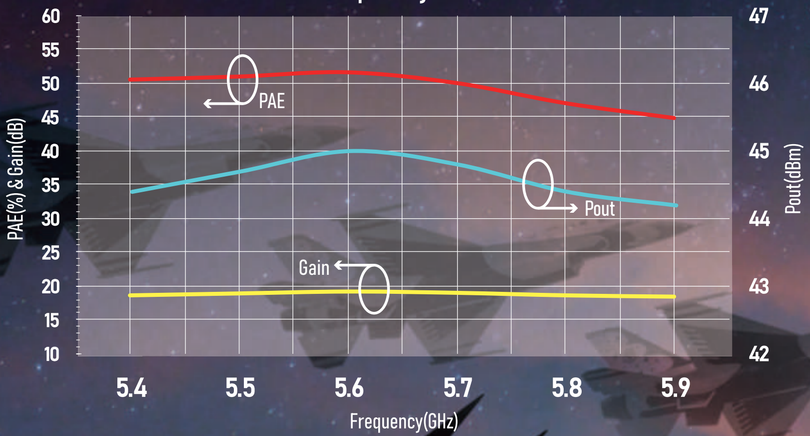

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MODEL VERIFICATION AND DISCUSSION

The present compact empirical large-signal model has been applied to various sized InP HBT transistors; with limited space, only the 1 × 15 μm^2 emitter area transistor is discussed in this article. The parameter extraction procedure starts by extracting the access resistors using the open collector method.[6-7] Second, the DC parameters are extracted from forward and reverse Gummel plots using a semiconductor parameter analyzer. Third, the small-signal model parameters are extracted from a large number of small-signal S-parameters at multiple bias points.

To verify the model, DC and small-signal characteristics were measured at multiple bias points. The measured data was obtained on-wafer with a Keysight B1500A semiconductor device analyzer for DC parameters and an HP8510C network analyzer for small-signal S-parameters, across the range from 0.1 to 40 GHz. The measurements were performed after the substrate was thinned to 100 µm and the backside gold-electroplated.

The forward and reverse Gummel plots are shown in ***Figure 2***, comparing measured and simulated, and ***Figure 3*** plots the I_C-V_{CE} curve comparison. In addition to the output DC I_C-V_{CE} and Gummel characteristics, the model was validated by comparing measured and simulated S-parameters over a range of collector currents, from 1 to 21 mA, and from 0.1 to 40 GHz. ***Figure 4*** shows the S-parameter fit for I_C from 1 to 21 mA and V_{CE} = 1.7 V. The model versus measured S_{21} shows some deviation at low current and low frequency. As the model is formulated on a certain region for a special application, in this work, the main interest is in the operating region where IC = 11 mA; the model shows a better fit in this region.

CONCLUSION

A nonlinear circuit simulation model for InP DHBTs based on a charge formulation and an accurate large-signal model has been implemented using a seven-port SDD in Keysight ADS. The model is flexibly modified due to the equation-based SDD component and accounts for self-heating and soft knee effects. Good agreement between measured data and simulation was achieved.■

ACKNOWLEDGMENT

This work was supported by the National Natural Science Foundation of China (Grants 61804046, 61704049), the Doctoral Scientific Research Foundation of Henan University of Science and Technology (Grant 400613480011) and the Foundation of Department of Science and Technology of Henan Province (Grants 172102210258, 182102210295).

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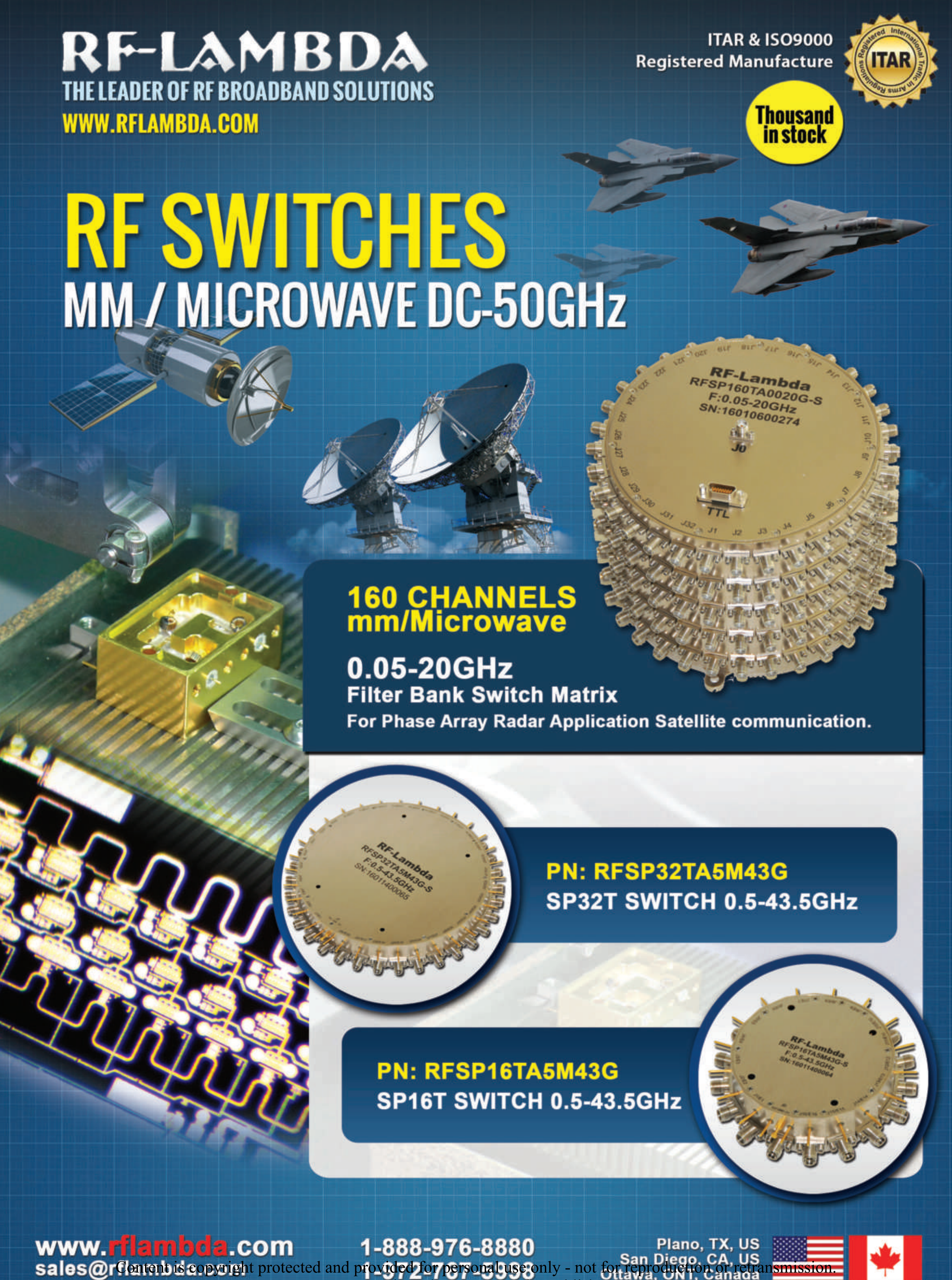
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Microwave Will Drive the Development of 5G

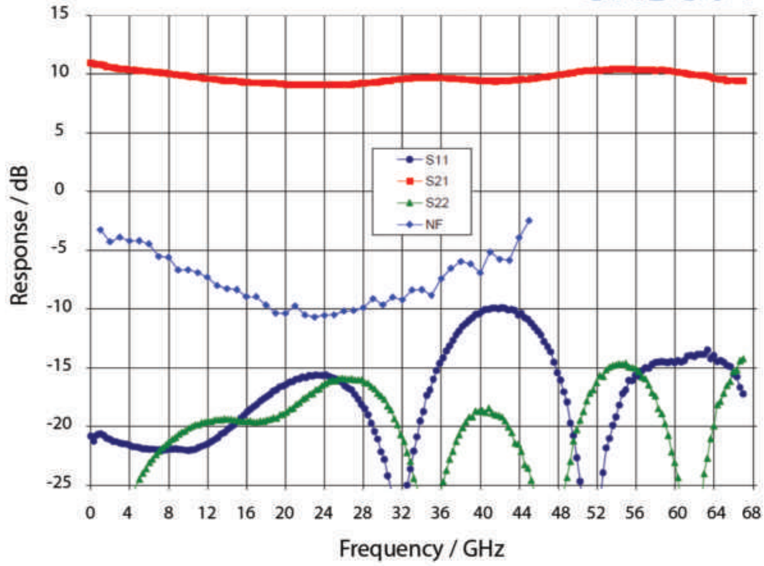
Tamas Madarasz
Nokia, Espoo, Finland

Mobile data traffic is growing rapidly, with current estimates suggesting a 40× increase between 2014 and 2020. Networks will also connect some 50 billion devices to the IoT by 2025—with a proliferation of smart objects from fridges to industrial controllers. Many communication service providers (CSP) are, therefore, rethinking their existing transport network architectures as they transition to 5G.

The shift to 5G is unlike the changes experienced with previous generations of mobile communication technology, because 5G is more than just an innovative radio technology using new spectrum. Beyond the extremely challenging capacity considerations already mentioned, 5G introduces a new approach to network architecture, enabling new business models for an industry looking toward the next trillion dollars of growth. This clearly will not come by just selling more smartphones or providing simple connectivity in developing markets; rather, it builds on new concepts such as densification, decomposition of network functions (e.g., the separation of user and control planes), programmable transport, network slicing and end-to-end automation and orchestration to enable new services and business models.[1] A complex interworking of different network domains, technologies, components and services is needed.

As 5G deploys, mobile transport networks must evolve to meet this complex range of new demands, forcing CSPs to respond with backhaul transformation projects to meet the needs of 5G radio access network (RAN) service provisioning. Casual observers might think the future of transport networks is all about fiber optics. It is true that the fiber presence in transport networks is increasing, as CSPs exploit the technology's advantages. Yet fiber is not always available and may be too expensive. When a fiber point of presence is a few hundred meters away from the radio access point, for instance, total cost of ownership (TCO) favors microwave connectivity. Microwave is already used in more than 50 percent of current cell sites, and any cost-effective evolution to 5G will continue to use existing 4G/LTE network assets, particularly since microwave technology is capable of supporting 5G's challenging capacity and latency requirements.

As noted, 5G will enable many new services, including enhanced mobile broadband, augmented reality (AR) and mission-critical communications, creating an unprecedented traffic mix requiring dramatically improved performance. For example, throughput must rise 10× (10 to 25 Gbps for the F1 link and cell site backhaul interfaces), and latency must come down to 1 ms end-to-end. To meet the increasing 5G capacity requirement, new microwave solutions that optimize spectrum use and dramatically increase capacity are already available, with more to follow. When it comes to addressing latency, physics favors microwave. Propagation medium latency depends on the density of the medium, so the latency of a wireless connection is fundamentally lower than that of a fiber cable of the same length. Equipment latencies must also be considered. Mission-critical applications require high resiliency. Wireless is generally more reliable than fiber during major events such as earthquakes, fire or simple road maintenance. In these cases, the recovery time is much faster with a microwave connection. For all these reasons, microwave transport will be a key enabler for 5G, playing an important role as CSPs ramp up their 5G rollouts.



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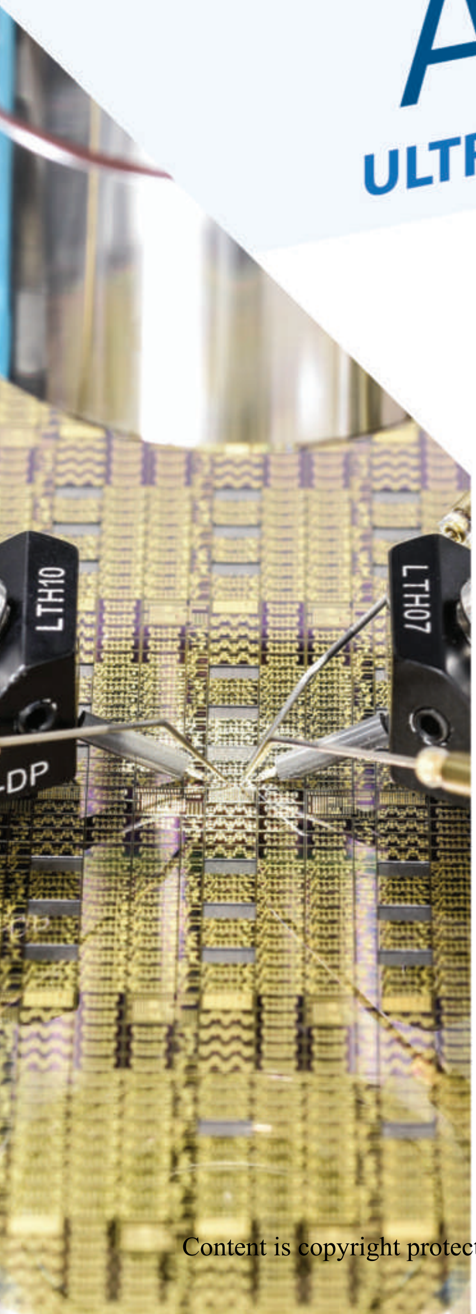

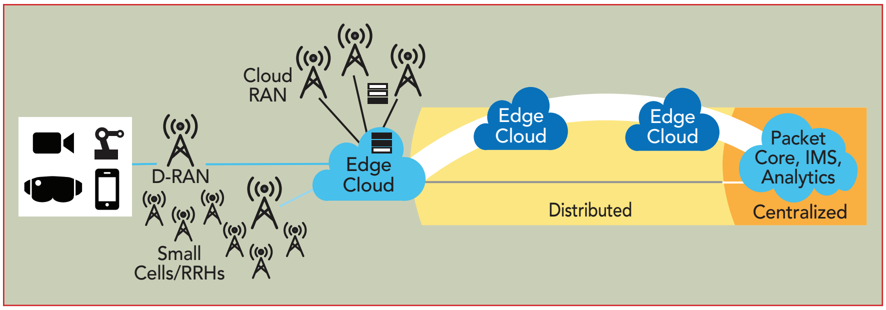

Fig. 1 Transport network slicing creates pipes to meet many different performance needs.

A NEW ARCHITECTURE

5G is more than just an innovative radio technology. It introduces a new approach to network architecture to deliver the dramatic improvements in performance that 5G users will expect. For example, CSPs traditionally treat the core, transport and RAN independently and tend to integrate the different infrastructure parts only after deployment. In 5G scenarios, however, post-deployment integration costs, time to market and the risk of degraded service quality will increase dramatically using this approach. Without cross-domain design and pre-deployment integration, CSPs risk missing out on new 5G business opportunities. Business-critical applications depending on ultra-reliable low latency communication (URLLC) and extreme network reliability can only be delivered with the seamless, error-free interaction of radio, transport, core, data center and management systems.

Network slicing (see ***Figure 1***) is one of the key enablers of next-generation services and business models. With network slicing, network resources—both virtual network functions and the transport network—are shared by different services. The network is virtually sliced into several, independent logical resources that simultaneously accommodate multiple application fulfillment requests. This is different than the conventional setup for sharing network resources, where a host provides hardware and software resources to one or more guests. Instead, it relies on the concept of software-defined networks (SDN). An SDN-capable microwave network makes its resources available through a virtualized transport service, with the SDN controller acting as a hypervisor to allocate the resources. For example, ultra-low latency applications can be served by a network slice allocating the service to an E-Band (i.e., 80 GHz) channel using carrier aggregation. Other services not requiring low latency can be allocated by a load balancing algorithm in the SDN controller to efficiently use carrier aggregation bandwidth.

Network slicing requires substantial service automation and optimization. Such a dynamic en-

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vironment cannot be managed by humans, due to network complexity and the required life-cycle speed of each service. Instead, it demands an end-to-end approach to service fulfillment, which means that newly converged networks must make the transition to IP to support it. The transport network, whatever the mix of microwave and fiber, must adapt in step with the distributed IP core and RAN functions provided by the base stations, to meet the service levels required for each network slice. Complex traffic engineering and the flexibility to deliver shorter service activation cycles—from days or hours to minutes—combine to make a step change in the level of network automation the only sensible option.

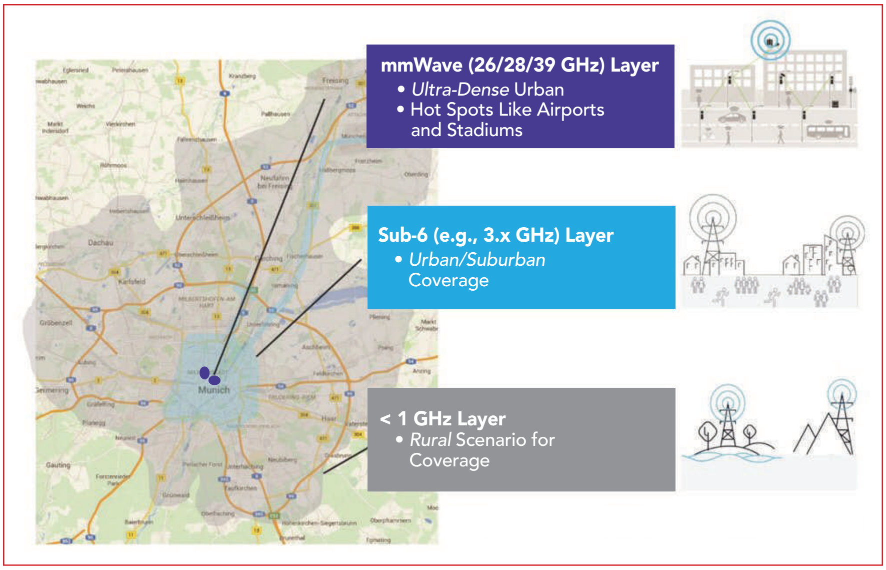
It all adds up to far greater complexity. For instance, virtual RAN functions will be distributed over multiple platforms and integrated via new interconnectivity interfaces. Some functions will shift into the cloud and be centralized to optimize cost and performance, while others will move closer to the end user, to better comply with stringent low latency requirements. Such flexible and complex networks will require unprecedented levels of automation, to allow granular end-to-end traffic engineering and satisfy the different service level agreements assigned to each service or network slice. Each slice will effectively be an automated and programmable transport pipe, which can adapt dynamically to meet changing needs.

Densification at the physical edge of the network means more sites to be connected, with significant implications for transport. For instance, in a typical deployment, a macro cell may be a pooling site for small cells in its coverage area. High user density (> 150,000 subscribers/km^2) implies increased connectivity between base station sites with different connectivity technologies, so densification needs a shift in topology toward a meshed or partially meshed structure.

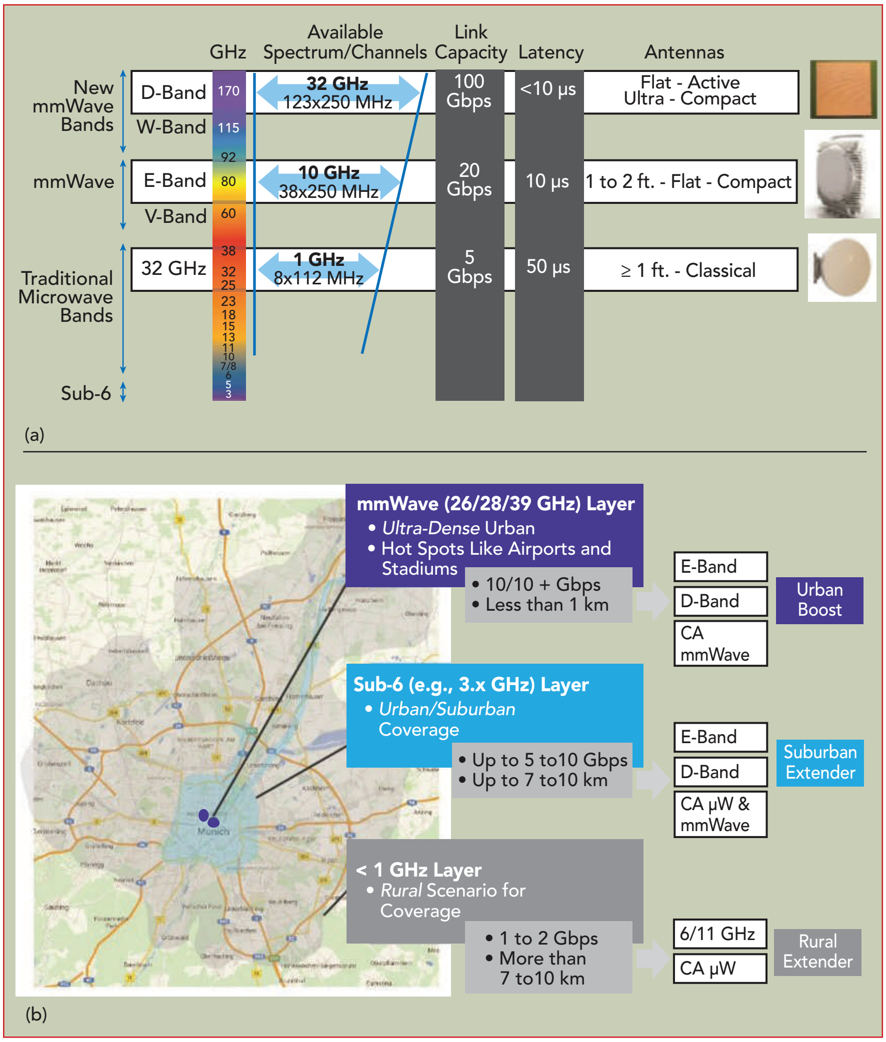
MICROWAVE SOLUTIONS FOR ALL SCENARIOS

From high traffic hotspots to rural coverage, there are strong arguments to support microwave solutions for every 5G network scenario (see ***Figure 2***). For example, in ultra-dense urban areas, such as crowded squares, airports and stadiums, 5G networks will be deployed using a mmWave radio access layer (e.g., 26, 28 or 39 GHz), as shown in ***Figure 3***. Very high capacity backhaul is needed (≥ 10 Gbps) with transport link lengths less than 1 km. Low visual impact is another consideration for deployments in dense urban environments, and microwave solutions with very small form factors will be integrated with RAN equipment. In the suburbs, where typical link distances range from 7 to 10 km, the access layer will be based on sub-6 GHz frequencies, with connectivity requirements not quite as extreme, yet still demanding capacity of 5 to 10 Gbps. This contrasts with rural settings, where the geographical coverage is larger, and the access network uses frequencies below 1 GHz. Here, the trans-

port network must backhaul up to 2 Gbps, and link lengths will commonly exceed 10 km.



▲ Fig. 2 **Microwave must meet the diverse transport needs, from dense urban hot spots to rural areas.**



▲ Fig. 3 **Microwave and mmWave transport networks (a) can meet 5G's data capacity and coverage needs (b).**

In addition to solutions for the full range of scenarios, CSPs must also address their end-to-end service capabilities, including access and management considerations in addition to transport. A microwave portfolio must be fully integrated into an end-to-end vision of the network and service fulfillment.

To meet the 5G requirement for more capacity, new microwave solutions for optimizing the use of spectrum are already available. Carrier aggregation using multiple bands on the same link, more powerful and efficient power amplifiers that use wider channels and the availability of mmWave spectrum meet key requirements for future network solutions. For example, in today's frequency bands used for RAN backhaul (6 to 42 GHz), several suppliers already offer transceivers capable of 2.5 Gbps in a single box, thanks to 4096-QAM modulation in 2 × 112 MHz frequency channels. Beyond this, current E-Band solutions stand ready to satisfy the initial wave of 5G introductions that require up to 10 Gbps transport capacity and 20 μs latency for urban environments. Combining E-Band with a traditional microwave frequency band between 6 and 42 GHz, it is possible to achieve longer distances while preserving high availability for the most valuable traffic. With efficient carrier aggregation, between 10 and 20 Gbps bi-directional capacity is achievable.

Looking further ahead, the telecommunications industry is considering the frequency bands above 100 GHz for the transport segment of future 5G networks. Recent activities reflect the highest interest at W-Band (92 to 114.25 GHz) and D-Band (130 to 174.8 GHz). While W-Band is viewed as a likely extension of E-Band, because the two share similar propagation behaviors, the peculiarities of D-Band enable innovative approaches to equipment design. Also, the very small form factor aids the integration of the radio and antenna—just a few centimeters square. Between transport and access products, this enables new network topologies such as point-to-multipoint and mesh connectivity combined with beam steering.

5G network transformation will affect the microwave solutions already deployed for 3G and the early stages of 4G probably more than any

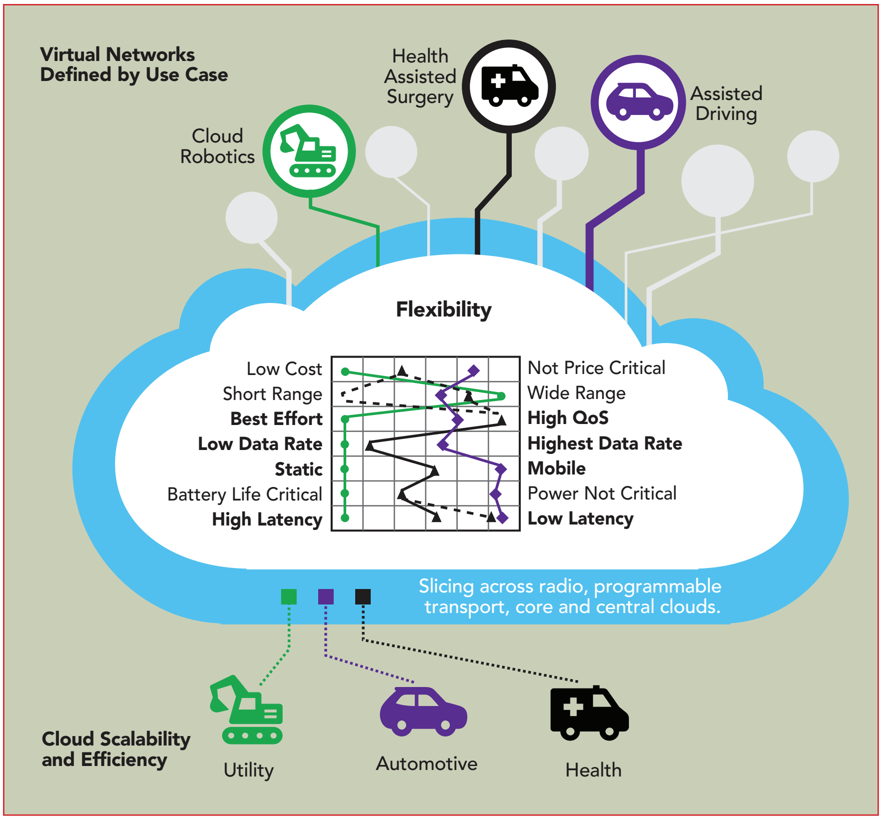


Fig. 4 Using network slicing across the radio, transport, core and central clouds, 5G has the flexibility to support diverse use cases with a common underlying infrastructure.

other transport technology. The substantial installed microwave base will inevitably be replaced by new microwave solutions—in some instances fiber—designed for 5G. The goal for CSPs is to optimize budgets during backhaul network upgrades to minimize the TCO of their evolving assets. The latest microwave designs are highly compact, often with integrated antennas and other components, enabling them to be used for a wide range of use cases. New microwave outdoor units also support multi-frequency systems and carrier aggregation, helping lower TCO.

SOLUTIONS TODAY AND TOMORROW

To have maximum flexibility when choosing the best way forward, companies must seek out appropriate solutions and tools to optimize budgets during backhaul network upgrades, considering both CAPEX and OPEX. The optimal solution combines an end-to-end portfolio including cross-domain cloud-native utilities and enabling rapid deployment of virtualized functions across a distributed cloud infrastructure. This will simplify service scaling, shorten time to market and deliver cost efficiencies across the radio, core and transport networks.

Companies seeking to digitally transform require a solution that answers the challenges of 5G transport by converging fronthaul, midhaul and backhaul to serve a variety of use cases within the same network. Every CSP will follow a unique path to 5G, but each one will tackle the evolving transport network. Right now, the transport layer must handle many technologies, both legacy and evolving, and will soon need to flex to meet more extreme demands (see ***Figure 4***). CSPs need to adopt an end-to-end approach to transport, and microwave technology will play a role as a key enabler of the new approach. It will help CSPs leverage existing investments while continuing to build the new capabilities needed for 5G.■

Reference

1. "The Evolution of Microwave Transport—Enabling 5G and Beyond," *Nokia*, 2019, pp. 1–24, https://nokia.ly/2NrxmWK

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Time Domain Simulation of Electrostatic Discharge Testing

Remcom
State College, Pa.

An electrostatic discharge (ESD) is the sudden flow of current between two electrically charged objects, caused by the breakdown of the dielectrics separating them, i.e., dielectric breakdown. In the case of electronic devices, the resulting current flow and possible spark can permanently damage the device (see ***Figure 1***). An often recited yet unsubstantiated quote is "…losses associated with ESD in the electronics industry are estimated at between half a billion and $5 billion annually." In reality, estimating the exact cost of ESD loss is extremely difficult; nonetheless, ESD forces the development and testing of many hardware prototypes during design and manufacturing and contributes to a high number of warranty claims with loss of consumer confidence if a failure occurs in the hands of the consumer. Therefore, electronics manufacturers go to great lengths to properly shield sensitive components and design systems to reduce, dissipate and neutralize static charge.

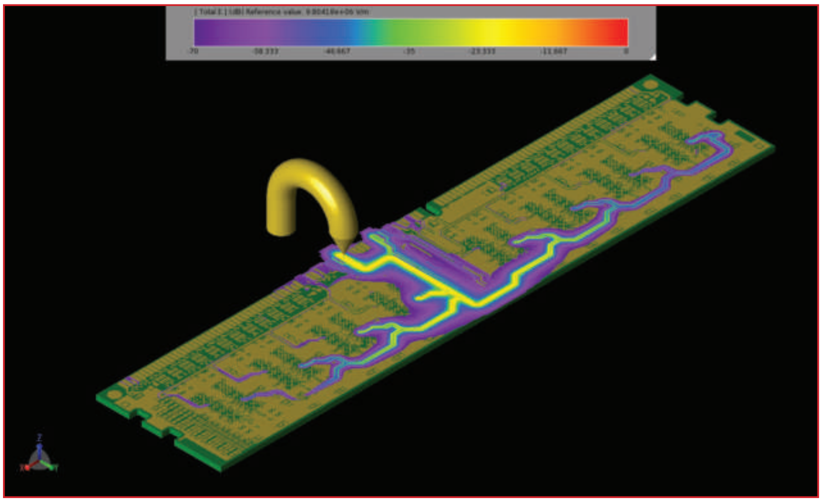

Fig. 1 **Electric fields during a simulated ESD test of a DDR3 RAM stick.**

To test ESD susceptibility, hardware engineers typically use test models defined by various standards, from organizations such

2 GHz Clock Generator

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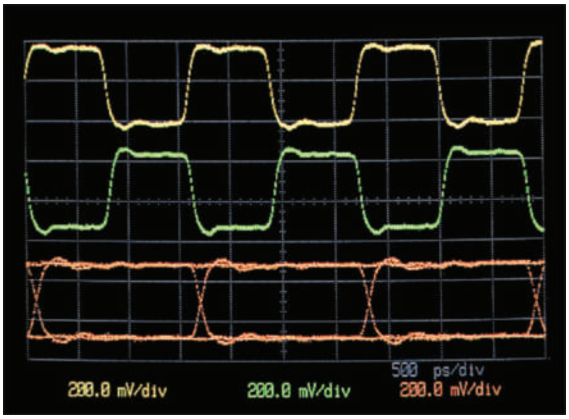
- *Phase adjustment & time modulation*



Plot shows complementary clocks and PRBS (opt. 01) outputs at 622.08 Mb/s with LVDS levels. Traces have transition times of 80 ps and jitter less than 1 ps (rms).

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as ANSI, JEDEC and the IEC. The most common and widely used ESD models are the human body model (HBM), which approximates a discharge from a charged human fingertip to a grounded device (see ***Figure 2***), and the charged device model (CDM), which approximates a discharge from a charged device to another conducting object at a lower electrostatic potential. These tests are generally performed using ESD simulators or ESD guns to apply high speed and high voltage pulses to various points of the device under test (DUT).

Even for an experienced engineer, pinpointing the location of an ESD failure during testing—or determining whether a failure occured at all—can be extremely challenging. ESD failures are typically categorized in three groups: catastrophic, latent or upset. In the case of a catastrophic failure, the DUT no longer functions and there is usually physical damage such as melted and/or charred components. Intuitively, a catastrophic failure may sound like the worst-case scenario; however, it is actually the most ideal to encounter during quality assurance testing, because it is easily recognized, located and accounted for in the final ESD mitigation design. On the other hand, latent and upset failures are much more difficult to diagnose because the DUT still functions, with little or no sign of physical damage. Latent failures are often not visible to the naked eye and result in a weakened device which functions at the time of testing and deteriorates over time with continued usage, often malfunctioning or failing in the consumer's possession. Upset failures result from over-currents which do not physically damage the DUT but compromise the components' semiconductive properties, leading to unpredictable behavior and data loss in use. Latent failures can sometimes be identified with magnification, but upset failures are nearly impossible to detect during testing.

Given the high cost of time and materials for ESD hardware testing and the difficulty locating latent and upset failures, simulating ESD testing is extremely valuable, as it can pinpoint locations susceptible to ESD damage and then help optimize ESD mitigation during product design. Responding to this growing need, new ESD simulation features have been added to Remcom's full wave electromagnetic simulation software package, XFdtd®. Using XFdtd's improved

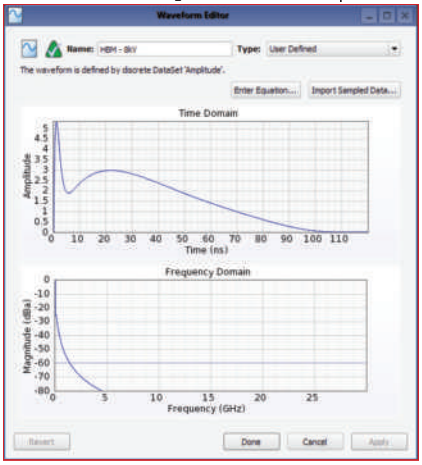


Fig. 2 8 kV HBM waveform in XFdtd.

user-defined waveform feature, engineers can import ESD waveforms defined by various testing standards, using them to create ESD current sources in an XFdtd project. At this point, ESD simulator/gun models can be created and used to excite the DUT geometry at locations of interest, with the resulting electromagnetic (EM) fields and current flows simulated and analyzed (see Figure 1).

To solve the challenge of determining if and where an actual ESD failure occured, a new material parameter, dielectric strength, was added to XFdtd's electric material definitions. The dielectric strength of a material defines the maximum electric field it can withstand without experiencing dielectric breakdown (i.e., losing its insulating properties). Upon adding the dielectric strength parameter to XFdtd, it is possible to monitor FDTD cell edges for potential breakdown during transient simulations using a dielectric breakdown near-field sensor (see ***Figure 3***). The sensor instructs the XFdtd calculation engine to monitor cell edges for electric fields exceeding the dielectric strength of their constituent materials, recording instances when dielectric breakdown is likely to occur. The sensor requires the user to define the free space dielectric strength, used

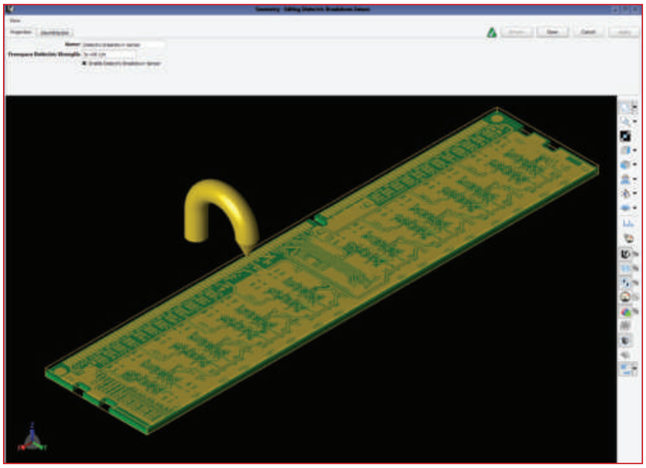


Fig. 3 **Definition of dielectric breakdown sensor.**

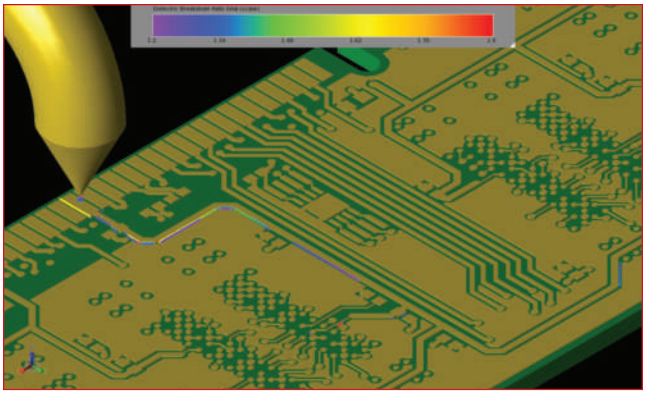
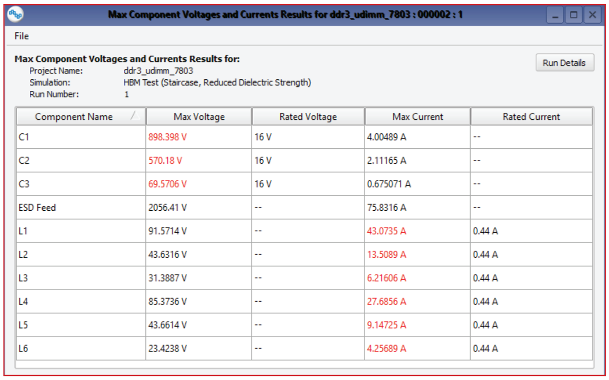


Fig. 4 **Risk areas for dielectric breakdown identified during simulated ESD testing.**



Component Name	Max Voltage	Rated Voltage	Max Current	Rated Current
C1	898.398 V	16 V	4.00489 A	--
C2	570.18 V	16 V	2.11165 A	--
C3	69.5706 V	16 V	0.675071 A	--
ESD Feed	2056.41 V	--	75.8316 A	--
L1	91.5714 V	--	43.0735 A	0.44 A
L2	43.6316 V	--	13.5089 A	0.44 A
L3	31.3887 V	--	6.21606 A	0.44 A
L4	85.3736 V	--	27.6856 A	0.44 A
L5	43.6614 V	--	9.14725 A	0.44 A
L6	23.4238 V	--	4.25689 A	0.44 A

Fig. 5 Summary of components exceeding rated design parameters during simulated ESD testing.

for all edges that do not contain a defined material. The default free space dielectric strength is set to 3 MV/m, the dielectric strength of air at sea level. The sensor also allows the user to define a bounding box to limit the volume monitored for dielectric breakdown. Using this feature saves on computation by defining the specific areas of interest, rather than examining the entire computational domain. At the conclusion of an FDTD simulation, the cell edges which exceed their respective dielectric strengths can be viewed, as shown in ***Figure 4***.

Functionality was also added to XFdtd to monitor specific electronic components that are taxed beyond their rated voltage and current input parameters, which can be obtained from the components' data sheets. Post-simulation results identify those components that are subject to permanent damage due to unsafe limits (see ***Figure 5***).

While simulation cannot and should not replace hardware testing entirely, these new computational features provide ESD engineers with more insight into the probable locations of ESD failure, enabling ESD mitigation designs to be optimized prior to prototyping hardware. Remcom believes this capability will reduce product development cost and time to market, while improving product reliability and consumer confidence. These new features lay the foundation for additional multiphysics capabilities, including plasma discharge and thermal simulation to model the current and heat generated from spark discharges. Merging these computational techniques will enable the analysis of downstream current flows after an initial dielectric breakdown, more accurately predicting dielectric and circuit component failures.

VENDORVIEW

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IQSTAR Simplifies Test Setup and Data Analysis

AMCAD Engineering
Limoges, France

Production testing of RF/microwave components and circuits is becoming a real challenge for many companies. Eager to get their latest developments to market, they must achieve performance that highlights the superiority of their products compared to the competition's. On the other hand, customers are continuously requesting additional information on the datasheets. No longer satisfied with simple small-signal measurements and frequency swept S-parameters, they are asking for information related to their specific applications.

Depending on the component and application, the datasheet may include small-signal RF, frequency sweeps, DC sweeps, RF power sweeps, single and two tone distortion using CW, pulsed and modulated signals. Application engineers are trying their best to satisfy customers' requests and run different measurement benches to compile all the data. Datasheet generation and formatting represent "60 to 70 percent of the total work done to take a new IC from prototype test to product launch," according to the management of a major IC manufacturer.

AMCAD Engineering has addressed this challenge by developing innovative and advanced measurement software for efficient and accurate circuit testing. The platform is equally suited for S-parameters and CW, pulsed, two tone and modulated signals with DPD optimization. Requiring no programming skills to set up, it helps developers design and debug their products, considerably reducing time to market.

TEST BENCH SCHEMATIC

IQSTAR is turnkey software with a versatile and customizable schematic editor for building a test bench with available laboratory instruments and configuring it for an application (see ***Figure 1***). Multiple configurations are possible: scalar, vector or a combination of scalar and vector.

Scalar measurements use power meters and a vector signal analyzer. The setup is basic and performs single tone power measurements, including input and output power, transmission efficiency, transmission gain and DC power. The measurements can be done with CW or pulsed signals or using a vector signal generator, modulated signals.

Vector measurements use the direct receiver access option of the vector network analyzer (VNA). The main advantages of this configuration are the large dynamic range

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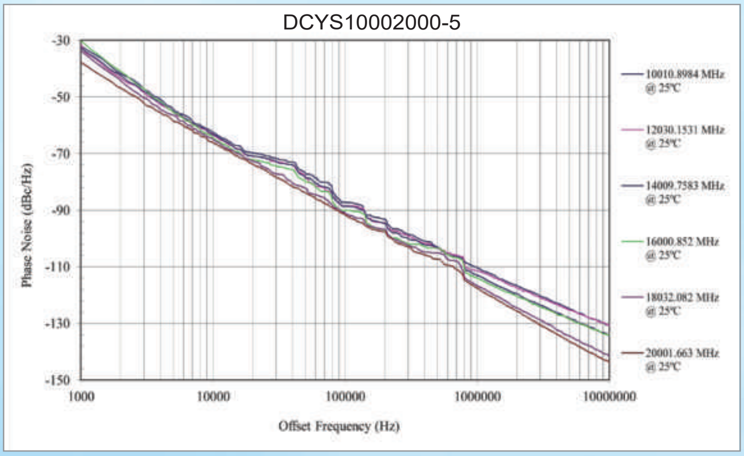
DCYS100200-12	1 - 2	-105	-125	0 - 28	+4
DCO200400-5	2 - 4	-90	-110	0 - 18	-2
DCYS200400P-5	2 - 4	-93	-115	0 - 18	0
DCO300600-5	3 - 6	-75	-104	0 - 16	-3
DCYS300600P-5	3 - 6	-78	-109	0 - 16	+2
DCO400800-5	4 - 8	-75	-98	0 - 15	-4
DCO5001000-5	5 - 10	-80	-106	0 - 18	-2
DCYS6001200-5	6 -12	-70	-94	0 - 15	> +10
DCYS8001600-5	8 - 16	-68	-93	0 - 15	> +10
DCYS10002000-5	10 - 20	-65	-91	0 - 18	> +10



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of the receiver and measurement speed. This setup supports S-parameters and single and two tone power measurements. Using a- and b-waves in amplitude and phase, engineers get better insight of the characteristics of the device under test (DUT). In addition to the measurements possible with the scalar setup, the vector setup can measure input return loss, power gain, power-added efficiency, AM-to-PM distortion, calibrated harmonic power, intermodulation distortion and video bandwidth (VBW).

A third configuration combines scalar and vector, adding a vector signal generator and vector signal analyzer to the vector measurement configuration. To the previous measurement capabilities, this third configuration supports tests with modulated signals: ACPR, PAPR, CCDF, simultaneously in raw and linearized mode.

The software handles setup calibration, suggested to the user for each configuration. A calibration wizard guides the user through a step-by-step procedure.

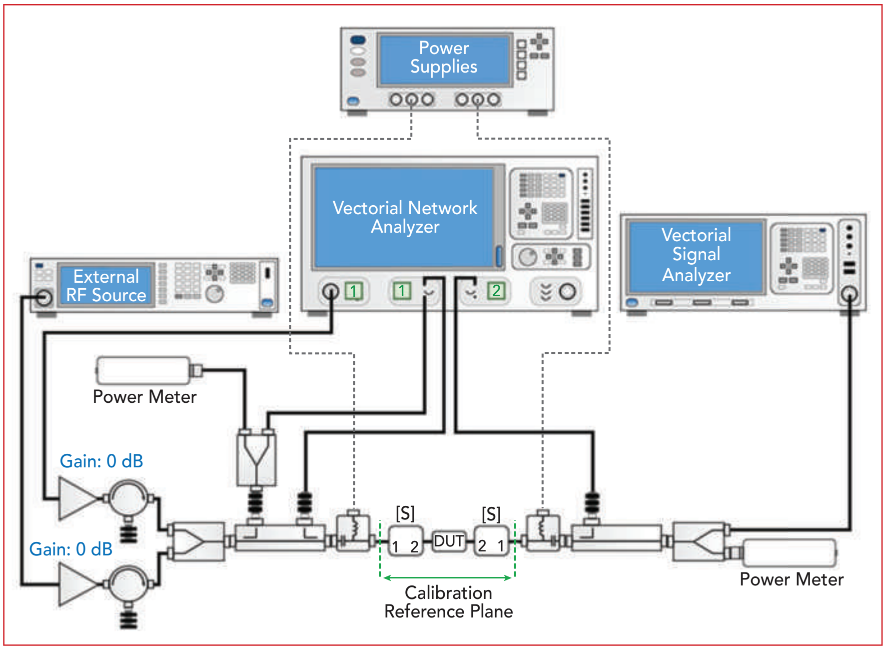


Fig. 1 Example measurement test bench setup in IQSTAR.

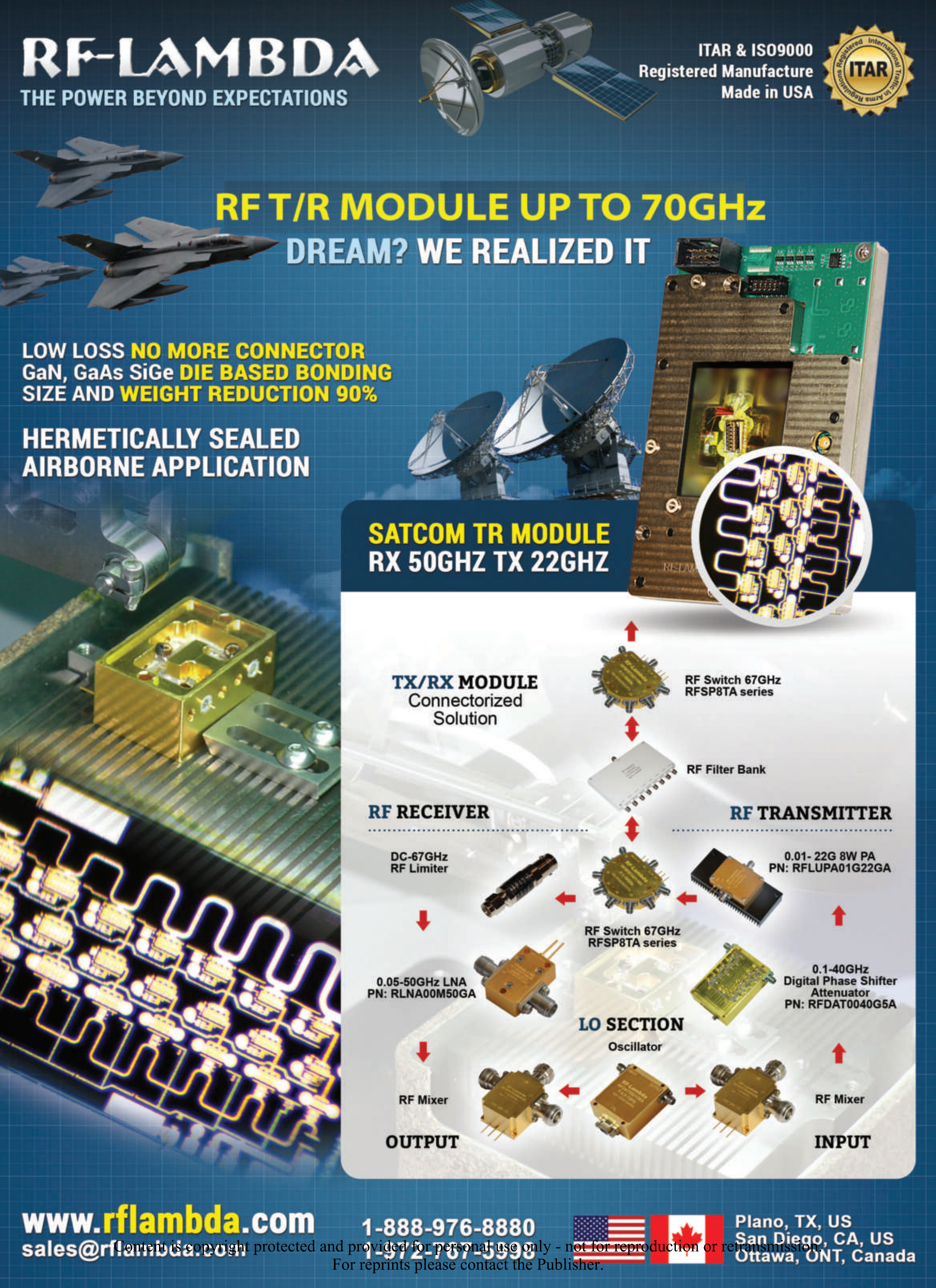
MEASUREMENTS

IQSTAR has separate measurement tabs for S-parameters, single tone, two tone, VBW and modulated signals. Depending on the measurement setup and calibration file selected, the software will only activate the possible combinations. Measurement conditions are an important aspect of the configuration, particularly protecting the DUT by setting stop conditions. IQSTAR provides three power and frequency sweep modes:

- Power per frequency, with a complete power sweep for each frequency, saving the parameters for every measurement.
- Frequency per power, with a frequency sweep for each power level and saving the parameters for every measurement.
- Smart sweep using adaptive power steps, where the sweep uses a fast mode to find the compression point. Only the measured parameters at the compression point are saved.

IQSTAR includes a current stabilization feature that waits for the DUT to recover between consecutive power sweeps. This is useful when testing GaN designs, which may have trapping and self heating effects. The recovery time can be saved and used as a reference for technology evaluation and enhancement.

VBW measurements represent a challenging measurement task. IQSTAR handles this measurement efficiently, setting the amplitude of the tones according to the target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third-order intermodulation distortion (IMD3) value set by the user. The software sweeps the spacing between the tones and adjusts the balance between them before recording the intermodulation—up to the ninth order. Taking advantage of the speed of VNA sweeps, this measurement takes just a few minutes.

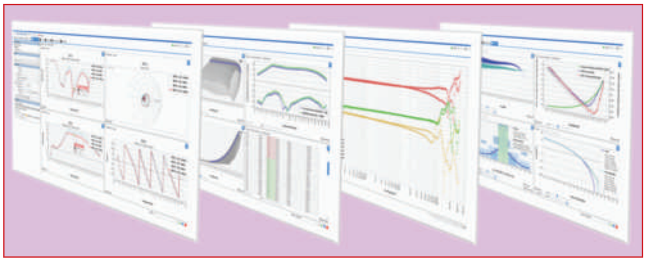

Fig. 2 Whiteboard provides tools, interactive displays and multiple pages to view and analyze measurement data.

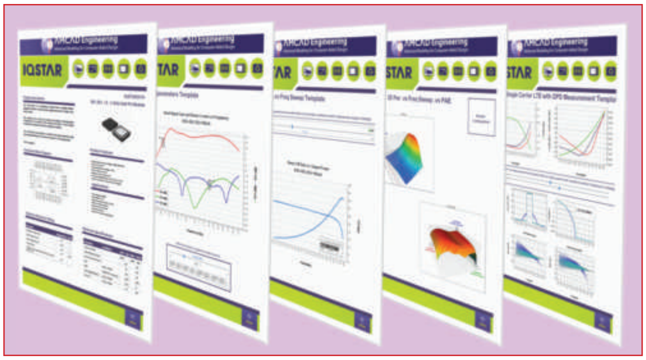

Fig. 3 Pages of a Whiteboard workspace can be exported as PDFs, making data sheets much easier to create.

IQSTAR includes a real-time configurable visualization tool, making it easy for test engineers to detect abnormal behavior of the DUT during measurement. Target tuning enables visually assessing if the DUT is reaching the target values by using color-coded data; the display shows a specified color for certain parameters when they are below the target. The history display compares the prior four measurements, which helps debug the DUT and see whether the performance is improving. Live measurements can be compared with references from simulation or previous measurements.

The sweep plan option creates a customized automated test flow, including sweeping the DUT biasing and temperature, as well as wafer mapping. The intuitive user interface makes it easy to create the test plan by dragging and dropping and recalling saved setups and configurations.

WHITEBOARD DATA VIEWER

With all the measurements and test flows, data management is very complex, and the quantity of information can be overwhelming. Whiteboard enables the data to be managed and analyzed (see ***Figure 2***). As the name indicates, Whiteboard is like a white board, providing the freedom to imagine how best to view and analyze data: 2D graphs, tables, 3D plots, labels, pictures, editable texts. In addition to the usual axis and data configuration, Whiteboard includes special features like sliders, filters, extractors and stackers—functions to create interactive displays that respond to adjustments in frequency, frequency range, compression point, the specific device on a wafer and more options. The Whiteboard has the capability to highlight the specifications of a component in the exact end user configuration. Multiple pages in the same workspace can be created to sort measurement results by types or devices.

Workspaces can be saved and templates created, defined by device type or technology, for example. Dragging and dropping measurement files in the data editor will automatically update the template, and all graphs will reflect the new values. Plots and graphs can be exported as images and the pages of the workspace exported as PDFs, making measurement reports and data sheets much easier to create (see ***Figure 3***).

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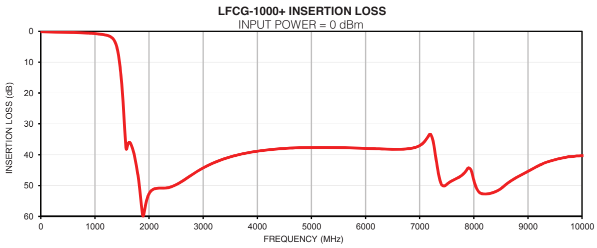

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High linearity electronic warfare (EW) receivers for radar warning receivers, jammers and electronic countermeasures are among the most important capabilities for the modern warfighter. A common subcomponent in an EW receiver is the microwave tuner, which scans across frequency—frequently from 2 to 18 GHz—and converts signals to a baseband receiver. A direct conversion architecture from this band to a low IF generates excessive spurious signals, requiring steep channel selection filters. An alternative approach up-converts the band with a high side local oscillator (LO) to a high IF, followed by filtering and down-conversion to a low IF.

To support this alternative architecture and achieve the highest linearity, Marki Microwave developed a GaAs MMIC mixer (MM1-1850S) and LO driver amplifier (AMM-6702) chipset. The mixer has a wide RF/LO bandwidth from 18 to 50 GHz, an IF spanning DC to 20 GHz and exceptional IP3 and spurious performance. Marki developed the LO driver to provide sufficient drive for high linearity mixers such as the MM1-1850S. With greater than 20 dBm saturated output power over temperature and more than 20 dB gain over temperature, the AMM-6702 can drive an H or S diode mixer from a 0 dBm input source across −40°C to above 85°C. It can be biased to consume less than 1 W of power, even in heavy saturation, with an added benefit of operating above the traditional 45 GHz cutoff for GaAs PHEMT amplifiers. This amplifier has enough bandwidth and power to drive an H diode mixer as high as 55 GHz, providing additional capability for the microwave tuner.

Both the MM1-1850S mixer and AMM-6702 LO driver are available in connectorized modules and as wire-bondable die.

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

PMI Model No.	Frequency Range (GHz)	Insertion Loss (dB Typ)	Isolation (dB Typ)	Switching Speed (Typ)	Power Supply	Configuration Size (Inches) Connectors
P1T-DC40G-65-T-292FF-1NS https://www.pmi-rf.com/product-details/ p1t-dc40g-65-t-292ff-1ns	DC - 40	5.5	65	5 ns	+15 V @ 15 mA -15 V @ 40 mA	SPST, Absorptive 1.2" x 1.3" x 0.5" 2.92mm (F)
P2T-100M50G-100-T https://www.pmi-rf.com/product-details/ p2t-100m50g-100-t	0.1 - 50	5	100	50 ns	+5 V @ 88 mA -5 V @ 63 mA	SP2T, Absorptive 1.0" x 0.75" x 0.4" 2.4mm (F)
P3T-500M40G-60-T-55-292FF https://www.pmi-rf.com/product-details/ 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)
P4T-100M50G-100-T-RD https://www.pmi-rf.com/product-details/p4t-100m50g-100-t-rd	0.1 - 50	5	100	50 ns	+5 V @ 154 mA -5 V @ 135 mA	SP4T, Absorptive 1.25" x 1.25" x 0.4" 2.4mm (F)
P5T-500M40G-60-T-55-292FF-5G40G https://www.pmi-rf.com/product-details/ p5t-500m40g-60-t-55-292ff-5g40g	0.5 - 40	8	60	40 ns	+5 V @ 55 mA -5 V @ 45 mA	SP5T, Absorptive 1.25" x 1.25" x 0.4" 2.92mm (F)
P6T-2G18G-60-T-512-SFF-LV https://www.pmi-rf.com/product-details/ 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 https://www.pmi-rf.com/product-details/ 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)
P8T-500M40G-50-T-55-292FF https://www.pmi-rf.com/product-details/ p8t-500m40g-50-t-55-292ff-	0.5 - 40	10	50	50 ns	+5 V @ 300 mA -5V @ 50 mA	SP8T, Absorptive 4.0" x 1.5" x 0.4" 2.92mm (F)
P9T-500M40G-60-R-55-292FF-OPT1222 https://www.pmi-rf.com/product-details/ 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 https://www.pmi-rf.com/product-details/ 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)
P16T-100M50G-100-T-DEC https://www.pmi-rf.com/product-details/ p16t-100m50g-100-t-dec	0.1 - 50	18	70	100 ns	+5 V @ 1100 mA -12 V @ 720 mA	SP16T, Absorptive 8.0" x 3.0" x 0.65" 2.4mm (F)
P16T-100M52G-100-T-DEC https://www.pmi-rf.com/product-details/ p16t-100m52g-100-t-dec	0.1 - 52	18	100	100 ns	+5 V @ 1100 mA -12 V @ 720 mA	SP16T, Absorptive 8.0" x 3.0" x 0.65" 2.4mm (F)
P20T-7G18G-80-T-515-SFF-SP https://www.pmi-rf.com/product-details/ p20t-7g18g-80-t-515-sff-sp	7 - 18	5	80	250 ns	+5 V @ 500 mA -15 V @ 200 mA	SP20T, Absorptive 4.0" x 4.0" x 0.63" SMA (F)
P32T-0R5G18G-60-T-SFF https://www.pmi-rf.com/product-details/ p12t-0r5g18g-60-t-sff	0.5 - 18	9.5	60	100 ns	+5 V @ 1450 mA -5 V @ 20 mA	SP32T, Absorptive 8.0" x 3.5" x 1.0" SMA (F)


P6T-2G18G-60-T-512-SFF-LV


P7T-0R8G18G-60-T-SFF-SMC


P8T-500M40G-50-T-55-292FF


P9T-500M40G-60-R-55-292FF-OPT1222


P12T-0R5G18G-60-T-SFF


P16T-100M50G-100-T-DEC
P16T-100M52G-100-T-DEC


P20T-7G18G-80-T-515-SFF-SP


P32T-0R5G18G-60-T-SFF

West Coast Operation:
4921 Robert J. Mathews Pkwy, Suite 1
El Dorado Hills, CA 95762 USA
Tel: 916-542-1401, Fax: 916-265-2597

East Coast Operation:
7311-F Grove Road
Frederick, MD 21704 USA
Tel: 301-662-5019, Fax: 301-662-1731

sales@pmi-rf.com • www.pmi-rf.com

ISO 9001-2015 REGISTERED

K-Band SDR Kit Supports Digital Beamforming and MIMO

Software-defined radar (SDR) developer Ancortek has released a SDR kit with digital phased-array beamforming and MIMO capabilities. The SDR-KIT 2400T2R4 was designed for direction of arrival measurement, radar interferometry, digital beamforming and MIMO radar. It has the capability to monitor human activity, sense occupancy and gestures and create 3D images.

The compact hardware contains a coherent transmitter-receiver with two transmit channels, four receive channels and integrated phase-locked loop. Using time-division multiplexing, the radar transmits FMCW, FSK or CW waveforms at K-Band, with an adjustable frequency from 24 to 26 GHz. The radar uses Infineon's highly integrated transmit and receive RFICs, the BGT24MTR12 and BGT24MR2, which support a typical output power of 20 dBm, phase noise of −96 dBc/Hz at 1 MHz offset and 12 dB noise figure. All four receive channels provide I and Q data. Six female SMA connectors on the front panel enable easy connection to external antennas.

An FPGA-based processor module in the kit contains the microcontroller, signal processing and power management. Using an FPGA provides the user with flexibility and standard programmable logic. Four, 40 MSPS analog-to-digital converters process the four receive channels, and a high speed USB peripheral controller enables the raw sampled data to be streamed to a PC for processing. The PC-based graphical user interface enables users to easily select the center frequency and bandwidth, choose signal waveforms, sampling rates, filtering, display parameters and record or export the receive I/Q data.

The software-defined architecture provides flexibility and enables the hardware to be compact: 5.4 in. long, 4.1 in. wide and 1.2 in. high. Without modifying the hardware, the operating modes, waveforms, bandwidth and processing functions can be changed to tailor the system to handle multiple applications and scenarios. An embedded version of the kit is available, which adds battery power, a 7 in. touch screen display and Linux operating system.

Ancortek Inc.
Fairfax, Va.
www.ancortek.com

SIX DAYS ■ THREE CONFERENCES ■ ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2019
PARIS EXPO PORTE DE VERSAILLES, PARIS, FRANCE
1 place de la Porte de Versailles
29TH SEPTEMBER - 4TH OCTOBER 2019

EUROPEAN MICROWAVE WEEK
PORTE DE VERSAILLES
PARIS, FRANCE
29TH SEPT - 4TH OCT 2019
www.eumweek.com
EuMW 2019
UNIVERSALITY THROUGH MICROWAVES

EUROPEAN MICROWAVE WEEK 2019

REGISTRATION INFORMATION

EUROPE'S PREMIER MICROWAVE, RF, WIRELESS AND RADAR EVENT

Register online at:

www.eumweek.com

EuMA
European Microwave Association

Official Publication: Microwave Journal

Organised by: horizon house

Supported by: IET

Co-sponsored by: MTT-S

Co-sponsored by: IEEE

EuMIC 2019
The 14th European Microwave Integrated Circuits Conference
Co-sponsored by: GAAS, Electron Devices Society

49TH EUROPEAN MICROWAVE CONFERENCE 2019
The 49th European Microwave Conference
Co-sponsored by: EurAAP

EuRAD 2019
The 16th European Radar Conference
Co-sponsored by: EurAAP, AESS

EUROPEAN MICROWAVE WEEK
PORTE DE VERSAILLES
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EuMW 2019
UNIVERSALITY THROUGH MICROWAVES

EUROPEAN MICROWAVE WEEK 2019

THE ONLY EUROPEAN EVENT DEDICATED TO THE MICROWAVE AND RF INDUSTRY

European Microwave Week 2019 takes place in Paris “La Ville Lumière”. Bringing industry and academia together, European Microwave Week 2019 is a SIX day event, including THREE cutting edge conferences and ONE exciting trade and technology exhibition featuring leading players from across the globe. EuMW 2019 provides access to the very latest products, research and initiatives in the microwave sector. It also offers you the opportunity for face-to-face interaction with those driving the future of microwave technology.

EuMW 2019 will see an estimated 1,500 conference delegates, over 4,000 attendees and in excess of 300 international exhibitors (inc. Asia & US).

REGISTRATION TO THE EXHIBITION IS FREE!

- **Over 300 International Companies** - meet the industry’s biggest names and network on a global scale
- **Cutting-edge Technology** - exhibitors showcase the latest product innovations, offer hands-on demonstrations and provide the opportunity to talk technical with the experts
- **Industrial Workshops** - get first hand technical advice and guidance from some of the industry’s leading innovators
- **MicroApps** - attend our annual European Microwave Week Microwave Application Seminars (MicroApps)

BE THERE

Exhibition Dates	Opening Times
Tuesday 1st October	09:30 - 18:00
Wednesday 2nd October	09:30 - 17:30
Thursday 3rd October	09:30 - 16:30

FAST TRACK BADGE RETRIEVAL

Entrance to the Exhibition is FREE and attending couldn’t be easier.

VISITORS

Registering for the Exhibition

- Register as an Exhibition Visitor online at **www.eumweek.com**
- Receive a confirmation email with barcode
- Bring your barcode with you to the Exhibition
- Go to the Fast Track Check In Desk and print out your visitor badge
- Alternatively, you can register onsite at the self service terminals during the Exhibition

Please note NO visitor badges will be mailed out prior to the Exhibition.

EUROPEAN MICROWAVE WEEK 2019
THE CONFERENCES

Don’t miss Europe’s premier microwave conference event. The 2019 week consists of three conferences and associated workshops:

- European Microwave Integrated Circuits Conference (EuMIC) 29th September - 2nd October 2019
- European Microwave Conference (EuMC) 1st - 3rd October 2019
- European Radar Conference (EuRAD) 2nd - 4th October 2019
- Plus Workshops and Short Courses (From 29th September 2019)
- In addition, EuMW 2019 will include, for the 10th year, the Defence, Security and Space Forum on 2nd October 2019 and for the first time the Automotive Forum on 30th September 2019.

The three conferences specifically target ground breaking innovation in microwave research. The presentations cover the latest trends in the field, driven by industry roadmaps. The result is three superb conferences created from the very best papers submitted. For the full conference programme including a detailed description of the conferences, workshops and short Courses, please visit **www.eumweek.com**. There you will also find details of our Partner Programme and other Social Events during the week.

FAST TRACK BADGE RETRIEVAL

Register online and print out your badge in seconds onsite at the Fast Track Check In Desk

CONFERENCE PRICES

There are TWO different rates available for the EuMW conferences:

- **ADVANCE DISCOUNTED RATE** – for all registrations up to and including 30th August 2019
- **STANDARD RATE** – for all registrations made after 30th August 2019

Please see the Conference Registration Rates table on the back page for complete pricing information.
All payments must be in Euro – cards will be debited in Euro.

Online registration is open now, up to and during the event until 4th October 2019

DELEGATES

Registering for the Conference

- Register online at **www.eumweek.com**
- Receive an email receipt with barcode
- Bring your email, barcode and photo ID with you to the event
- Go to the Fast Track Check In Desk and print out your delegate badge
- Alternatively, you can register onsite at the self service terminals during the registration opening times below:

  - Saturday 28th September (16:00 - 19:00)
  - Sunday 29th September - Thursday 3rd October (08:00 - 17:00)
  - Friday 4th October (08:00 - 10.00)

Once you have collected your badge, you can collect the conference proceedings on USB stick and delegate bag for the conferences from the specified delegate bag area by scanning your badge.

CONFERENCE REGISTRATION INFORMATION

EUROPEAN MICROWAVE WEEK 2019, 29th September - 4th October, Paris, France

Register Online at www.eumweek.com

ALL FEES ARE INCLUSIVE OF FRENCH VAT @ 20%

ONLINE registration is open from 28th May 2019 up to and during the event until 4th October 2019.

ONSITE registration is open from 16:00 on 28th September 2019.

ADVANCE DISCOUNTED RATE (up to and including 30th August) STANDARD RATE (from 31st August & Onsite).

Reduced rates are offered if you have society membership to any of the following*: Eu*MA*, GAAS, IET or IEEE.

Eu*MA* membership fees: Professional € 25/year, Student € 15/year.

If you register for membership through the EuMW registration system, you will automatically be entitled to discounted member rates.

Reduced Rates for the conferences are also offered if you are a Student/Senior (Full-time students 30 years or younger and Seniors 65 or older as of 4th October 2019). The fees shown below are invoiced in the name and on behalf of the European Microwave Association. Eu*MA*'s supplies of attendance fees in respect of the European Microwave Week 2019 are inclusive of French VAT.

ADVANCE REGISTRATION CONFERENCE FEES (UP TO AND INCLUDING 30TH AUG.)

CONFERENCE FEES	ADVANCE DISCOUNTED RATE			
	Society Member (*any of above)		Non Member	
1 Conference	Standard	Student/Sr.	Standard	Student/Sr.
EuMC	€ 470	€ 130	€ 660	€ 190
EuMIC	€ 360	€ 120	€ 510	€ 170
EuRAD	€ 320	€ 110	€ 450	€ 160
2 Conferences				
EuMC + EuMIC	€ 670	€ 250	€ 940	€ 360
EuMC + EuRAD	€ 640	€ 240	€ 890	€ 350
EuMIC + EuRAD	€ 550	€ 230	€ 770	€ 330
3 Conferences				
EuMC + EuMIC + EuRAD	€ 810	€ 360	€ 1140	€ 520

STANDARD REGISTRATION CONFERENCE FEES (FROM 31ST AUG. AND ONSITE)

CONFERENCE FEES	STANDARD RATE			
	Society Member (*any of above)		Non Member	
1 Conference	Standard	Student/Sr.	Standard	Student/Sr.
EuMC	€ 660	€ 190	€ 930	€ 270
EuMIC	€ 510	€ 170	€ 720	€ 240
EuRAD	€ 450	€ 160	€ 630	€ 230
2 Conferences				
EuMC + EuMIC	€ 940	€ 360	€ 1320	€ 510
EuMC + EuRAD	€ 890	€ 350	€ 1250	€ 500
EuMIC + EuRAD	€ 770	€ 330	€ 1080	€ 470
3 Conferences				
EuMC + EuMIC + EuRAD	€ 1140	€ 520	€ 1600	€ 740

WORKSHOP AND SHORT COURSE FEES (ONE STANDARD RATE THROUGHOUT)

FEES	STANDARD RATE			
	Society Member (*any of above)		Non Member	
	Standard	Student/Sr.	Standard	Student/Sr.
Half day WITH Conference registration	€ 100	€ 80	€ 130	€ 100
Half day WITHOUT Conference registration	€ 130	€ 100	€ 170	€ 130
Full day WITH Conference registration	€ 140	€ 110	€ 180	€ 130
Full day WITHOUT Conference registration	€ 180	€ 140	€ 240	€ 170

SPECIAL FORUM FEES

	ADVANCED RATE (UP TO & INCL 30TH AUG)	
Automotive Forum Monday 30th September	€ 260 For Delegates (those registered for EuMC, EuMIC or EuRAD)	€ 360 For All Others (those not registered for a conference)
	STANDARD RATE (FROM 31ST AUG & ONSITE)	
	€ 320 For Delegates (those registered for EuMC, EuMIC or EuRAD)	€ 420 For All Others (those not registered for a conference)
	ONE STANDARD RATE THROUGHOUT	
Defence, Security and Space Forum Wednesday 2nd October	€ 20 For Delegates (those registered for EuMC, EuMIC or EuRAD)	€ 60 For All Others (those not registered for a conference)

EUROPEAN MICROWAVE WEEK WORKSHOPS & SHORT COURSES

SUNDAY 29th September		
Full Day	WS-01	EuMC/EuMiC
Full Day	WS-02	EuMC/EuMiC
Full Day	WS-03	EuMC
Full Day	WS-04	EuMC
Full Day	WS-05	EuMC
Half Day AM	WS-06	EuMC
Half Day PM	WS-07	EuMC
Full Day	WS-08	EuMC/EuMiC
Full Day	WS-09	EuMC
Full Day	SS-01	EuMC
Half Day AM	SS-02	EuMC/EuMiC

THURSDAY 3rd October		
Half Day AM	WTh-01	EuRAD
Full Day	WTh-02	EuMC/EuRAD

MONDAY 30th September		
Half Day AM	WM-01	EuMC/EuMiC
Half Day PM	WM-02	EuMC
Full Day	WM-03	EuMC
Full Day	WM-04	EuMC/EuMiC
Full Day	WM-05	EuMC
Full Day	WM-06	EuMC
Half Day AM	WM-07	EuMC
Half Day PM	WM-08	EuMC
Half Day AM	WM-09	EuMC/EuMiC
Half Day PM	SM-01	EuMC

TUESDAY 1st October		
Half Day AM	STu-01	EuMC

WEDNESDAY 2nd October		
Full Day	WW-01	EuRAD
Full Day	WM-02	EuRAD

FRIDAY 4th October		
Half Day AM	WF-01	EuRAD
Full Day	WF-02	EuMC
Half Day AM	SF-01	EuRAD

OTHER ITEMS

Proceedings on USB Stick

All papers published for presentation at each conference will be on a USB stick, given out FREE with the delegate bags to those attending conferences. The cost for an additional USB stick is € 50.

Partner Programme and Social Events

Full details and contacts for the Partner Programme and other Social Events can be obtained via the EuMW website www.eumweek.com.

SPECIAL SESSIONS

Date	Time	Title	Location	No. of Days	Fee
Tuesday 1st October and Wednesday 2nd October	08:30 - 17:50	European Microwave Student School	Room 746 - Tuesday Booth by Reg. Desk - Wednesday	1 full day & 2 half-days	€ 40
Tuesday 1st October and Wednesday 2nd October	13:50 - 17:50 Tuesday 09:00 - 17:50 Wednesday	European Microwave Doctoral School	Room 741BC - Tuesday Booth by Reg. Desk - Wednesday	1 half-day & 2 half-days	€ 80

Product Catalog 2019

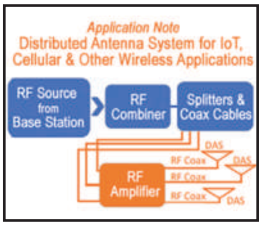
AnaPico is a technology leader developing, manufacturing and supplying RF and microwave test & measurement instruments for a wide range of civilian and governmental applications. The company's updated product catalog includes a selection of their product line:

- RF and microwave signal generators up to 40 GHz
- Standard and customized frequency synthesizer modules
- Signal source analyzers and phase noise analyzers up to 40 GHz

All products are manufactured and 100 percent tested in Switzerland.

AnaPico Ltd.
www.anapico.com

DAS for IoT, Cellular and Wireless Applications



The rapid growth in IoT promises lucrative business opportunities. In places where traditional distribution services cannot provide the required signal strength, Distributed Antenna System (DAS) can be used. By deploying a robust and economical DAS system, governments or businesses can ensure robust support for IoT within their facilities and be positioned to deliver critical wireless services now and in the future. AR's process of choosing the right amplifiers and antennas for your DAS requirements helps you select the right system for your application.

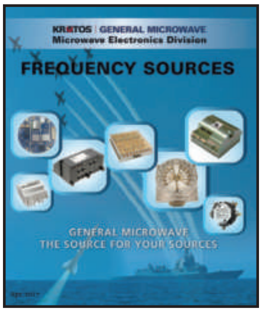
AR RF/Microwave Instrumentation
www.arworld.us/html/appNote-request.asp?appnote=78

Selection Guide 2019

Get the technical information you need on over 160+ high performance RF and microwave MMIC products including amplifiers, attenuators, mixers, multipliers, phase shifters and switches and much more. Learn why Custom MMIC is a RF and microwave MMIC innovation and performance leader in the industry. Also explore the company's space product screening and qualification capabilities that they offer their valued customers.

Custom MMIC
www.custommmic.com/resources/custom-mmic-brochure-web.pdf

Frequency Sources Short Form Catalog



General Microwave Corp. has designed and manufactured cutting edge microwave frequency sources since 1987. This Short Form Catalog includes sources ranging from free running voltage and digitally controlled oscillators to fast (1 usec) indirect synthesizers, company profile and a wideband frequency modulation applications and techniques tutorial. Specially featured is the Series SM60 family of fast indirect synthesizers capable of analog and digital frequency modulation while center frequency remains in the pure locked mode.

General Microwave Corp.
www.kratosmed.com

New Product Catalog

K&L Microwave designs and manufactures a full line of RF and microwave filters, duplexers and subassemblies, including ceramic, lumped element, cavity, waveguide and tunable filters. K&L supplies many of today's most significant military and homeland security electronics programs. Applications include space flight, radar, communications, guidance systems and mobile radio base stations, as well as air traffic communication and control. Visit their website to download the complete catalog or sections of interest.

K&L Microwave
www.klmicrowave.com

New Product Guide – Q1

Mini-Circuits released over 400 models in 2018, and the company continues to develop new products at a rapid clip. Their Q1 2019 product guide highlights some of the latest additions to their portfolio to keep you informed. Highlights include new hi-rel ceramic MMIC amplifiers, wideband MMIC gain slope equalizers, LTCC filters with rejection up to 45 dB, ultra-wideband coaxial couplers and splitters up to 40 and 50 GHz and more.

Mini-Circuits
www.minicircuits.com

CatalogUpdate

Solutions for 4G and 5G

Pivotone specializes in designing, manufacturing and selling RF/microwave and mmWave components, devices and module products used in 4G and 5G applications including wireless base stations, indoor coverage and network optimization systems, microwave point-to-point communication systems, IoT and SATCOM equipment. Products include low PIM filters and diplexers; dielectric filters; multiplexers, combiners and POI; TMA, RRU/RRH; RF multiport antenna; 5G MIMO antenna; off-the-shelf products; microwave filter and diplexers; microwave couplers, OMT, isolators and integrated modules. Product technology covers frequency ranges up to 90 GHz and beyond.

Pivotone Communication Technologies Inc.
www.pivotone.com

Short Form Hermetically Sealed Adapters

The new catalog, issued April 2019, shows the updated product spectrum. To the N, TNC and 2.92 mm series the 2.4 mm and 1.85 mm units were added. The standard Hermeticity specifies 10^{-8} atm. cm^3/s minimum. As several applications do not need this high class hermeticity, more economical priced products with hermeticity of 10^{-5} atm. cm^3/s were added. All adapters use fused in glass seals between center contact and outer conductor. The adapters are normally used at vacuum chambers testing products that are undergoing tests for outer space applications.

Spectrum Elektrotechnik GmbH
www.spectrum-et.com

Updated Catalog

VENDORVIEW

Spectrum Instrumentation have introduced eight brand new arbitrary waveform generators (AWG) to their 2018/2019 print and PDF catalog. These new "65" series AWGs are optimized for signal quality, size and cost. They use the latest 16-bit digital-to-analog converters and a card length of only 168 mm to fit into nearly every PC, turning it into a highly flexible signal source with 40 or 125 MS/s and 1 to 8 channels per card. Download or order the catalog on their website.

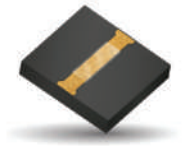
Spectrum Instrumentation
www.spectrum-instrumentation.com

NEW PRODUCTS

FOR MORE NEW PRODUCTS, VISIT WWW.MWJOURNAL.COM/BUYERSGUIDE
FEATURING VENDORVIEW STOREFRONTS

COMPONENTS

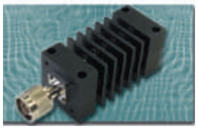
Transmission Line Capacitors



AVX Corp. introduced a new line of ultraminiature, thin film transmission line capacitors for high frequency links, DC blocking in the UHF range (300 MHz to 3 GHz) and other high performance RF/microwave applications. The new capacitors have a novel metal-insulator-metal (MIM) structure, copper traces for optimal circuit conductivity, a transmission line wire-bond pad, a gold-metallized backside ground and can be supplied on a variety of low loss substrates, including quartz, alumina, glass and silicon.

AVX Corp.
www.avx.com

DC to 6 GHz Termination

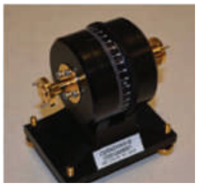


BroadWave Technologies announced a new termination with an operating frequency range of DC to 6 GHz. Model 552-313-030 is a 50 Ω convection cooled RF termination designed for lab and field applications. The unit has an average power rating of 30 W with 1.5:1 maximum VSWR. The temperature range is –40°C to +40°C and RF connector is N male. Other RF connector types and genders are available in this package.

BroadWave Technologies, Inc.
www.broadwavetechnologies.com

Direct Reading Phase Shifters

VENDORVIEW



Cernexwave's CDS Direct Reading Phase Shifters provide highly accurate measurement of phase shift from 0° to 360° over each full waveguide band from 26.5 to 110 GHz. They feature low VSWR, low insertion loss and low variation of insertion loss due to the rotation of the phasing section. The WR-12 Model CDS12609001 has an accuracy of less than 3°, an insertion loss of less than 1.3 dB and a VSWR of 1.3:1 all the way from 60 to 90 GHz.

Cernex/Cernexwave
www.cernexwave.com

High Inductance Shielded Power Inductors

Coilcraft's new XAL7050 Series of high temperature power inductors is available with inductance values from 22 to 47 µH and current ratings as high as 5.5 A, with low DCR for greater efficiency. For lower inductance values, Coilcraft offers a lower-profile companion, the XAL7030, with an identical footprint and inductance range of 0.16 to 10 µH. The XAL7050 features RoHS-compliant tin-silver (96.5/3.5) over copper terminations and offers a maximum reflow temperature of 260°C. COTS Plus tin-silver-copper and tin-lead terminations are also available.

Coilcraft
www.coilcraft.com

60 to 90 GHz Block Down-Converter

Model SNG-12-01 is a full E-Band block down-converter. Its primary function is to extend the testing capability of low cost, low frequency noise figure meters. It also allows noise figure testing of E-Band devices without a noise figure meter, using the Y-factor method. The block down-converter is also versatile for use with various other applications. With a low cost design, Model SNG-12-01 is an affordable expansion to mmWave labs that do not have the budget for large scale equipment.

Ducommun
www.ducommun.com

Relay Controlled Programmable Attenuators

Fairview Microwave Inc. has introduced a new line of relay controlled programmable attenuators that offer accurate and stable performance with very low harmonic distortion (IMD) and cover multiple RF frequency bands down to DC. They are popular for use in military and commercial satellite and ground communication systems, cable modem and cellular telephone testing, radar, telecommunications and automatic test equipment (ATE). Typical applications include signal conditioning and level control, matching impedances of sources and loads and measuring the gain or loss of two-port devices.

Fairview Microwave Inc.
www.fairviewmicrowave.com

mmWave Controlled Components

General Microwave Corp. is a key partner with major OEMs and primes, having been chosen for their broad and comprehensive understanding of mmWave controlled components. General Microwave offers a wide range of mmWave products operating in the 18 to 40 GHz frequency range including catalog attenuators, switches and phase shifters as well as integrated microwave assemblies. If it is a standard catalog unit or a highly customized mmWave product designed specifically for high performance, General Microwave can provide products to support your requirements.

General Microwave Corp.
www.kratosmed.com

Broadband SMA Couplers 6 to 18 GHz

VENDORVIEW

MECA announced the addition of broad band miniature SMA couplers in 10, 20 and 30 dB models covering 6 to 18 GHz, 50 W (2 kW peak), offering typical electrical performance of 0.5 dB insertion loss, VSWR of 1.35:1 and a minimum directivity of 15 dB. In addition to its extensive line of miniature couplers covering up to 50 GHz. Made in U.S. with 36 month warranty.

MECA Electronics Inc.
www.e-MECA.com

MMIC Surface Mount Directional Coupler

VENDORVIEW

Mini-Circuits' EDC10-183+ is a 10 dB directional coupler that operates from 6 to 18 GHz packaged in MCLP 4 × 4 mm, 24-lead package. It provides excellent coupling flatness over a broad bandwidth and good return loss. This coupler also provides a quadrature phase shift between the signal at the through port and coupler port. Manufacturing using GaAs technology, this model results in relatively high repeatablility in performance.

Mini-Circuits
www.minicircuits.com

1.8 GHz 2 Wire 1:1 Transformer

VENDORVIEW

Need a very low insertion loss balun (1 dB max) with 23 dB return loss and 2 GHz BW? The MRFXF 6713 in MiniRF's 0.15 × 0.15 package is the right choice. Do not settle for a lab queen; obtain proven repeatable products from MiniRF that still provides excellent and phase amplitude between ports.

MiniRF
www.minirf.com

Capacitors

Passive Plus Inc. (PPI) is offering the 0708N (0.065 × 0.08 in.) series capacitor. With vertical electrodes which increase bandwidth, these capacitors have low ESR/ESL and high self-resonance. Uniquely designed for excellent heat transfer in high RF applications, the 0708N offers ultra-stable performance over temperature. These capacitors are 100 percent RoHS compliant and also available in tin/lead termination.

Passive Plus Inc.
www.passiveplus.com

4 to 5 GHz Limiter

VENDORVIEW

PMI Model No. LM-4G5G-1W-SFM is a limiter that operates over the frequency range of 4 to 5 GHz. It has a maximum insertion loss of 1 dB and a maximum VSWR of 1.5:1. This model is outfitted with a SMA female connector and a SMA male connector and in a housing that measures 0.51 × 0.51 x 0.31 in.

Planar Monolithics Industries Inc.
www.pmi-rf.com

GT Series Coaxial DC Pass RF Surge Protection

VENDORVIEW

The GT (Gas Tube) series of RF DC pass broadband surge arrestors are value-priced and applicable to many general applications. Products offer excellent VSWR and superior RF performance for equipment operating between DC and 7 GHz. They are available in a variety of connector options, for 50 and 75 Ω RF networks. Replaceable gas-tube options are also available.

PolyPhaser
www.polyphaser.com

New**Products**

SPDT Switch

RLC Electronics introduces an addition to their miniature SPDT switch product line. This switch is offered in a unique package with connectors in a "T" configuration for ease of connection/mating at the system level, and is a perfect drop-in replacement for pin diode switches. The switch is offered in both surface mount and connectorized versions and operates from DC to 18 GHz. Standard options available include indicators and TTL Drivers. The switch measures 1 × 1 × 0.9 in.

RLC Electronics Inc.
www.rlcelectronics.com

Optocouplers

Vishay Intertechnology Inc. broadened its optoelectronics portfolio with the release of two new optocouplers with a phototriac output in the compact flat SOP-4 package. Featuring high off-state voltage of 800 V and dV/dt of 1000 V/μs, the Vishay Semiconductors VOT8024AM and VOT8121AM deliver high robustness and noise isolation for home appliances and industrial equipment. The optocouplers announced isolate low voltage logic from 120, 240 and 380 VAC lines to control resistive, inductive or capacitive loads, including motors, solenoids, high current thyristors or TRIACs and relays.

Vishay Intertechnology Inc.
www.vishay.com

CABLES & CONNECTORS

High Temp Cable Assemblies

MilesTek's high temp cable assemblies feature FEP jackets that are rated for a wide temperature range of –55°C to +150°C and a double shielded cable with both 100 percent foil and 85 percent braid shields that provide maximum EMI and RFI protection. These cables are offered off-the-shelf in Cat6a, Cat5e and Cat5e slim construction versions and comply with all RoHS directives. Furthermore, the fire properties of these Ethernet cables meet FAR (Federal Aviation Regulation), Airbus and Boeing requirements.

MilesTek
www.milestek.com

Ruggedized Industrial Cable Assemblies

NAI announced an expansion of their design and manufacturing capabilities to produce ruggedized industrial cable assemblies, box and panel builds. This expansion supports industrial technology companies in industries such as industrial controls, communications, test & measurement, instrumentation and machinery, to name a few. The industrial IoT (IIoT), facilitates the innovation and growth of these companies, as this macro trend reshapes manufacturing with a focus on automation, connectivity and sensing.

NAI
www.nai-group.com

AMPLIFIERS

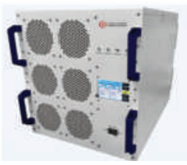
GaN Amplifier

COMTECH PST introduced a new GaN amplifier for applications in the X-Band radar market. The AB linear design operates over the 9.2 to 10 GHz frequency range intended for use in radar applications. The amplifier design features include options for control of phase and amplitude to allow for integration into high-power systems utilizing conventional binary or phased array combining approaches for power levels of up to 10 kW.

COMTECH PST
www.comtechpst.com

Solid-State Power Amplifier System

VENDOR**VIEW**



Exodus Advanced Communications introduces a high-power 10 kHz to 250 MHz 600 W amplifier. Exodus AMP2080DA provides 600 W minimum power with a minimum gain of 58 dB. The unit has excellent gain flatness, < 5 usec switching speeds for enable/disable functions. Included are amplifier monitoring parameters for forward/reflected power, as well as voltage, current and temperature sensing for optimum reliability and ruggedness for all applications. Nominal weight is 80 lbs and dimensions of 19 × 24 × 17.5 in.

Exodus Advanced Communications
www.exoduscomm.com

650 V GaN E-HEMTs

Richardson RFPD Inc. announced the availability and full design support capabilities for a new family of 650 V GaN E-HEMTs from GaN

Systems Inc. The GS-065-0xx-1-L devices are ideal for low power applications, including charging, power supplies, lighting and appliances. Some features are industry standard 5 × 6 mm PDFN packages, assembly using standard SMT process, scalable: 3.5 to 11 A in the same footprint, fast, clean switching speed, high switching frequency (20 MHz+) and low switching losses.

Richardson RFPD Inc.
www.richardsonrfpd.com

SOURCES

Low Noise Signal Source

The FCPH-1950-13 is a self-programmable, plug and play ready, low noise signal source for single frequency applications. This model multiplies a stable 13 MHz reference input frequency to 1950 MHz with output power of 0 dBm minimum, and reaches phase noise of –116 dBc/Hz at 10 kHz offset with ultimate floor nearing –165 dBc/Hz at carrier offset frequencies of more than 1 MHz. This versatile product is ideal for high speed clock translators in ADC, DAC and DDS clocks for improved signal purity or for the front-end source in block frequency up-/down-converters. It comes in a surface mount package measuring 0.94 × 0.94 × 0.23 in.

Synergy Microwave Corp.
www.synergymwave.com

Fixed Frequency Synthesizer

VENDORVIEW

Z-Communications Inc. announced a new RoHS compliant fixed frequency phase locked loop model SFS1520C-LF operating in the L-Band. The SFS1520C-LF is a plug and play PLO allowing for quick integration and designed to produce a fixed signal at 1520 MHz when utilized with an external 10 MHz reference oscillator. This simple to use PLO features a typical low phase noise performance of –100, –110 and –133 dBc/Hz at the 1, 10 and 100 kHz offsets, respectively.

Z-Communications Inc.
www.zcomm.com

SOFTWARE

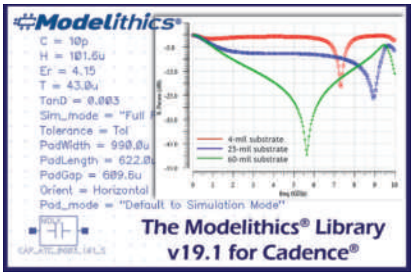
Kaelus Unify

Kaelus Unify provides remote visibility of all test & measurement instruments through an easy-to-install software application. PC, tablet or mobile workstation users now have real-time monitoring of each Kaelus test & measurement instrument. Kaelus Unify provides test & measurement support through both the mobile app and online portal. The Kaelus Unify mobile app controls the iPA, iTA and iVA, while the Kaelus Unify Portal allows real-time monitoring of each test & measurement device.

Kaelus
www.kaelus.com

Modelithics Library™

VENDORVIEW



Modelithics Inc. announced support for additional electronic design automation (EDA) tools with the new Modelithics Library™ for the Cadence® Spectre® RF Option and Virtuoso® RF Solution. The library was developed through collaboration with Cadence Design Systems Inc. to make Modelithics Microwave Global Models™ available to designers using these Cadence solutions. The new Modelithics Library, v19.1, brings an extensive collection of precision measurement-based, scalable RF and microwave simulation models to designers.

Modelithics Inc.
www.Modelithics.com

IsoPro 2019

IsoPro 2019 is the intelligent, automated tool path generator. It incorporates machine motion control functions supporting automatic tool change with intelligent feed and speed routines. IsoPro 2019 provides simple control of your Quick Circuit milling, drilling and routing operations. It is compatible with Windows 7—10 × 64. Some of the newly added and updated features include compatible with All Quick Circuit from 1990 or 29 years, airline pressure monitoring and adjustable PSI settings and contact by touch sensing for programable tool offsets.

T-Tech Inc.
www.t-tech.com

MATERIALS

Electrically Conductive Adhesive

Dow introduced new DOWSIL™ EC-6601 electrically conductive adhesive, a next-generation material engineered for reliable performance and electromagnetic compatibility (EMC) in demanding electrical and electronics applications in the transportation, communications and consumer markets. This novel adhesive combines strong electromagnetic interference (EMI) shielding capabilities across a wide range of frequencies with durable mechanical and conductive properties over time, underscoring how Dow is further growing its highly differentiated EMI shielding solutions portfolio.

Dow
www.dow.com

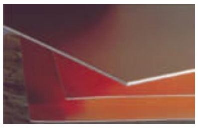
40-3906 Silver Filled Epoxy Adhesive

Most assemblies that use electrically conductive epoxy adhesives require 24 hours of cure time or the use of elevated temperatures for faster setting times. The 40-3906 is thin film set within 90 minutes at room temperature and within six hours is close to full hardness. This product has a unique combination of a quick cure speed and a reasonable working time of 30 minutes. 40-3906 is solvent-free and filled with unique silver particles.

Epoxies Etc.
www.epoxies.com

TC350 Plus Laminates

VENDORVIEW



Rogers Corp. introduced TC350 Plus laminates. TC350™ Plus laminates are ceramic filled PTFE-based woven glass reinforced composite materials providing a cost effective, high performance, thermally enhanced material for the circuit designer. With a thermal conductivity of 1.24 W/mK, this next-generation PTFE-based laminate is ideally suited for higher power microwave and industrial heating applications requiring higher maximum operating temperatures, low circuit losses and excellent thermal dissipation within the circuit board.

Rogers Corp.
www.rogerscorp.com

ANTENNAS

mmWave Waveguide Antennas

VENDORVIEW

Pasternack has released a new line of waveguide antennas designed to address R&D, military/aerospace, experimental radar, test & measurement and wireless communication applications from 40 to 220 GHz. Pasternack's new line of mmWave waveguide antennas consist of 85 new models that cover broad frequency ranges of 40 to 220 GHz, feature waveguide sizes ranging from WR5 to WR19 and offer gain ranging from 3.5 to 25 dBi nominal.

Pasternack
www.pasternack.com

MICRO-ADS

BookEnd

Applications of Modern RF Photonics

Preetpaul Singh Devgan

This unique new resource presents applications of modern RF photonic systems that use RF photonic components for commonly used signal processing systems. This book provides insight into how a variety of systems work together, including RF down-conversion, analog to digital conversion, RF oscillators and frequency identification. A comparison of analog versus digital systems is presented. Readers find in-depth coverage of analog delay lines using RF photonics, various system architectures and details about RF photonic component performance. Signal processing utilizing RF photonics and the need for down-conversion is discussed. The many advancements in analog delay line performance are explained, including those in photodetector, optical fibers and optical and amplifier modulators.

The book highlights the advantages of using oscillators utilizing RF photonics and explores the elements of phase noise, timing jitter and optoelectronic oscillators. The benefits of signal identification, isolation and separation of RF photonics are identified. Professionals are brought up to speed on RF frequency identification using optical injection locking. The book provides discussions on the fundamentals and advancements in integrated RF photonics and explains how to design an RF photonic down-converter. It covers additional applications of integrated photonic circuits and gives an explanation of why to use different modulation formats for different applications.

To order this book, contact:

Artech House
www.artechhouse.com
Email: artech@artechhouse.com
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The 2019 Defence, Security & Space Forum

At European Microwave Week

EuMA Microwave Journal

Wednesday 2 October – Porte De Versailles, Paris, France – 08:30 to 18:30, Room N01

A one-day focused Forum addressing New Radio Architectures: The Evolution of Satellite Constellations.

Programme:

08:30 – 10:10 **EuRAD Opening Session**

10:10 – 10:50 **Coffee Break**

10:50 – 12:40 **Challenges in Satellite Constellations and Impact on Communications Technologies**

12:40 – 13:40 **Strategy Analytics Lunch & Learn Session**
The Implications of Expanding the UAS Mission Envelope in Military and Civilian Airspace
Asif Anwar, Strategy Analytics, UK

13:50 – 15:30 ***Microwave Journal* Industry Session**
- High Throughput Satellite – Test & Measurement Challenges for the Next Generation Communication Satellites – Rohde & Schwarz
- Next Generation X- to Ku-Band MMIC's – OMMIC
- Next Generation Radio Architectures for Satellite Communications – Qorvo

15:30 – 16:10 **Coffee Break**

16:10 – 17:30 **Round Table: Concepts, Technologies and Systems Addressing Ultra-High Capacity and Data Traffic for Future Wireless Communications**

17:50 – 18:30 **Cocktail Reception**
The opportunity to network and discuss informally the issues raised throughout the Forum.

Registration and Programme Updates

Registration fee is €20 for those who registered for a conference and €60 for those not registered for a conference.
As information is formalized, the Conference Special Events section of the EuMW website will be updated on a regular basis.

Register online at www.eumweek.com

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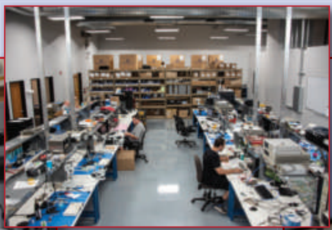
How Do You Define Value? Signal Hound



Signal Hound, the test and measurement (T&M) company with a mission to provide capable and affordable RF/microwave instruments, would not have been born if Bruce Devine had passed an aptitude test. While an E6 sergeant in the Air Force, he was considered for the job of software programmer. But he failed the aptitude test, and so was assigned to a measurement lab calibrating test equipment. Devine took to the work, developing a passion for metrology and RF, and was promoted to lab chief, overseeing calibration labs in Korea and Arizona. Planning for life after the service, he started a side business buying, selling and repairing used test equipment—at night, as he was supervising calibration labs during the day. This demanding routine lasted six long years, from 1996 until 2002.

After retiring from the Air Force, Devine moved to Washington state to devote his energy to this side business, Test Equipment Plus (TEP). Repairing equipment naturally leads to redesigning, and he saw the opportunity to develop a low cost spectrum analyzer, one delivering "good" performance for a compelling price. The SA44 analyzer was introduced in 2010, the first Signal Hound product and first USB instrument. At the time, the T&M market was well served by very high performance and expensive equipment, yet no one was addressing the need for value. The Signal Hound product family emerged from Devine's new passion and, in 2014, market success led the company to be renamed Signal Hound.

Signal Hound's product concept is straightforward: not every test requires the highest frequency, highest resolution instrument. Signal Hound aims to deliver accurate measurements for a fraction of the cost of the high-end equipment, focusing on the components and features that set measurement accuracy and eliminating all the nonessential elements that add cost. Signal Hound has successfully repeated this strategy from that first spectrum analyzer to a family of spectrum analyzers, signal generators and tracking generators, supported with spectrum analysis, calibration and application software.

By pioneering the value segment of the T&M market, Signal Hound has made high performance test equipment accessible to many small companies, as well as enabling larger companies to deploy much more equipment throughout their R&D labs and manufacturing lines. Inspired by Signal Hound's success, other T&M companies have entered this segment; however, the competition has not fazed Devine. He and his team continue to respond to customer needs with innovative and affordable instruments. To support the growth, Signal Hound recently moved into a 20,000 square foot facility in Battle Ground, Wash., filling half the space, with room to double the size of the company.

Signal Hound's mission to provide value to customers extends beyond price and performance. Orders can be placed online and are usually shipped the same day—no later than the next day—as the company keeps a healthy stock of inventory and has 16 international distributors to support customers outside the U.S. All instruments have a two-year warranty and 30-day money back guarantee. If a customer finds an instrument will not meet the need and returns it within 30 days, Signal Hound will refund the price less shipping costs. That is quite a commitment, reflecting confidence in the quality and value of Signal Hound's products.

Bruce Devine has proven that affordability and performance are not contradictory. His many satisfied customers appreciate that and are thankful he failed that aptitude test.

www.signalhound.com

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Keynotes, Technical Sessions & Workshops/ Product Demos

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Mike Violette


Anil Pandy


Caroline Chan


Eli Bookner


Eric Bogatin


James Drewniak


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Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	Phase Balance (±°)	VSWR	Connector Type
D10119	4-Way	700-4200	2,000	0.3	6	1.35	13-30 DIN-Female, N-F
D8182	5-Way	1175-1375	1,500	0.4	2	1.35	1 5/8" EIA, N-F
D8454	8-Way	370-450	10,000	0.25	5	1.30	3 1/8" EIA, N-F
D9816	8-Way	330-530	10,000	0.25	5	1.30	3 1/8" EIA, N-F
D9710	8-Way	1000-2500	2,000	0.3	5	1.40	1 5/8" EIA, N-F
D9529	8-Way	2305-2360	1,000	0.2	5	1.15	7/16-Female, N-F
D9528	8-Way	2305-2360	2,000	0.2	5	1.15	7/8" EIA, N-F
D10851	8-Way	2400-2500	8,000	0.2	5	1.25	WR340, 7/16-F
D5320	12-Way	470-860	500	0.3	5	1.30	All N-Female
D11028	16-Way	2305-2360	2,000	0.2	5	1.15	1 5/8" EIA, N-F
D6083	16-Way	2310-2350	2,000	0.2	5	1.15	7/8" EIA, SMA
D11433	16-Way	2700-3500	2,000	0.3	3	1.35	WR284, N-F
D11815	16-Way	2700-3750	6,000	0.3	3	1.35	WR284, N-F
D9582	16-Way	3100-3500	2,000	0.25	6	1.50	WR284, N-F
D11839	16-Way	5300-5900	10,000	0.15	5	1.40	WR159, QD 7/16-M
D6857	32-Way	1200-1400	4,000	0.5	5	1.35	1 5/8" EIA, N-F
D10795	32-Way	900-930	25,000	0.25	3	1.30	WR975, 4.3-10-F