Vol. 56 • No. 12

December 2013

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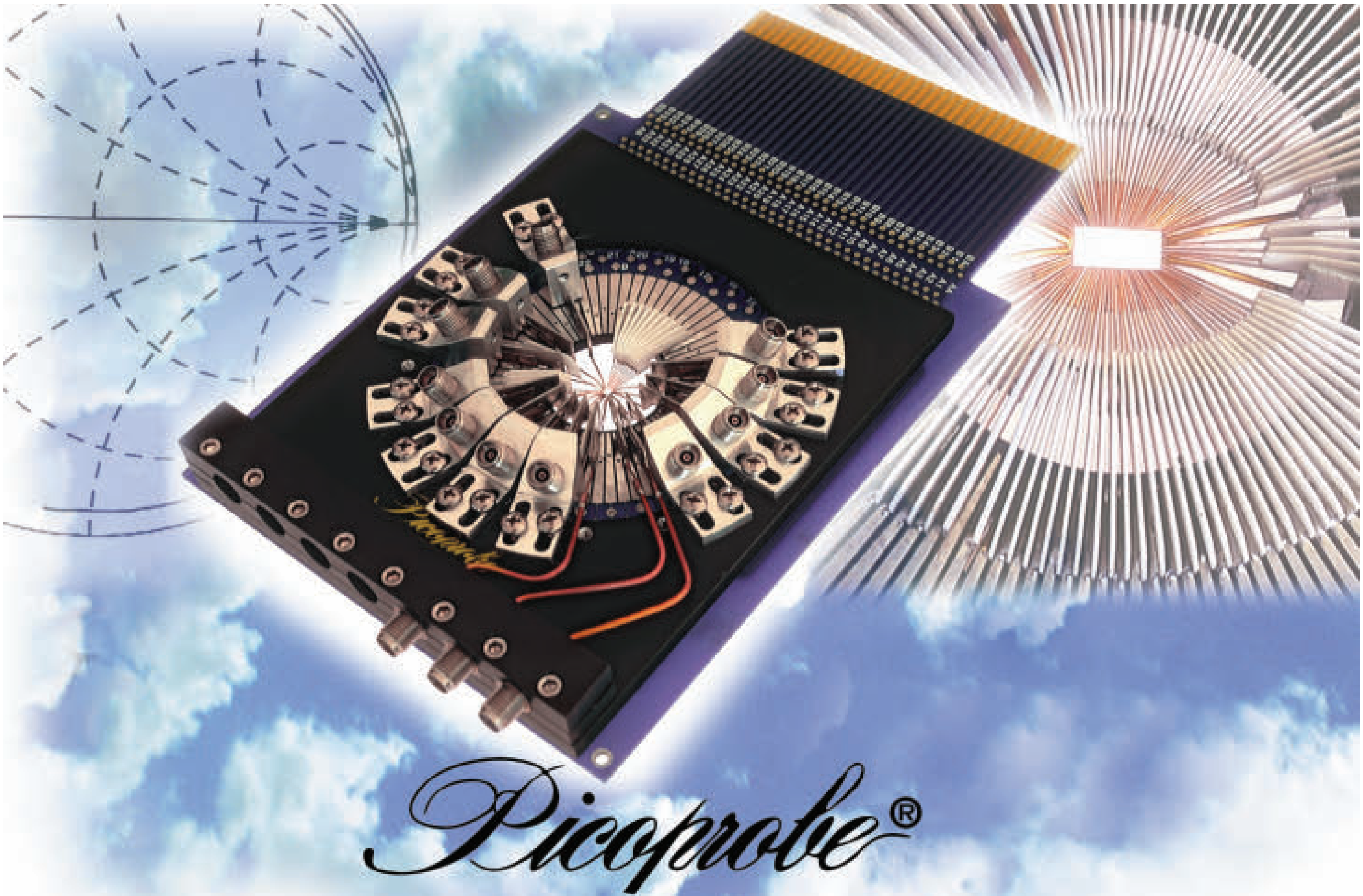

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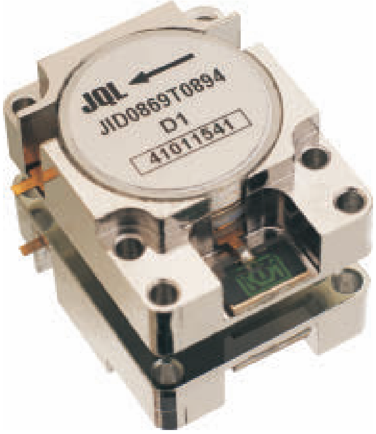

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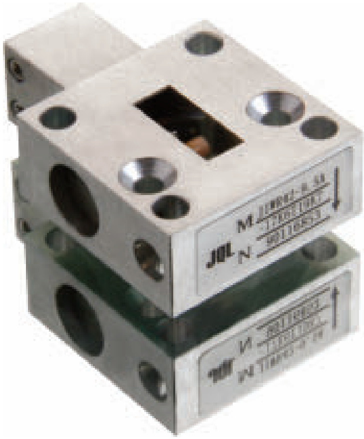

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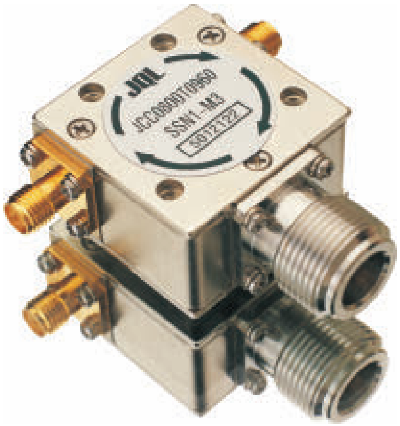

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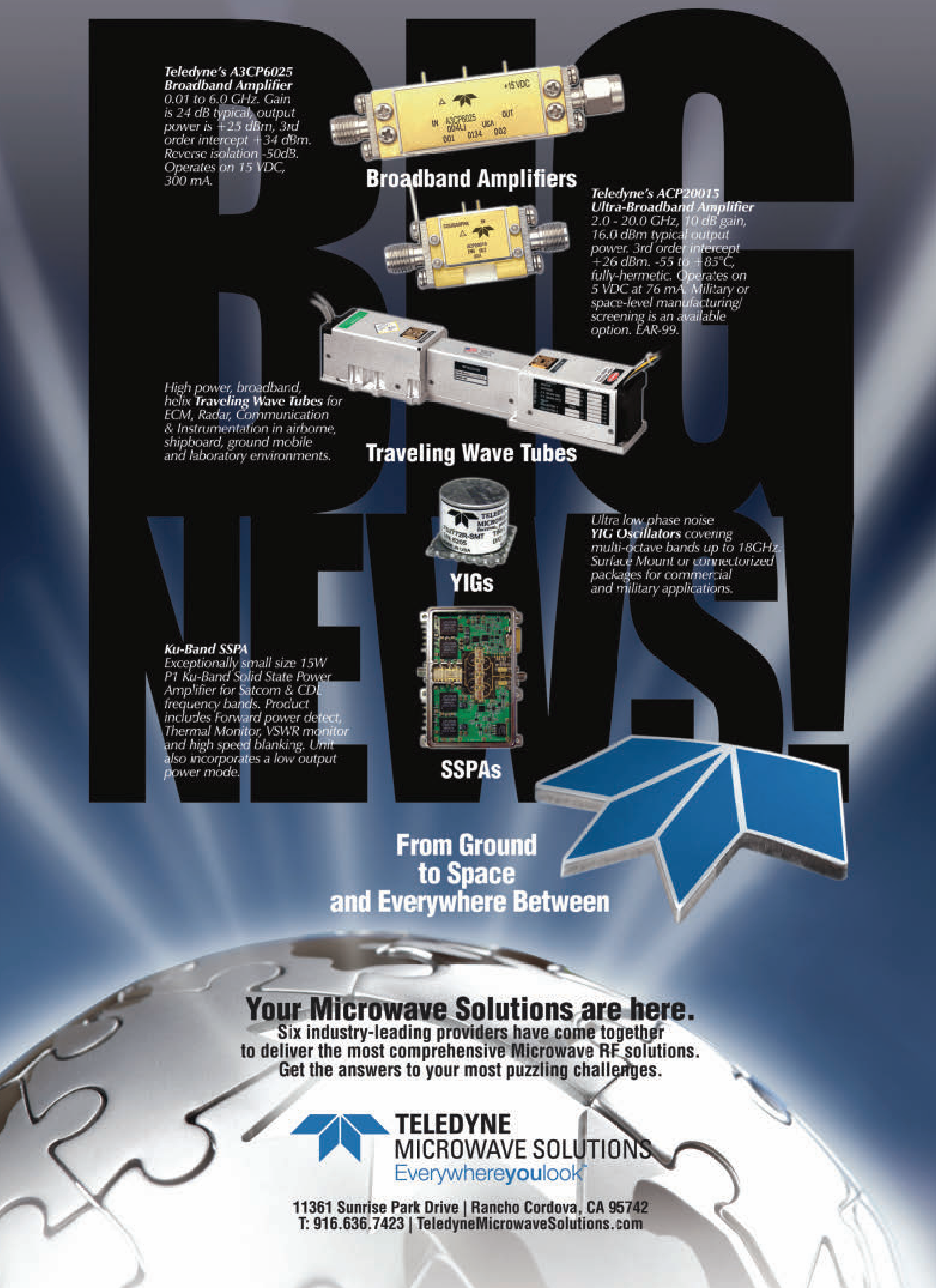
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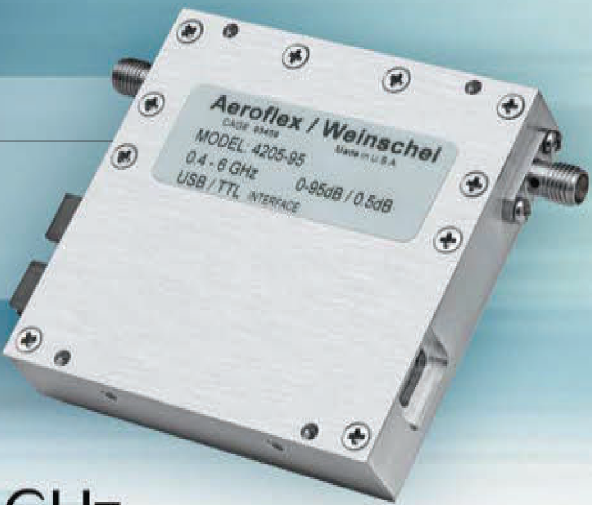

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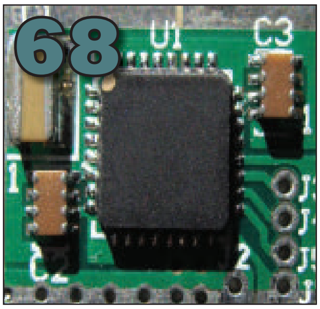

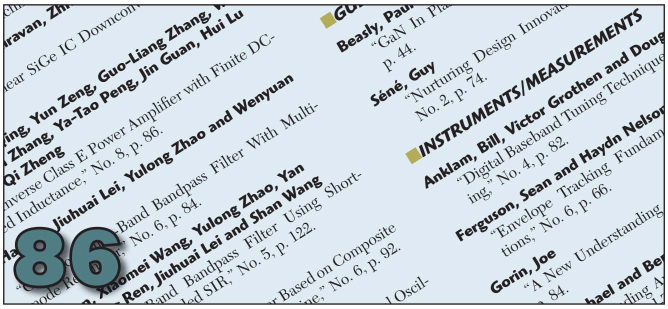

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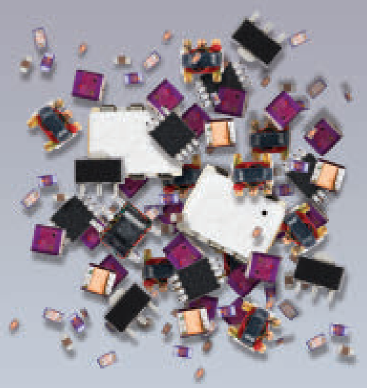

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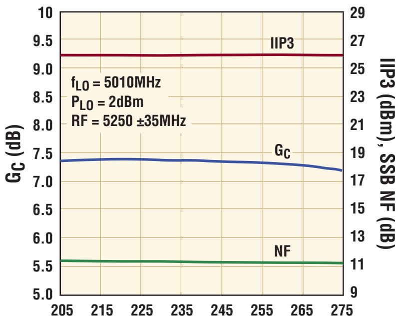

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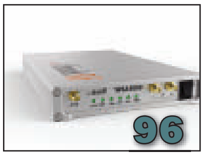

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Executive Interview

Rick Hess, CEO of **Hittite Microwave Corp.**, discusses the company's new product priorities and strategies for continued growth.

Web Survey

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October Survey

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Two words – "Babe Magnet" [32 votes] (13%)

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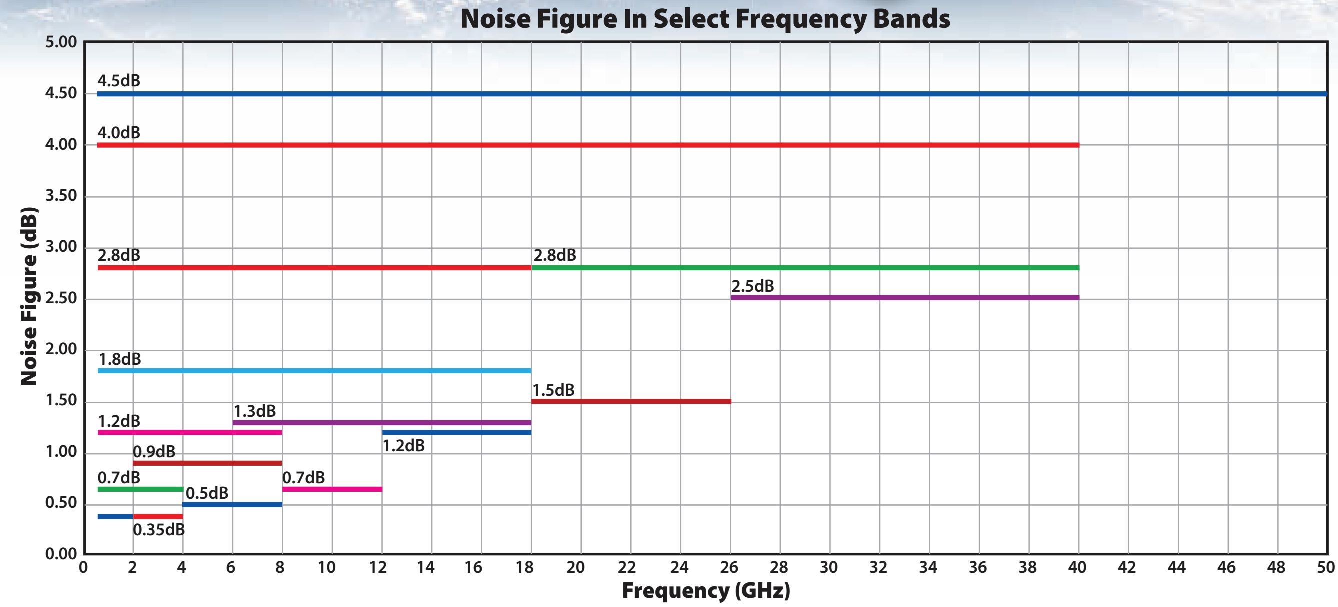

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5	6	7	8	9	10	11
12	13 **Call for Papers Deadline** RFIC 2014	14 **Webinar: Fundamentals of Troubleshooting RF and Microwave Systems in the Field** Sponsored by Agilent Technologies	15	16	17	18
19 ←	20 Radio Wireless Week (RWW)	21 IEEE	22 → **Webinar: Fundamentals of Noise Figure Measurements** Sponsored by Agilent Technologies	23 **Webinar: Carrier Aggregation: Fundamentals and Type of Deployments** Sponsored by Agilent Technologies	24	25
26	27	28 ←	29 DesignCon 2014	30	31 →	1

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www.ieee-aemc.org

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SPACOMM 2014
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www.iaria.org

MWC 2014
Mobile World Congress
February 24–27, 2014 • Barcelona, Spain
www.mobileworldcongress.com

NATE UNITE 2014
Annual Conference for the National Association of Tower Erectors
February 24–27, 2014 • San Diego, CA
www.natehome.com/annual-conference

MARCH

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www.isqed.org

SATELLITE 2014
March 10–13, 2014 • Washington D.C.
www.satellite2014.com

TAEECE 2014
2nd International Conference on Technological Advances in Electrical, Electronics and Computer Engineering
March 18–20, 2014 • Kuala Lumpur, Malaysia
www.sdiwc.net/conferences/2014/taeece2014

Microwave & RF 2013
March 19–20, 2014 • Paris, France
www.microwave-rf.com

ACES 2014
30th International Review of Progress in Applied Computational Electromagnetics
March 23–27, 2014 • Jacksonville, FL
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IWCE 2014
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www.iwceexpo.com

APRIL

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www.inmmic.org

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MAY

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83rd ARFTG Microwave Measurement Symposium
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IEEE Wireless and Microwave Technology Conference
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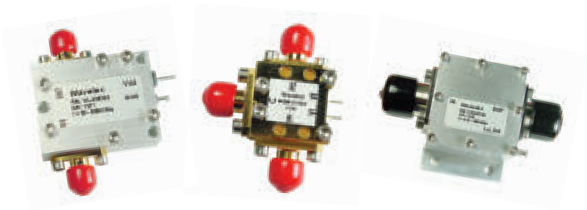

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The Year That Was...

DAVID VYE, *MICROWAVE JOURNAL* EDITOR

I was pleased to learn from a number of business leaders that 2013 was actually a pretty good year, ending with a strong finish despite a slow start. The companies that faired best were the ones with the right products for the complex systems that serve the public and private sectors. Suppliers to essential programs were often the ones who had invested in developing new technologies. 2013 offered many examples of technical innovation and we were pleased to publish these achievements. When it comes to technology, progress often occurs at the steady rate of Moore's law. Among the evolution of advanced materials, semiconductors, new circuit architectures and computational algorithms to support smarter, more efficient communication networks, this year had its share of watershed moments.

Many of these were reflected in this year's most popular articles online, including "Phase Noise Measurements and System Comparisons" by Rohde/Poddar of Synergy Microwave; "MIMO Radar: Demystified" by Brookner of Raytheon; RF CMOS technology "The New Mobile RF Front-end" by Carson/Brown of Qualcomm; "HTS Ka- vs. Ku-Band for Mission Critical SATCOM" by Pawling/Olds of Harris CapRock; and "Automotive Radar: From Its Origins to Future Ditrctions" by Meinel/Dickmann of Daimler AG.

Big developments for the mobile RFIC market were announced earlier in the year to coincide with Mobile World Congress. Several companies touted envelope tracking (ET) solutions to cover higher bandwidth architectures and future handset capabilities such as carrier aggregation, MIMO, and LTE-Advanced (LTE-A). Qualcomm achieved groundbreaking performance with a CMOS chip set solution that leveraged multiple innovations including a dynamic antenna matching tuner, envelope power tracking, an integrated PA/antenna switch and advanced 3D packaging. While the price or performance did not blow away products from other RF chip providers, the move did catch the attention of the industry, largely due to Qualcomm's size and position in this cut-throat market.

While Qualcomm discussed details of its technology in our June issue, Skyworks demonstrated its fully integrated single front-end module with a featured article in our August issue. The engineering challenges in today's RF front-ends was presented in our November supplement feature, "The Economics of GaAs and CMOS PAs" by Mobile Experts analyst Joe Madden. Next year, we will continue our look at evolving PA technology with a special report on performance enhancing techniques and a report on advances in multi-chip module technology and innovations in millimeter-wave packaging.

Semiconductor and packaging innovations are being driven by a multitude of emerging communication networks. LTE network deployments continued to grow rapidly worldwide with Time-division duplex (TDD) networks gaining more market traction. TD-LTE and LTE-A will dominate the LTE installed base of macro base stations as early as 2015 with SK Telecom, now upgrading its networks to LTE-A and China Mobile deploying a massive TD-LTE network (over 200,000 base stations). According to analysts from ABI research "LTE-A will progress in a phased rollout with carrier aggregation implemented first, followed by the eICIC, CoMP, Enhanced MIMO and HetNet support features which will all help operators address the upsurge in network traffic."

With China Mobile's massive deployment of base stations, the active antenna market heated up with roughly 500,000 beamforming antenna units deployed this year alone. Active antenna systems provide the necessary capacity boost in mobile networks when less expensive HetNet alternatives are not available. In the evolution of HetNet architecture, look for all different kinds of radio solutions: femtocells, picocells, microcells, metrocells, DAS systems, repeaters, and macro base stations, which will serve as the foundation for ongoing research into carrier Wi-Fi, backhaul and semiconductors for small cells.

In other sectors, the total market for open short-range wireless (SRW) ICs, including Bluetooth, Wi-Fi, ZigBee, NFC and GPS, reached nearly 5 billion units in 2013 and is expected to grow to 8 billion by 2018. SRW technologies enabled low-cost connectivity between devices, helping make 2013 the year that the Internet of Everything (IoE) became more of a reality. Fitting with this month's theme, the Millennium Research Group reported that RF and microwave ablation devices will be the fastest growing segment in the U.S. nonvascular interventional radiology device market. The microwave-enabled devices offer a minimally invasive alternative to traditional surgical treatment of various cancers. The increasing popularity of minimally invasive treatments should help the overall market to grow to $295 million by 2017.

Interest in China helped make the first ever Electronic Design Innovation Conference (EDI CON) a success in 2013. Participating companies helped define an event in which the technical program focused on practical design issues with content from industry for engineers. At EDI CON, companies presented educational information in live workshops, which provided a level of interaction not possible with white papers, educational videos or even webinars alone. This year, companies increasingly recognized that education is an essential part of developing new markets. Innovators are necessary to create and serve new markets. If 2013 proved that such innovators fared better during uncertain economic times, we look forward to helping spread the knowledge that produces more of them.

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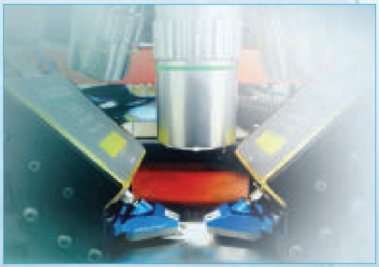

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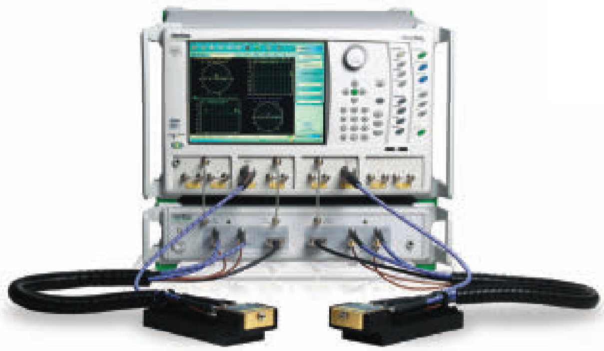

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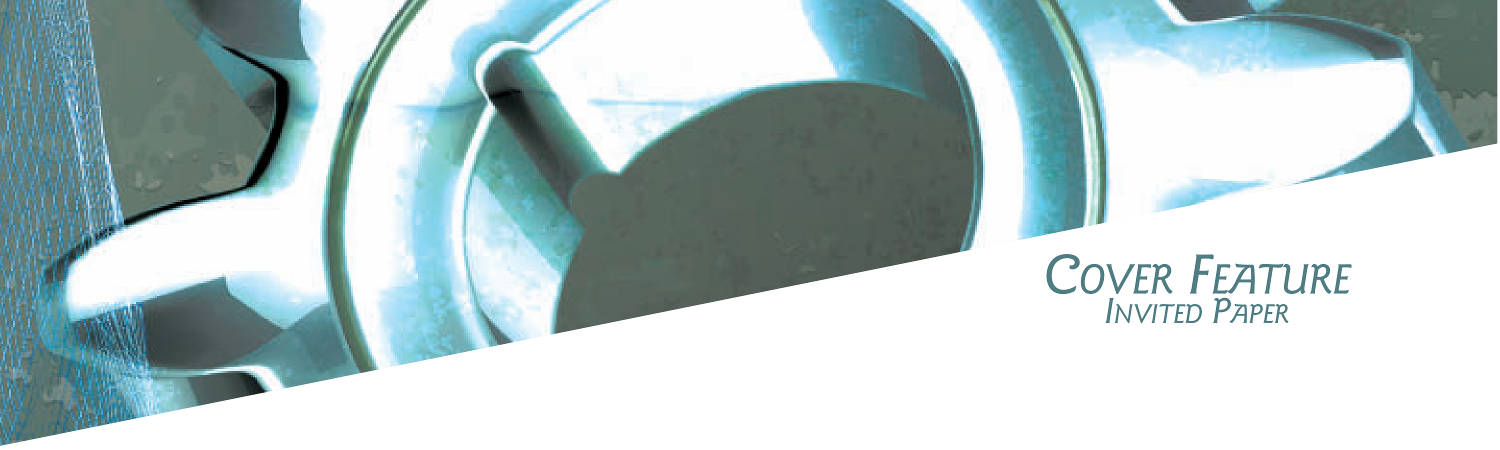

COVER FEATURE
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RF Technology in Semiconductor Wafer Processing

This article provides an overview of radio frequency (RF) delivery systems including RF generators and matching networks, which are one of the most critical surrounding components of the plasma chamber in wafer processing. Subcomponents of the RF generators including RF power amplifiers, combiners, couplers and filters are presented. Radio frequency power levels, frequency allocation and operational modes are studied. Matching networks and RF amplifier topologies used in RF delivery systems are also discussed.

Semiconductor wafer processing is used to manufacture integrated circuits (IC) that are components in the most sophisticated electronic products that are used in everyday life. In fact, the state of technology in semiconductor wafer processing is a driving force for the invention and development of new electronic devices due to enhanced features of the manufactured ICs. Devices or ICs are formed, for the most part, on the typical silicon wafer surface where 200 to 300 identical devices are formed on each wafer. The area on the wafer occupied by the discrete device or IC is called a chip or die. Bare and patterned silicon wafers are illustrated in ***Figure 1***. Fabrication processes of ICs involve many steps including layering, patterning, doping and heat treatment.[1-4] Layers consist of insulators, semiconductors or conductors. Layers can be added by deposition that can be implemented by chemical vapor deposition (CVD)[5] or physical vapor deposition (PVD).[6] The main categories of PVD processing are classified as evaporation and sputtering.[7] The process of etching is also used in manufacturing ICs mainly to remove the unwanted material from the wafer. There is conductor etching and dielectric etching depending on the application. All the processes described take place when the wafer is placed inside a chamber which is also commonly called as a process or plasma chamber.

The typical illustration of the process chamber for semiconductor wafer processing with its surrounding components is illustrated in ***Figure 2***. Inside the process chamber, partially ionized gas with a combination of free electrons, ions, radicals and neutral species called plasma is used to accomplish the processes described including deposition, etching and cleaning. The generation and sustaining of a plasma inside the process chamber is possible with the RF energy. RF waves are used to provide energy to target materials (typically insula-

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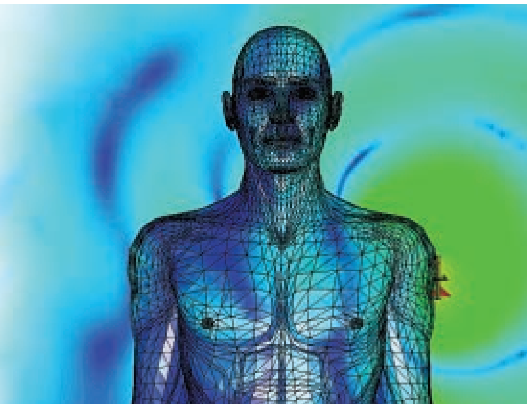

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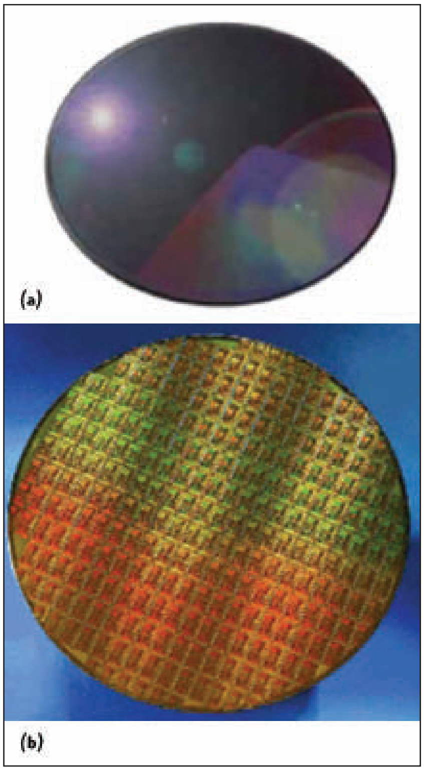
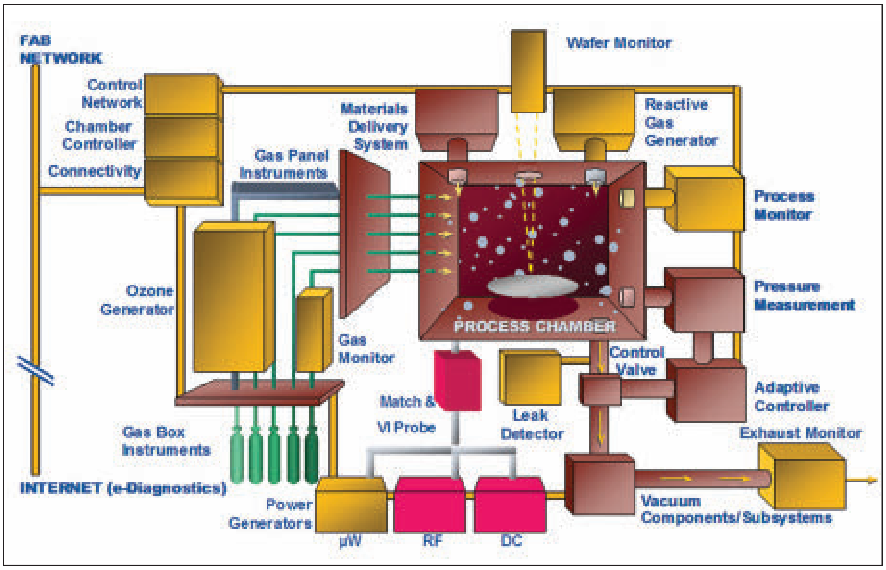
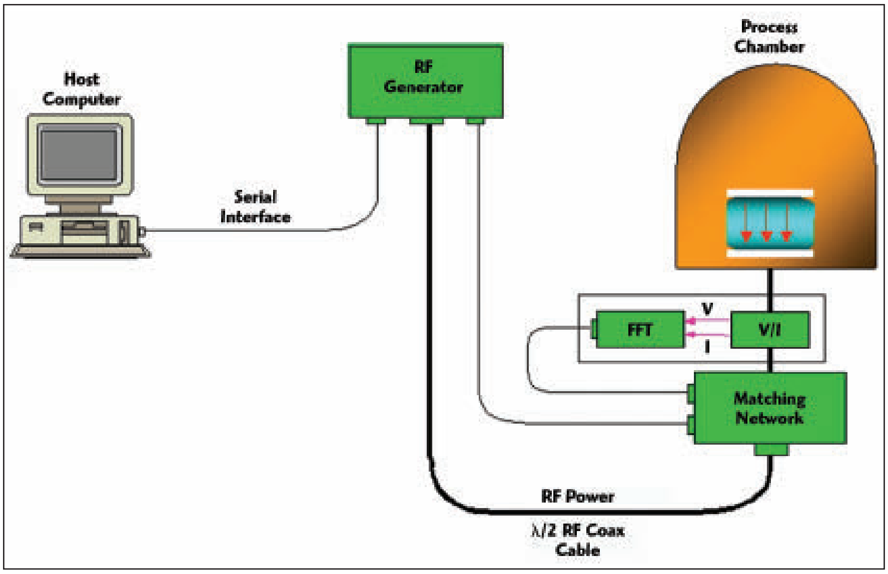


▲ *Fig. 1 Bare (a) and patterned silicon wafers (b).*



▲ *Fig. 2 Illustration of process chamber with surrounding components for semiconductor wafer processing.*

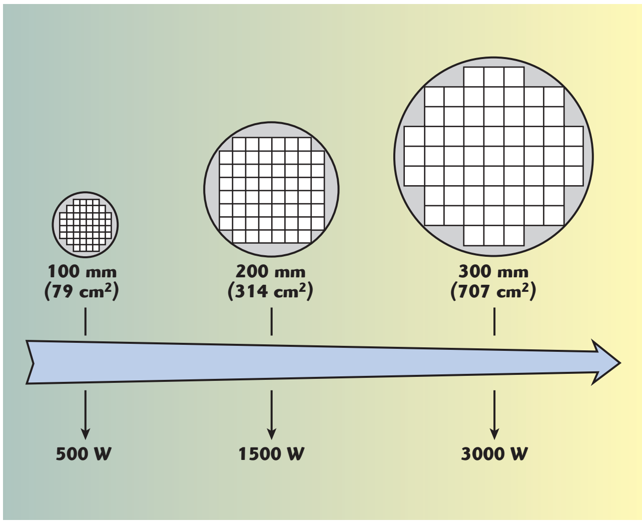


▲ *Fig. 3 Typical RF delivery system for the process chamber.*

tors) and bias substrates in processes where plasma is required. As a result, the level of RF energy, RF signal purity, RF interface impedance, application frequency and RF wave shape applied carry great importance to accomplish selective wafer processing including uniformity, etch rate, anisotropy, etc. RF energy is applied via RF generators that are connected to process chambers with matching networks. Impedance and power measurement devices such as a V/I probe[8] can be included in the system to give users the ability to monitor several important parameters such as the level of RF energy, chamber impedance and the corresponding RF frequency.

RF DELIVERY SYSTEM

Typical RF delivery systems consist of an RF generator, matching network, impedance and power measurement device, which are illustrated in ***Figure 3***. In the system shown, RF power is provided at the desired power level and the operational frequency is set by the user via a host computer that communicates with the generator using series type communication such as RS-232 or RS-485. RF generator power output is connected to an automated matching network using half a wavelength RF coax cable at the operational frequency. The communication between RF generator and matching network is usually established with optical communication for immunity to electromagnetic interference. Output of the matching network is connected to an impedance and power monitoring device such as a V/I probe before it is connected to the



▲ *Fig. 4 Wafer size transitions and corresponding cost per watt.*

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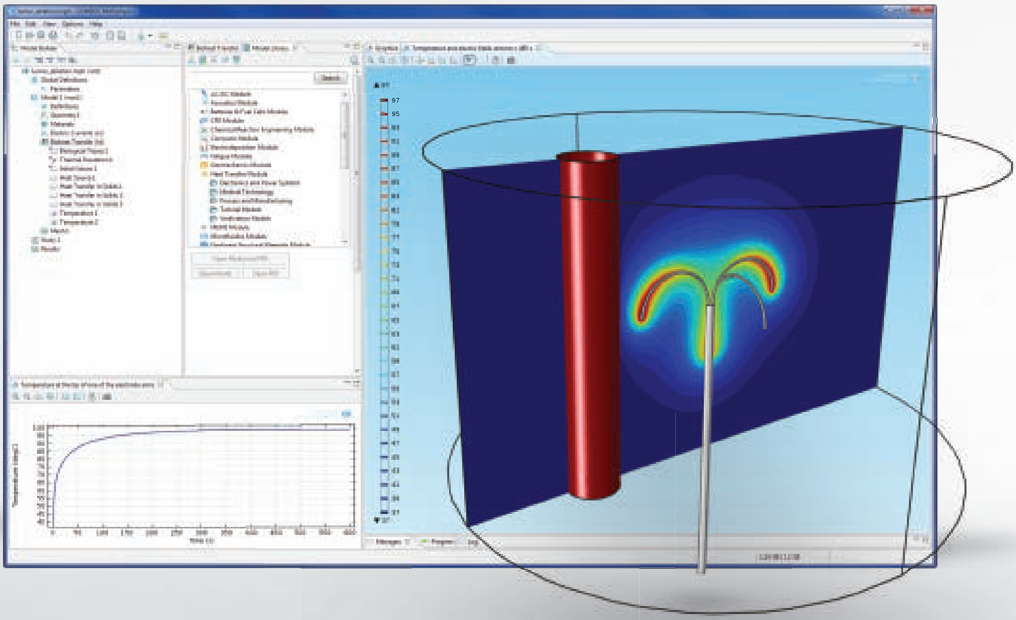

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plasma chamber as shown in Figure 3. The V/I probe captures the forward and reflected voltage, current and associated phase information and feeds them to the matching network to find the tune point to match the generator output impedance to the plasma impedance so that maximum power transfer is accomplished.

After the 1990s, use of RF energy became necessary to achieve sophisticated structures for IC manufacturing in processes such as high density CVD, PVD and plasma enhanced physical vapor deposition (PECVD) and etching. Wafer size transitions have occurred because of the overall cost benefits resulting from the larger number of dice per wafer, thereby using the same number of process steps to produce more dice. Wafer size transitions and corresponding cost per watt are shown in ***Figure 4***. The most common frequencies for providing RF energy range from 200 kHz to 40.68 MHz with power levels from 1250 to 6000 W as shown in the ***Table 1*** for processes such as sputtering of metallic/conductive or insulating and semi-conductive materials onto substrate, biasing of substrate during deposition and etching. RF generators and matching networks are designed to meet the power requirements in Table 1 at the frequencies given. It is also possible to obtain higher power levels from RF generators using RF amplifiers in modular structure by paralleling them. In the recent years, it also became apparent for original equipment manufacturers (OEM) to use RF pulsing in conjunction with continuous wave to enhance their manufacturing process.

RF GENERATORS

A typical RF generator architecture used in semiconductor wafer processing is illustrated in ***Figure 5***. In the design and implementation of RF generators, it is common practice to design PA modules for lower power levels and obtain higher power levels by paralleling them via combiner as shown in Figure 5. The output of combined RF power then goes through the filter which eliminates higher order harmonics. RF generators have an internal directional coupler located

TABLE I

THE RF FREQUENCY RANGE AND THE CORRESPONDING POWER LEVELS FOR RF DELIVERY SYSTEM

Frequency Range	*Frequency Coverage*	*Rated Power Output*
Low	200 kHz- 1 MHz	1250 W 2500 W 5000 W
Mid	1-4 MHz	1250 W 2500 W 5000 W
High	13.56 MHz 27.12 MHz 40.68 MHz	1250 W 2500 W 5000 W 7000 W 8500 W 2500 W 3000 W 6000 W

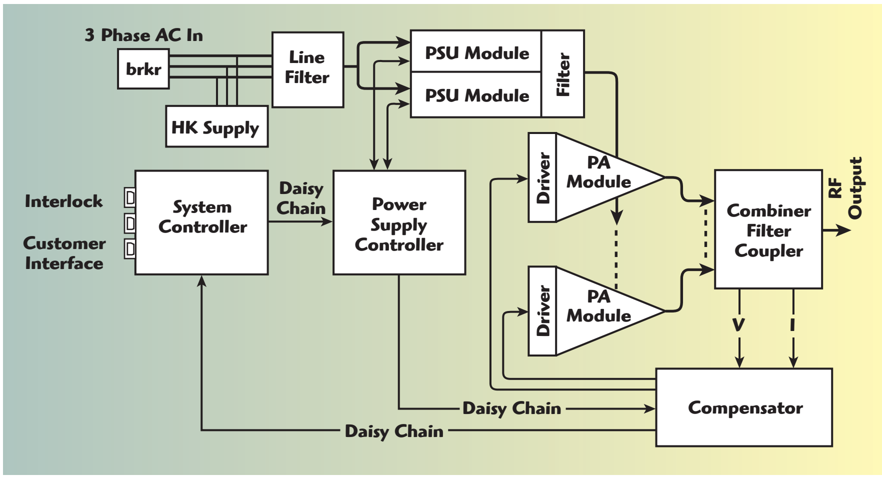

Fig. 5 Typical RF generator architecture used in wafer processing.

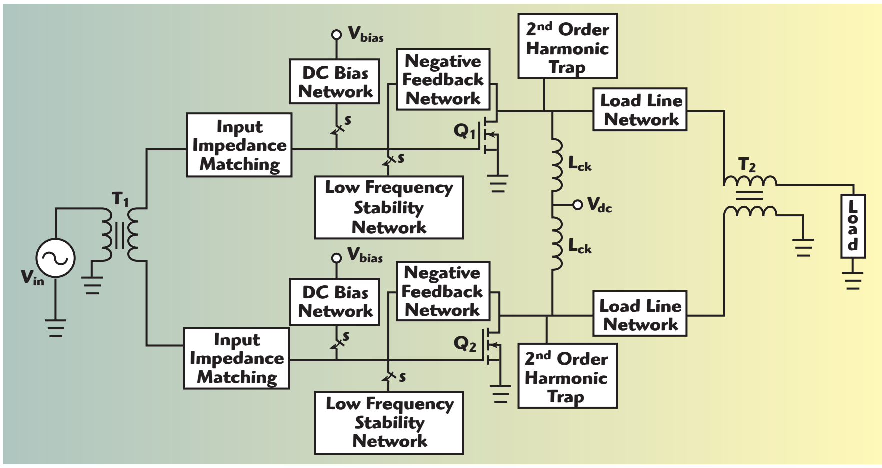

Fig. 6 Linear and nonlinear RF amplifier topology implemented as push-pull amplifier.[9]

Control Method	Class AB	Class E
Drive On-Off	Limitations Due to Harmonic Terminations	Limited by Drive Control Design
DC Rail Voltage On-Off Control	Increased Parts Count & Power Losses (Due to Series Power Switch)	
PA Phase Control	High Power Dissipation	Resonance & Stability Constraints

(a)

Control Method	Class AB	Class E
Drive Control	Dissipative	Lack of Controllability
DC Rail Voltage Control	Pulse Power Quality Limited by Speed of Response of the DC Rail	
Combined Rail Voltage & Drive Control	Reduced Dissipation, Improved Power Quality	Lack of Controllability
PA Phase Control	High Power Dissipation	Resonance & Stability Constraints

(b)

Fig. 7 Pulsing capability of linear and switch-mode amplifiers in ON/OFF mode (a) and 2-Level Pulsing Model (b).

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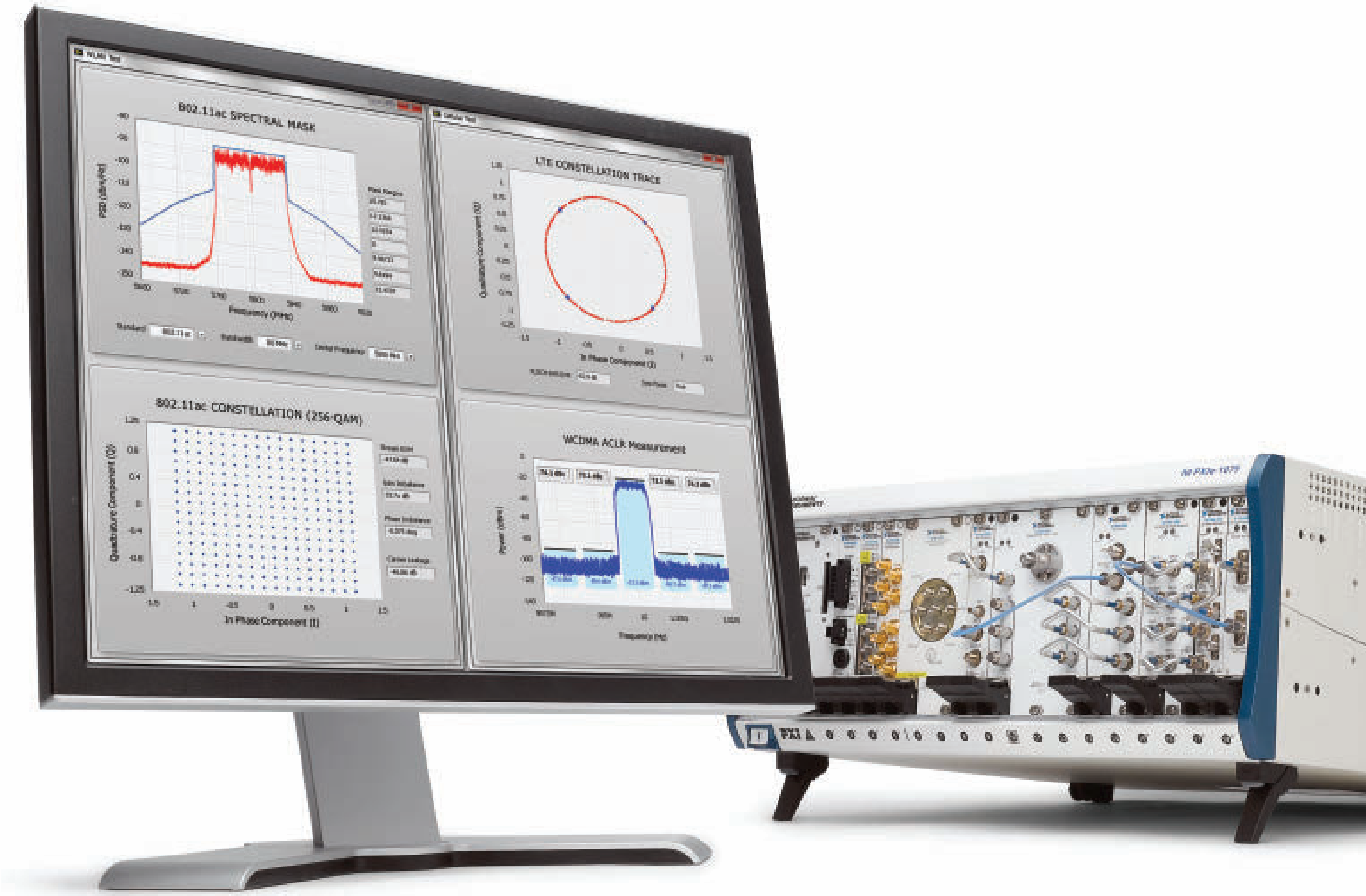

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right before an RF signal is sent to the matching network for sensing forward and reverse reflected powers and providing feedback signal to the system controller to maintain stability. The stability of the generator is essential to meet the strict requirements to have selective wafer processing. The RF signal purity in semiconductor wafer processing is so critical that manufacturers demand RF generators to provide RF signal output to have spurious and harmonics levels lower than –30 dB for any load condition.

RF power amplifier topologies used in wafer processing also range from linear to nonlinear amplifiers such as switch mode amplifiers. Commonly used linear amplifiers are usually implemented in Class AB mode whereas nonlinear amplifiers are implemented in Class C, D or E modes. The biggest differences between linear and nonlinear type switch-mode amplifiers are their efficiency and the signal purity. As a result, there is a trade off when one of the topologies is preferred. For instance, when a linear mode amplifier topology is used, although RF signal purity is inherently good, it is a cost driving factor to obtain a higher level of output power due to lower efficiency. Several linear type PA modules have to be combined to obtain the desired power level. When a switch-mode amplifier is used, it is possible to obtain higher power levels with fewer PA modules, however, designers have to implement filter sections to purify the signal that exists at the output of the amplifier due to its nonlinear characteristics. The operational principle of linear and nonlinear amplifier modes are illustrated in ***Figure 6*** when two amplifiers are working as push-pull amplifiers.[9] Removing the bias and adjusting the low frequency stability network by opening the switch S and slightly modifying input impedance matching network and the load line network in Figure 6 changes the operational mode from linear to nonlinear mode.

In recent years, OEMs have also required RF generators to have pulsing capability in addition to all the requirements in continuous mode including signal purity, power levels, dual frequency capability, bandwidth, etc. The RF pulsing capability of amplifiers depends on the amplifier topology used. There are several factors that affect the pulsing capability of the amplifier. These factors for ON/OFF and 2-Level Pulsing are shown in ***Figure 7*** for linear and switch-mode amplifiers. The typical waveforms for ON/OFF pulsing using linear mode Class AB and switch mode Class E amplifiers are shown in ***Figure 8***.

RF MATCHING NETWORKS

Automated RF matching networks are critical components that provide the matched impedance interface to RF generator even when there is a change in the plasma impedance, as shown in Figure 3. In fact, the plasma impedance that is formed during the processes can vary from very low impedance to very high impedance in a short time period due to the dynamic structure of the plasma. As a result, matching networks should be

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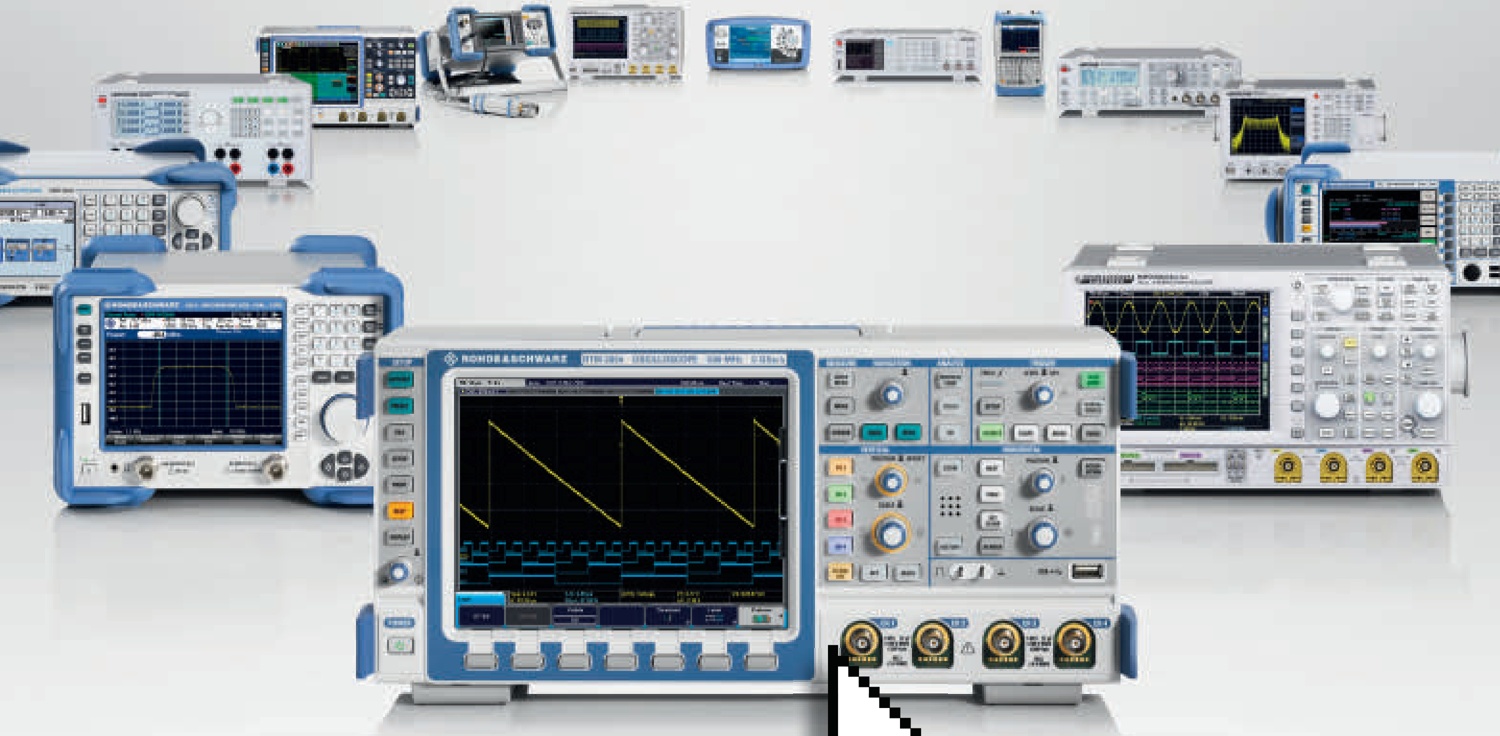

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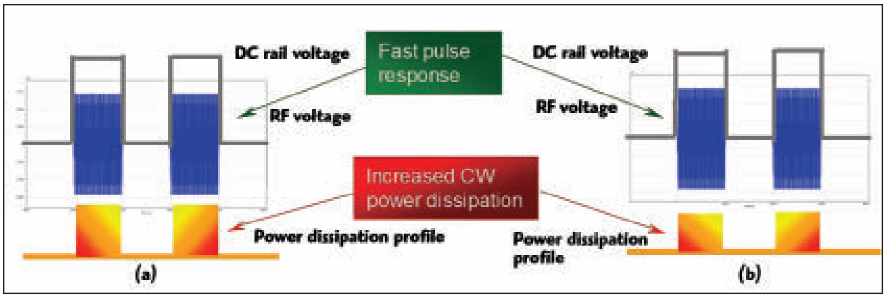
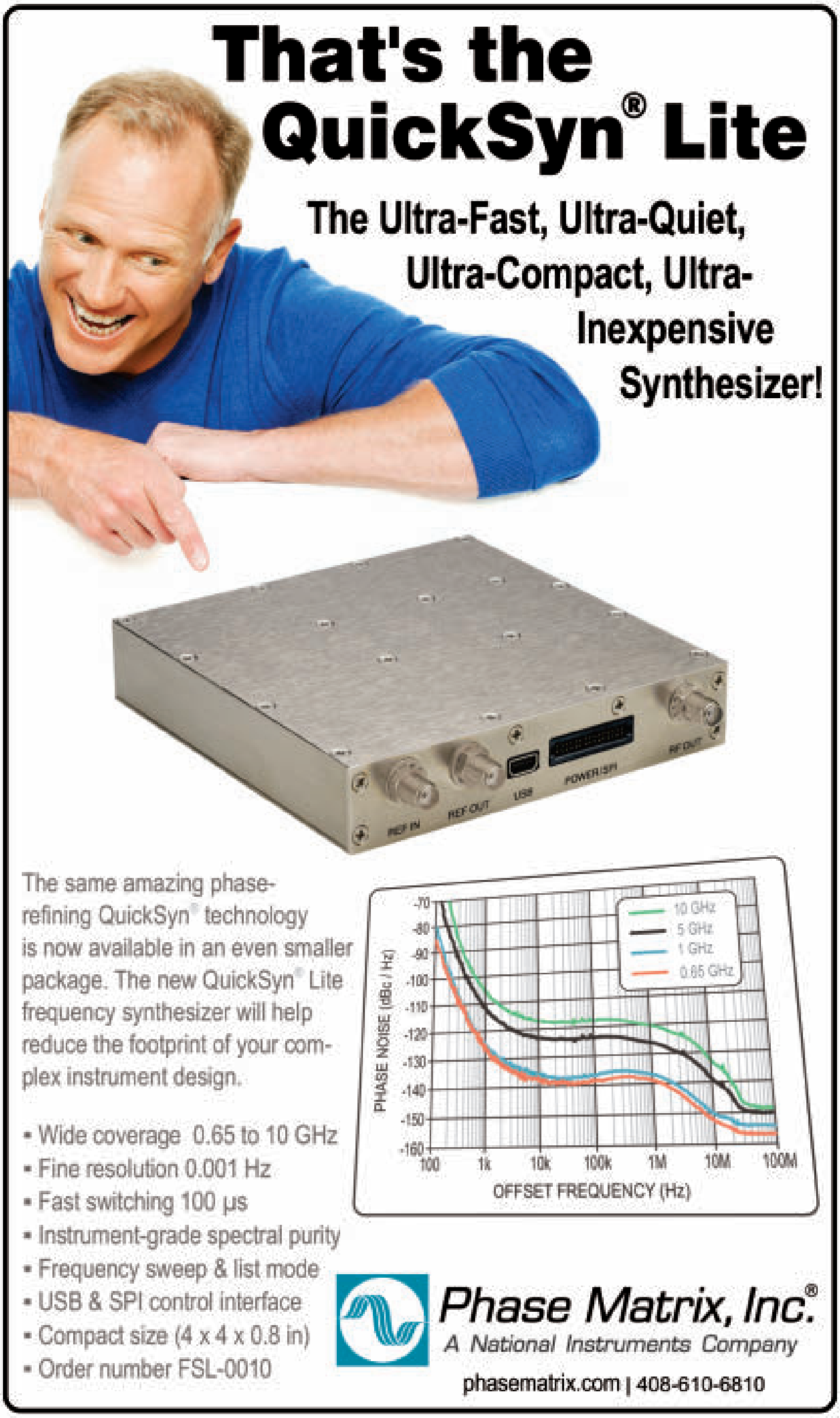
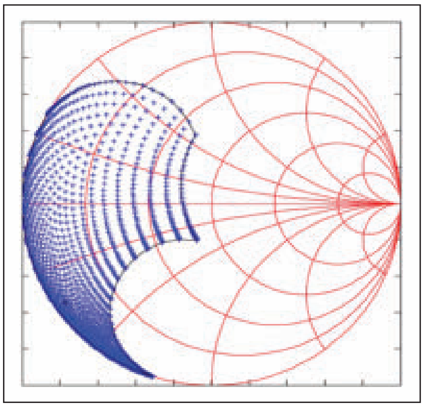


▲ *Fig. 8 ON/OFF Pulsing illustration of linear (a) and switch mode (b) RF amplifiers.*



able to respond to the sudden changes occurring in the process chamber. One of the ways matching networks accomplish a tune point is to follow the changes in the impedance of the plasma using a device called Phase/Magnitude detector. The Phase/Magnitude detector captures the magnitude of the RF voltage and current and phase information to determine the impedance. Once the calculated impedance information is fed back to the controller system, the control system determines the capacitance needed to accomplish the tune point with fuzzy logic. Most of the time two vacuum variable capacitors are used inside matching networks. The reason for the use of vacuum variable capacitors is due to the fact that they have very high voltage breakdown values. The vacuum variable capacitors are connected to the stepper motors which control the position of the plate inside the capacitor that changes its capacitance value. The capacitor position information to achieve the tune point is sent to the stepper motors via a controller system of the matching network. Continuous closed loop operation in the matching network minimizes the error in the phase and the magnitude information that is acquired by the Phase/Magnitude detector and matching is accomplished this way.

Matching networks use L or PI type topology depending on the specific process and operational frequency. Approximate plasma impedance is usually provided to matching network manufacturers for implementation of their design. Matching networks can only accomplish matching if the impedance of the plasma falls within the



▲ *Fig. 9 Tuning range of MKS Instruments' matching network, MWH-100.*

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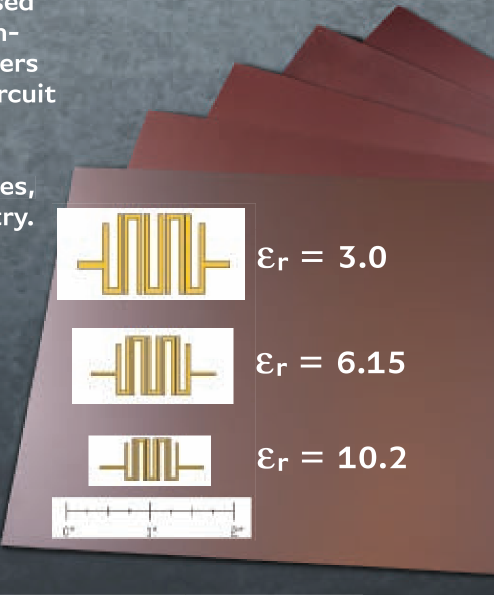

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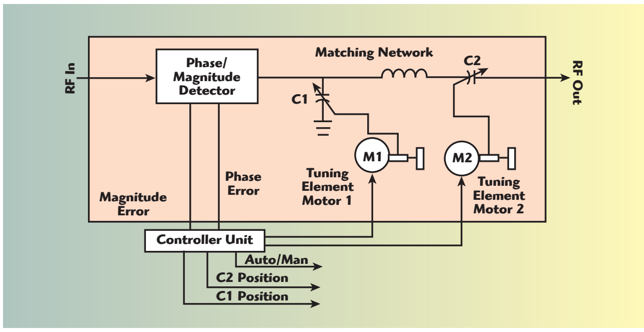

▲ *Fig. 10 The architecture of the matching network used in practice.*

tune range of the matching network. For instance, the tune range of MKS Instruments' 13.56 MHz matching network MWH-100 is shown in ***Figure 9***.[10] The architecture of commonly used matching networks is illustrated in ***Figure 10*** where M1 and M2 represent the stepper motors whereas C1 and C2 represents vacuum variable capacitors.

CONCLUSION

In this article, the RF delivery system with its critical components including RF generators and matching networks for semiconductor wafer processing have been analyzed in detail. The architectures used in practice to design and implement RF generators and matching networks are given. The processes where RF delivery system are used, operational frequencies and corresponding power levels are presented. RF amplifier topologies, a comparison of linear versus nonlinear amplifiers for continuous wave and pulsing modes have been discussed. Matching networks, network topologies and a method to control the tuning mechanism have been detailed. The information regarding wafer size changes and their impacts on cost and technology are also summarized. ■

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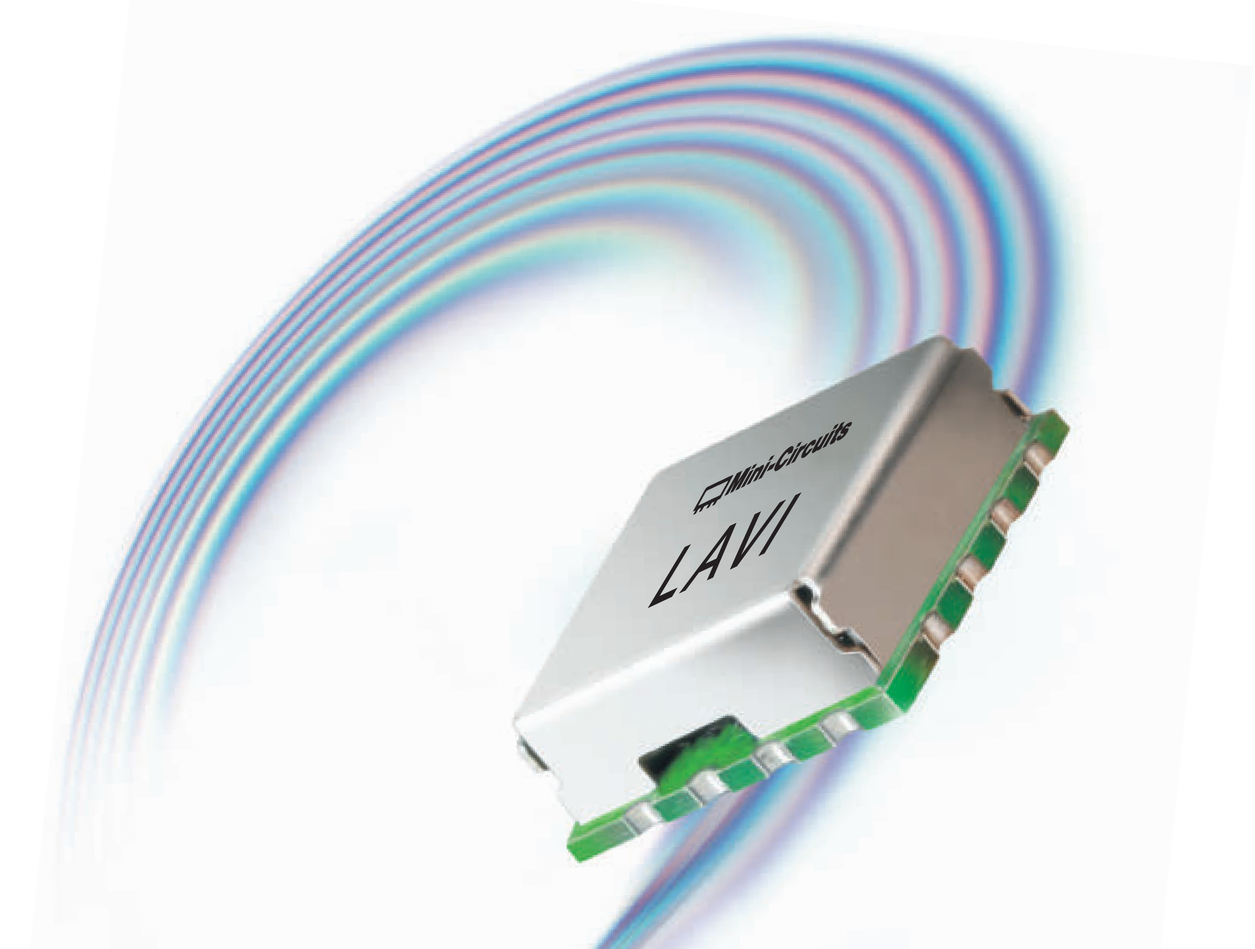

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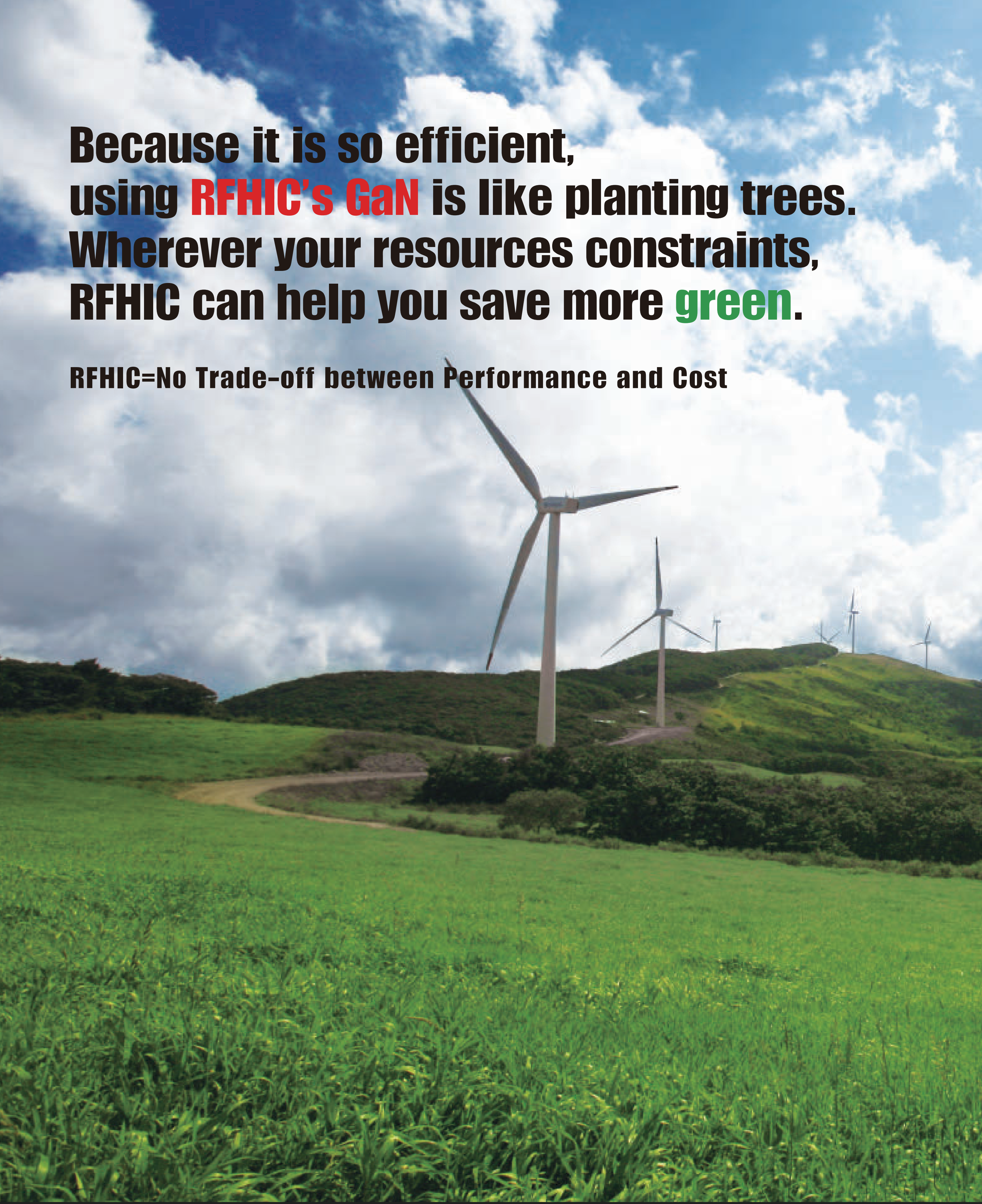

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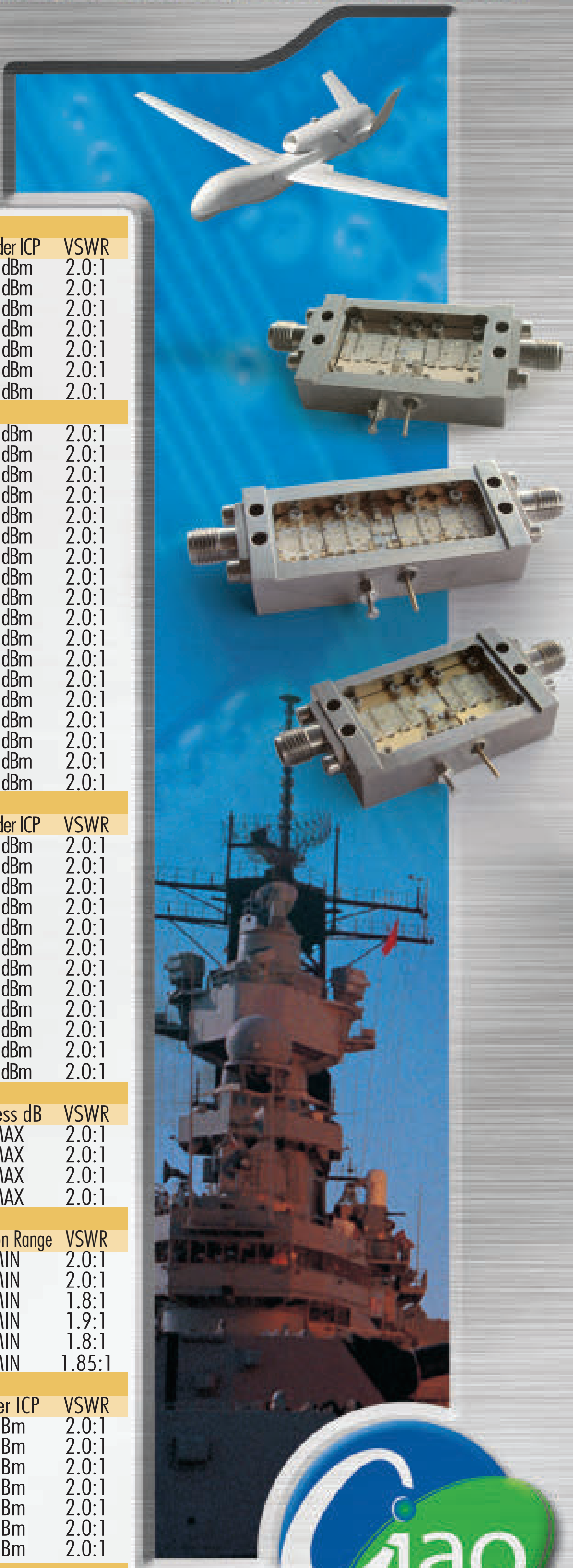

OCTAVE BAND LOW NOISE AMPLIFIERS

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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Defense News

Cliff Drubin, Associate Technical Editor

NGC to Supply AN/SPQ-9B Radars for U.S. Navy Vessels

Northrop Grumman Corp. has been awarded a contract by the U.S. Navy to supply three AN/SPQ-9B radar systems for amphibious and Arleigh Burke class ships.

Under the $20.4 million contract award, Northrop Grumman will supply three AN/SPQ-9B radar systems for delivery in the second quarter of 2015. This contract adds to the 53 radar systems the company has already delivered or is under contract to deliver. Northrop Grumman began low-rate initial production of the AN/SPQ-9B in 2000 and full-rate production in 2004.

This latest series of radars will be installed on the LPD-27, LHA-7 and DDG-79 ships. The latter will be the first guided missile destroyer (DDG) to be modernized, which will lead the way for installation of the AN/SPQ-9B radars onto the upcoming Flight III DDG-51 destroyers.

The high-resolution, X-Band AN/SPQ-9B radar system will greatly improve the vessels' ability to defend against small high-speed threats…

"This is a significant step for Northrop Grumman because it leads the way for a potential of more than 60 DDG-51 radar backfits as well as 16 forward fits on the next Flight III destroyers," said Bill Hannon, vice president of Northrop Grumman's Maritime Systems business unit. "The AN/SPQ-9B's performance supplies greater radar capability to surface ships, and represents another milestone in our long term legacy of supplying radars to the Navy."

The high-resolution, X-Band AN/SPQ-9B radar system will greatly improve the vessels' ability to defend against small high-speed threats, such as surface-skimming anti-ship missiles, and will be integrated with the ships' fire-control systems. The multimission radar system is designed to detect small fast-moving targets in the presence of clutter from ocean waves, rain and land returns, as well as chaff and jamming.

The work will be performed at Northrop Grumman's facilities in Baltimore beginning in the second quarter of 2014.

Raytheon Awarded U.S. Navy Next Gen Air and Missile Defense Radar Contract

Raytheon Co. has been awarded a $385,742,176 cost-plus-incentive-fee contract for the engineering and modeling development phase design, development, integration, test and delivery of Air and Missile Defense S-Band Radar (AMDR-S) and Radar Suite Controller (RSC). AMDR is the Navy's next generation integrated air and missile defense radar and is being designed for Flight III Arleigh Burke (DDG 51) class destroyers beginning in 2016.

AMDR consists of an S-Band radar, an X-Band radar and a Radar Suite Controller. AMDR-S is a new development integrated air and missile defense radar designed for long range detection and engagement of advanced threats. The X-Band radar is an existing horizon-search radar. The RSC provides S- and X-Band radar resource management, coordination and interface to the Aegis combat system.

Under the contract, Raytheon will build, integrate and test the AMDR-S and RSC Engineering Development Models (EDM). For the ship sets covered under this contract, the AMDR suite will integrate with the existing AN/SPQ-9B X-Band radar. The base contract begins with design work leading to Preliminary Design Review and culminates with system acceptance of the AMDR-S and RSC engineering development models at the end of testing.

This contract includes options which, if exercised, would bring the cumulative value of this contract to $1,633,363,781. Previously appropriated FY13 funding in the amount of $156,960,000 will be obligated at time of award. This contract includes options for manufacturing low-rate initial production systems which may be exercised following Milestone C planned for fiscal year 2017.

Source: U.S. Navy photo by Mass Communication Specialist 3rd Class Declan Barnes/Released

Army Looks to Blend Cyber, EW Capabilities on Battlefield

As new technologies emerge and new cyber and electronic warfare threats plague soldiers in the field, U.S. Army scientists and engineers continue to define next-generation protocols and system architectures to help develop technology capabilities to combat these threats in an integrated and expedited fashion.

As part of the Integrated Cyber and Electronic Warfare, or ICE, program, the U.S. Army Research, Development and Engineering Command's Communications-Electronics Center, known as CERDEC, researches the technologies, standards and architectures to support the use of common mechanisms used for the rapid development and

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integration of third-party cyber and electronic warfare, or EW, capabilities.

"Currently, within cyber and EW disciplines there are different supporting force structures and users equipped with disparate tools, capabilities and frameworks," said Paul Robb Jr., chief of CERDEC Intelligence and Information Warfare Directorate's Cyber Technology Branch.

The boundaries between traditional cyber threats... and traditional EW threats...that use the EM spectrum, have blurred...

"Under the ICE program, we look to define common data contexts and software control mechanisms to allow these existing frameworks to communicate in a manner that would support the concurrent leveraging of available tactical capabilities based on which asset on the battlefield provides the best projected military outcome at a particular point in time," said Robb.

The boundaries between traditional cyber threats, such as someone hacking a laptop through the Internet, and traditional EW threats, such as radio-controlled improvised explosive devices that use the electromagnetic spectrum, have blurred, allowing EW systems to access the data stream to combat EW threats, according to Giorgio Bertoli, senior engineer of CERDEC I2WD's Cyber/Offensive Operations Division.

Additionally, significant technological advancements including a trend toward wireless in commercial applications and military systems have occurred over the last decade, said Bertoli.

"This blending of networks and systems, known as convergence, will continue and with it come significant implications as to how the Army must fight in the cyber environment of today and tomorrow," said Bertoli.

"The concept of technology convergence originated as a means to describe the amalgamation of traditional wired versus wireless commercial services and applications, but has recently evolved to also include global technology trends and U.S. Army operational connotations – specifically in the context of converging cyber and EW operations," said Bertoli.

The Army finds itself in a unique position to help mitigate adverse outcomes due to this convergence trend.

"Post-force deployment, the Army has the vast majority of sensors and EW assets on the tactical battlefield compared to any other service or organization, posing both risks and opportunities. Our military's reliance on COTS [commercial-of-the-shelf] systems and wireless communications presents a venue for our adversaries to attack. Conversely, the proximity and high density of receivers and transmitters that we deploy can be leveraged to enable both EW and cyber operations," said Bertoli.

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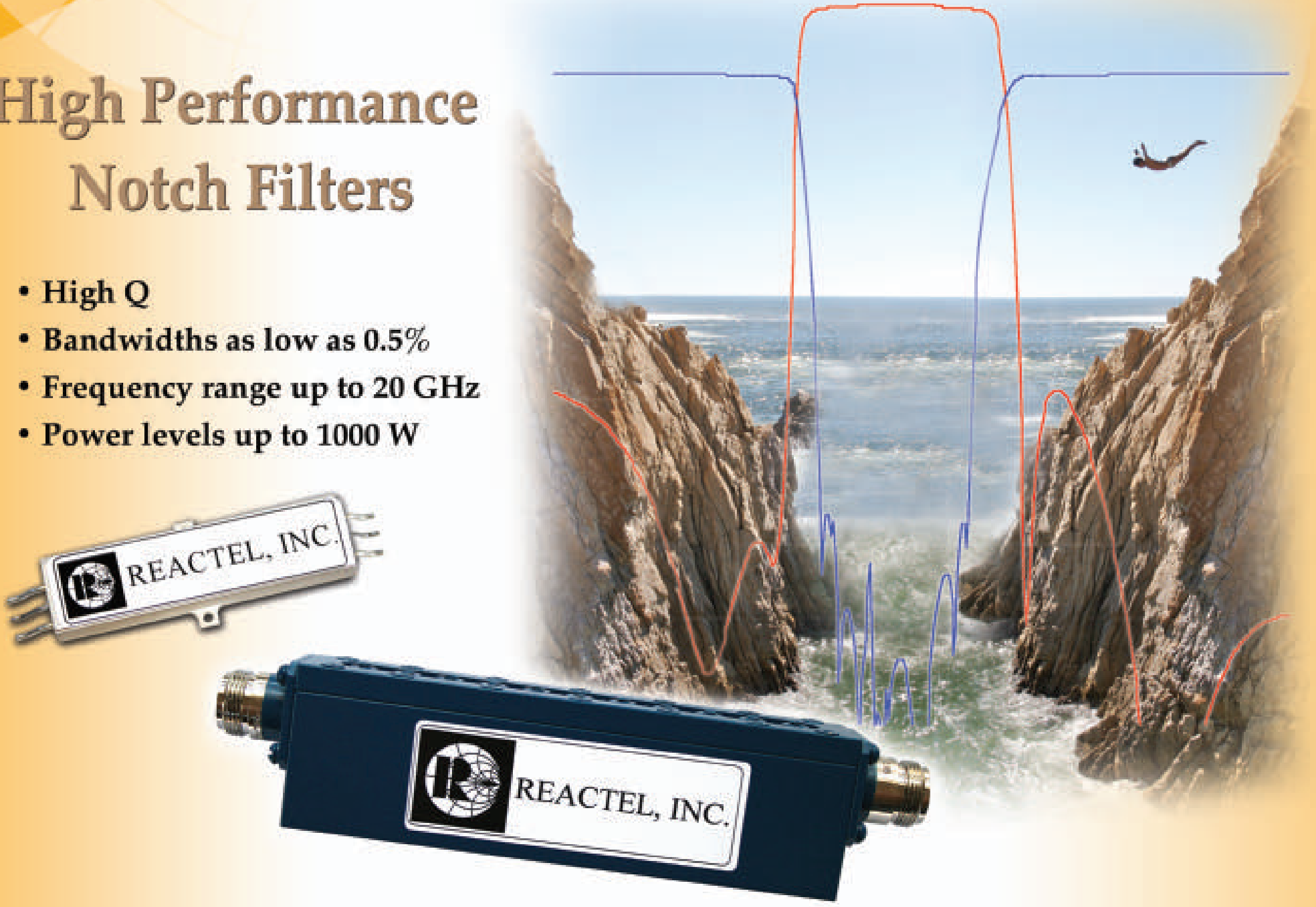

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Plans for UK 5G Innovation Centre Develop

A significant number of the world's most notable mobile network operators, infrastructure and tools providers, media and communications organisations and the UK's communications regulator have formally joined the University of Surrey in its ambitions to deliver a specialised 5G Innovation Centre (5GIC) on its main campus in Guildford.

The consortium, which includes Aeroflex, AIRCOM International, BBC, BT, EE, Fujitsu Laboratories of Europe, Huawei, Ofcom, Rohde & Schwarz, Samsung, Telefonica and Vodafone, has pledged time, expertise and other contributions which together total more than £30 million. This will be added to the £11.6 million that was awarded by the Higher Education Funding Council of England (HEFCE) under the UK Research Partnership Investment Fund (UKRPIF) in autumn 2012.

Together with the University of Surrey, they will conduct research into the development of advanced technologies for a 5G network of the future, to establish a world-leading position in mobile broadband communications and internet innovations. The project will include the development of a 5G 'test bed,' based on campus, on which to test technologies in a real-world environment. With an expected completion date of January 2015, the centre will be built to high environmental standards and will be home to 150 researchers and around 100 PhD students.

Professor Rahim Tafazolli, head of the University of Surrey's Centre for Communication Systems Research (CCSR), said: "We have had an extremely busy year since the initial funding announcement last October, and we are delighted that the formal agreements are now in place and plans are under way to start turning the vision for a 5G Innovation Centre into a reality."

"…turning the vision for a 5G Innovation Centre into a reality…"

Tafazolli added, "By bringing together leading academics with heavy-weight industry partners, I believe we can develop the technologies that are required to provide much-needed capacity, drive economic growth and actively contribute to and shape the future 5G system.

Huawei to Invest $600M in 5G Research and Innovation

Huawei will invest a minimum of $600 million in research and innovation for 5G technologies by 2018. The investment will cover a range of key enabling technologies, including the research of air-interface technology. The company predicts that the first 5G networks will be ready for commercial deployment starting in 2020 and will deliver peak data rates of over 10 Gbps, 100 times faster than today's 4G networks.

Eric Xu, rotating CEO of Huawei, said: "Innovation is a continuous journey. While we continue to evolve our existing 4G network capabilities, we plan to invest a minimum of $600 million over the next five years on research and innovation for 5G mobile network technologies to ensure that we are meeting the consumers' demands for increasingly faster and better connections. This number does not include investment to productize 5G technologies.

The company's approach to 5G innovation has been open and collaborative, working extensively with ecosystem partners. To date, Huawei has participated in the EU's 5G research projects, worked on the establishment of the 5G Innovation Centre (5GIC) in the UK (see previous news story), and participated in joint research programs with over 20 universities around the world. The company will also be an active contributor in building 5G standards and ecosystems to drive a globally consistent standard across the industry.

"There are several issues that must be resolved before 5G can become a reality," said Xu. "These include the availability of spectrum and technological challenges, such as how to engineer network architectures capable of handling increasingly higher data volumes and transmission speeds necessary to accommodate more users on the network. By 2020, it is estimated that 6.5 billion people worldwide will use mobile networks for data communications and 100 billion of additional 'things,' such as vehicles, meters, medical devices and home appliances, will also be connected to the network over 5G. We have already achieved many technological breakthroughs in 5G research and innovation, but the majority of the work remains ahead of us."

Anite Leads 5G Radio Channel Model Development

Anite has been appointed to lead the radio channel modelling Task Group within the Mobile and wireless communications Enablers for the 2020 Information Society (METIS) project. Co-funded by the European Commission, METIS is a consortium of 28 key wireless industry players and the first international and large-scale research activity on 5G.

As the only test equipment vendor involved in the METIS project, Anite has participated in defining five 5G scenarios that reflect the future challenges of wireless communications standards. The five scenarios, recently made public by METIS, shape the definition of propagation

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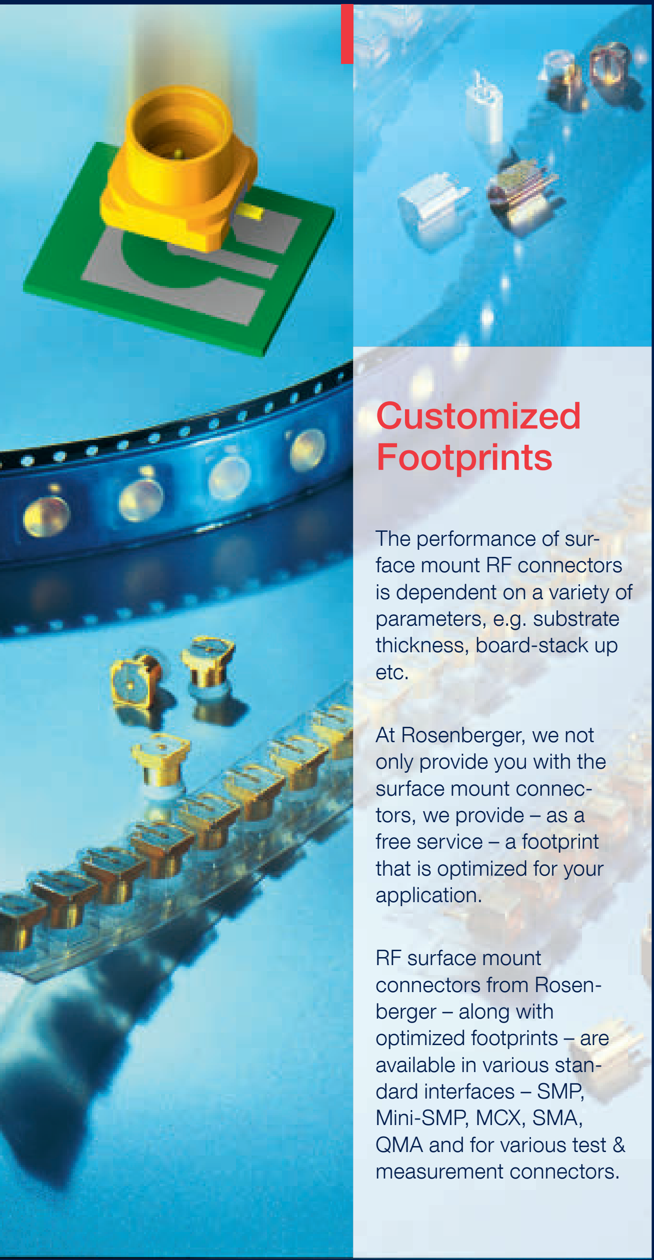

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conditions and form the basis of channel modelling development. METIS has derived a challenging set of requirements from these scenarios, including one thousand times more mobile data per area compared to today's average traffic. The radio channel modelling Task Group is expected to publish its first results in April 2014.

"Radio channel expertise is key..."

"Radio channel expertise is key to the success of 5G technology. Anite was selected to lead the channel modelling Task Group within the METIS project as they have proven success in previous projects, such as IST-WINNER, which defined the 4G channel models," said Dr. Afif Osseiran, METIS coordinator at Ericsson.

"Anite's participation in the METIS project clearly demonstrates our technology leadership and will enable us to continue to drive the industry forwards into the next stage of wireless communications," said Paul Beaver, products director at Anite.

NSN and CMRI Shape Tomorrow's Mobile Broadband

Nokia Solutions and Networks and China Mobile Research Institute (CMRI), the research and development branch of China Mobile, have expanded their Memorandum of Understanding (MoU), originally signed in 2010. Under the terms of the renewed agreement, the two parties will further their cooperation on research and standardization of advanced mobile broadband technologies in LTE as well as in 5G. The MoU reflects their vision of 2020 and outlines key focus areas for future mobile networks.

The parties agree to enhance joint research, standardization, and prototype development activities in advanced technologies such as 5G, LTE deployment optimization, cloud-based radio access network (C-RAN), the innovative 'Nanocell' concept for next-generation small cell deployments, coexistence of 2G/4G and core virtualization.

"...keep pushing the limits of technology..."

"Significant reduction of the unit cost of bandwidth is the key to success of future mobile networks," said Bill Huang, general manager of CMRI. "The alignment of NSN's and CMRI's technology vision on the future mobile networks is an important foundation for our long-term successful partnership. We are delighted to expand our MoU with NSN, the world's specialist in mobile broadband, to keep pushing the limits of technology, shape the telco industry and explore new ways of helping operators reduce operational costs."

"China Mobile Research Institute has paved the way for industry innovation in various aspects including TD-LTE, cloud-based RAN, IPv6 and packet networks. Since the outset, NSN and CMRI have consistently expanded and reinforced their collaboration to focus on leading research activities and to drive innovation and development of 4G technology and beyond," said Markus Borchert, president of NSN Greater China.

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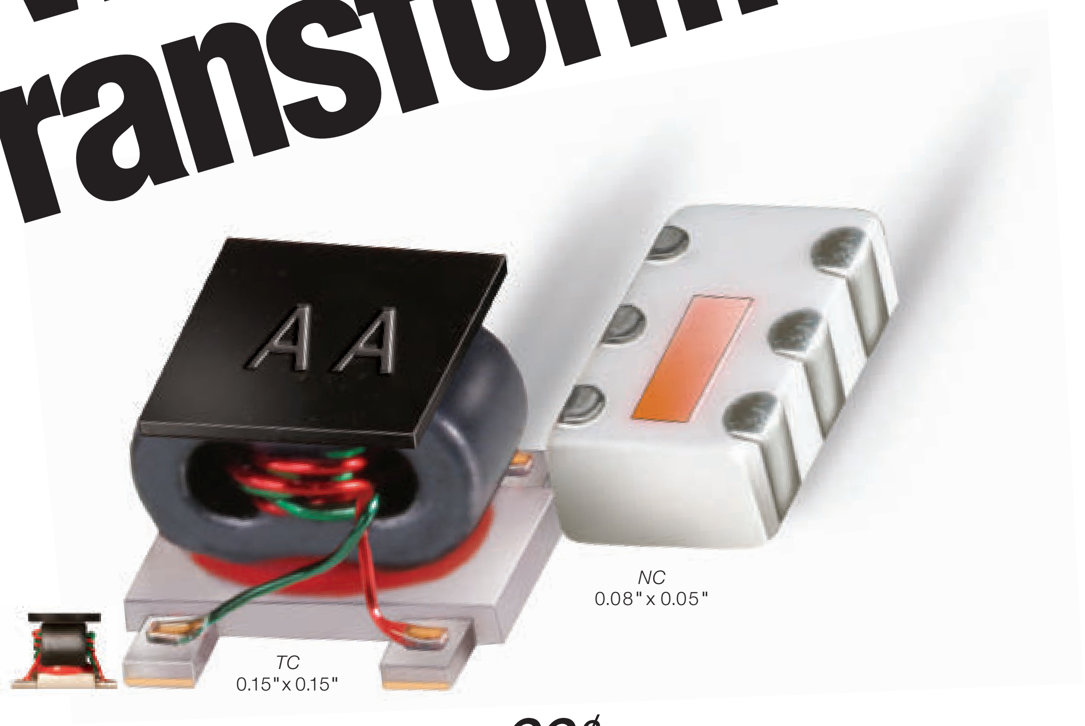

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Cliff Drubin, Associate Technical Editor

Small Cell Backhaul Equipment Market to Reach $5B in 2018

ABI Research expects the market for small cell backhaul equipment to grow to over $5 billion in 2018, up from a forecast $487 million for 2013 representing a 48 percent compound annual growth rate (CAGR).

Sub 6 GHz technology will capture over 47 percent of small cell backhaul equipment revenue, or $2.4 billion with 31 percent of last mile links in 2018, while millimeter-wave technology becomes the fastest growing technology over the forecast period, growing at 113 percent CAGR to reach a value of $668 million. Traditional microwave equipment remains a top technology for small cell backhaul applications with a 34 percent share of revenue or almost $1.8 billion and 25 percent share of links in 2018.

"Thanks to its NLOS properties, sub 6 GHz backhaul becomes the most popular backhaul technology for small cells by 2018..."

"Thanks to its NLOS properties, sub 6 GHz backhaul becomes the most popular backhaul technology for small cells by 2018," says Nick Marshall, principal analyst at ABI Research. ABI Research believes that the millimeter-wave bands from 60 to 80 GHz will also prove compelling for small cell backhaul in many situations.

"We believe that 4G/LTE small cell solutions will again drive most of the microwave and fiber backhaul growth in metropolitan, urban and suburban areas with backhaul for 4G/LTE small cells reaching a value of $3.1 billion in 2018, growing at two times the rate for 3G and surpassing 3G in 2016," continues Marshall.

Enterprise Small Cell Installations to Increase 70%

The femtocell market has continued its steady growth in 2013 with the number of installations rising by 70 percent over the last year in the enterprise market with some notable deployments recently, including Telefónica in Germany and Free in France. The femtocell ecosystem is also developing with more equipment providers looking to capture a share of the market, which has attracted vendors from different backgrounds including ICT, core network and in-building/DAS providers. This is reflected by the number of femtocell shipments, which will increase tenfold by 2018, jumping from 3.75 million in 2013 to 37.45 million.

The increasing need for indoor voice coverage and data capacity is creating a large market for femtocells, especially in the consumer and small-to-medium enterprise segments. These markets are also highly targeted by mobile network's long-standing rival, Wi-Fi.

Now that Wi-Fi has entered the gigabit era with the new 802.11ac standard delivering total data rate of 1.3 Gbps and femtocells migrating from 3G to LTE which offers considerably higher data rates than 3G, new applications and business models are emerging. "The market is generally promising for femtocells and Wi-Fi, and while progressively growing and advancing, both technologies are looking to serve wider markets and provide more revenue-generating applications and business models," comments Ahmed Ali, research analyst at ABI Research.

"The market is generally promising for femtocells and Wi-Fi..."

The enterprise femtocell market's fast paced and very demanding environment has become a top target for femtocell monetization. Businesses are moving away from traditional work environments and engaging more technologies and communications trends to increase efficiency. Femtocells, while fulfilling essential voice requirements, can offer other types of services, tailored to fit different enterprise sizes and businesses, such as unified communication and mobility management services.

Location-based applications and services also play a major role in developing this market demand for femtocells. Enterprise location-based applications are one of the fastest growing services and are expected to generate total revenue of $1.6 billion by 2018. "Femtocells long-term presence in the indoor solutions market is determined by operators being able to generate revenue out of their services," adds Ali.

Cellular Connectivity Delivers Nearly 60% of M2M Connectivity Revenues by 2018

M2M connectivity will be embedded in more than 2 billion devices across nine key industries by 2018, but it will be cellular that will bring the bulk of the value and the connectivity revenues.

A new generation of smart devices is set to have embedded connectivity and manufacturers have a number of technologies to select to deliver network connectivity. ABI Research has examined the demand and appeal for M2M connectivity across cellular, satellite, fixed-line and short-range wireless technologies within nine key industry verticals. Each technology has specific advantages and appeal, but cellular is best placed to deliver the most value, hence revenues, for the connection.

"Looking at demand for connectivity, while cellular will not have the highest number of connections, or the highest average revenue per connection, it will provide the great-

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est opportunity to drive the most overall value from those connections," says Jonathan Collins, principal analyst and author of the new report.

Industries including automotive, healthcare, manufacturing, retail, security and energy will all add connectivity to devices and products in a bid to improve efficiency, cut costs and improve customer service. Across M2M device connectivity options, a combination of mobility, flexibility, coverage and simple connection management will ensure strong adoption for cellular. The value around that proposition also positions cellular network operators to best leverage a return for those connections.

"While cellular will not have the highest number of connections, or the highest average revenue per connection, it will provide the greatest opportunity..."

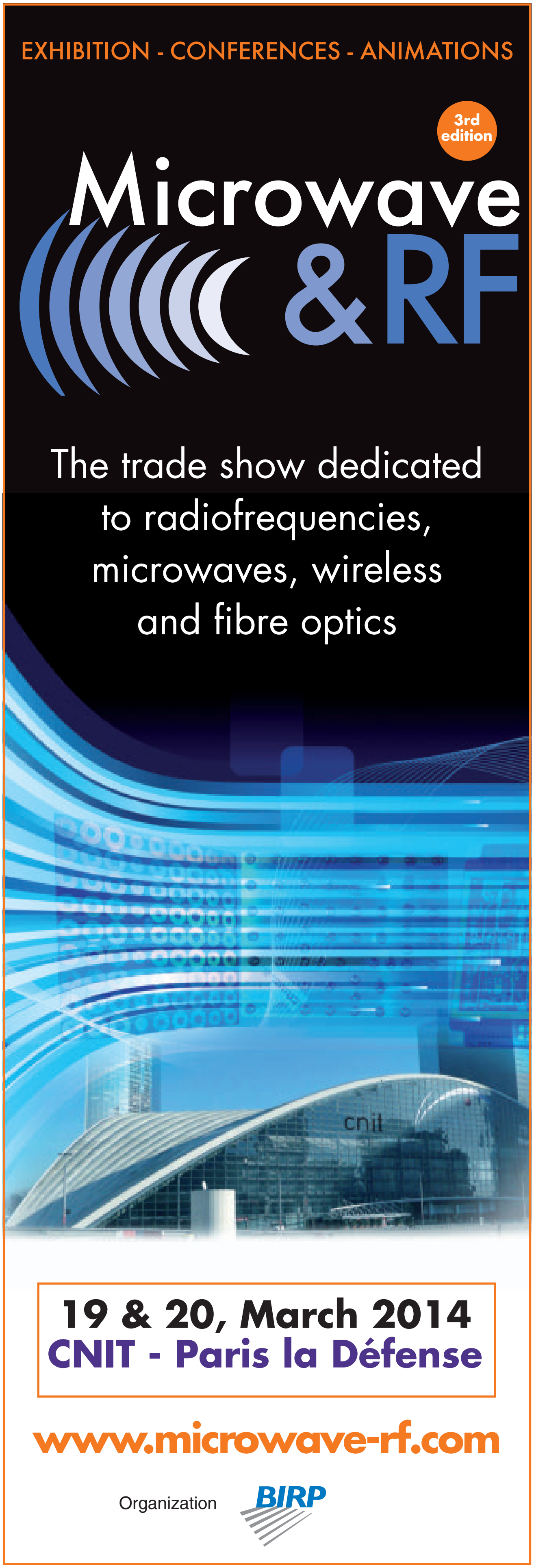
"Over the forecast period short-range wireless or wireless sensor network connectivity will outpace cellular connection growth, but there is little ability for those connections to directly deliver any revenues for the provision of that connectivity," adds Collins. "In addition, satellite with higher revenue per connection does not have the same versatility as cellular limiting its appeal to fewer verticals."

Global RFID Market to Reach $7.88B in 2013

According to a new RFID sector survey by ASDReports, the RFID market will increase from $6.98 billion in 2012 to $7.88 billion, and will reach $23.4 billion in 2020. This includes tags, readers and software/services for RFID cards, labels, fobs and all other form factors – for both passive and active RFID.

The market for RFID has grown steadily despite the economic meltdown due to the diverse nature of its applications from tagging retail apparel to transport ticketing to animals. Historically and today, Governments have driven most RFID orders as they improve efficiency (transit systems), safety (passport tagging) and protect industries (animal tagging). Since 2000, there has been a strong push to use passive RFID to improve supply chain visibility, with a wide range of investment in new RFID technologies, new standards and much publicity. Inevitably as with most new technologies, aspects were over hyped and demand not in sync with capacity, but as we entered 2010, the industry emerged from the hype cycle and over the following years until now, has entered a period of rapid growth and profitability for some.

There are different rates of growth for different applications and many challenges – and opportunities still exist. In total, IDTechEx find that 5.9 billion tags will be sold in 2013 versus 4.8 billion in 2012.

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Around the Circuit

Laura Glazer, Staff Editor

MERGERS & ACQUISITIONS

Anaren Inc. announced the signing of a definitive merger agreement under which Anaren will be acquired by an affiliate of **The Veritas Capital Fund IV L.P.** (Veritas Capital) for $28.00 per share in cash. The purchase price reflects a premium of approximately 12.4 percent over the closing price of Anaren common stock of $24.91 on November 1, 2013, the last day of trading prior to this announcement, a 42.8 percent premium over the closing price of Anaren common stock of $19.61 on April 15, 2013, which was the last close of trading before Vintage Capital Management LLC (Vintage Capital) made an offer of $23.00 per share following the close of trading on April 15, 2013, and a 21.7 percent premium over the $23.00 per share offer from Vintage Capital. The transaction is valued at approximately $381 million. The independent committee of Anaren's board of directors unanimously recommended and the board unanimously approved the merger agreement.

COLLABORATIONS

Peregrine Semiconductor Corp. and **GLOBALFOUNDRIES** are sampling the first RF switches built on Peregrine's new UltraCMOS 10 RF SOI technologies. This partnership unites Peregrine's 25 years of RF SOI experience with a tier-one foundry. In a joint development effort, GLOBALFOUNDRIES and Peregrine created a unique fabrication flow for the versatile new 130 nm UltraCMOS 10 technology platform. This new technology delivers a more than 50 percent performance improvement over comparable solutions.

The Boeing Co. and **Lockheed Martin Corp.** are teaming to compete for the **United States Air Force**'s Long-Range Strike Bomber program, with Boeing acting as the prime contractor and Lockheed Martin as the primary teammate. To this critical mission, the team brings together nearly two centuries of combined experience designing, developing and testing aircraft for defense customers around the world. The companies also bring expertise in integrating proven technologies, and their skilled workforces and critical infrastructure and scale, to meet the U.S. Air Force's cost and schedule requirements.

Alcatel-Lucent and **G-Mobile**, one of Mongolia's leading service providers, are to deploy small cell base stations to improve 3G mobile broadband coverage in densely populated areas in the capital city of Ulaanbaatar. The city, which is home to approximately 45 percent of the country's population, will be the location of an initial deployment to be followed by an expansion in 2014 covering the greater Ulaanbaatar area and other major Mongolian cities in 2014.

NEW STARTS

Global defense and security company **Saab** has announced the establishment of **Saab Defense and Security USA LLC** (SDAS). This represents the joining of several U.S.-based Saab defense companies into a single U.S. defense and homeland security provider. Shared management structures and security governance will increase synergies and improve efficiency. The company's goal is to build an agile and responsive U.S. company able to deliver innovative, timely and highly-effective solutions to meet local defense and security needs. SDAS will operate under a special security agreement with the U.S. Department of Defense. This will ensure the required protections remain in place so the company can sustain and build its defense and homeland security activities.

CONTRACTS

LONGBOW LLC, a joint venture between Lockheed Martin and Northrop Grumman, received a $92.8 million contract from the **U.S. Army** to provide Life Cycle Contractor Support (LCCS) for LONGBOW programs on the AH-64D and AH-64E helicopters. The LCCS contract provides integrated logistics support for LONGBOW Fire Control Radar (FCR) systems equipping AH-64D and AH-64E Apache helicopters. The contract also includes support for the AH-64E Unmanned Aerial System Tactical Common Data Link Assembly (UTA) and upgraded FCR Radar Electronics Unit (REU). The period of performance for the LCCS contract extends through 2016.

General Dynamics C4 Systems received the first production order from the **Federal Aviation Administration** (FAA) for new software-defined, Voice over Internet Protocol (VoIP) CM-300/350 UHF and VHF air traffic control (ATC) radios, related accessories and training materials. The $25 million order will begin a new chapter in ground-to-air communications as the next-generation radios deliver clear communication between pilots and air traffic controllers. Based on the FAA's implementation schedule, the radios will be installed in airport terminal ATC sites, regional control centers and other aviation facilities throughout the United States.

Harris Corp. received an $11 million order from a Middle Eastern nation to provide a comprehensive coastal intelligence, surveillance and reconnaissance communications network. Harris will provide Falcon III® RF-7800M Multiband Networking Radios, accessories and its battle management application in Coast Guard vehicles and strategic installations on land, at sea and in the air. The integrated solution will allow users to send and receive situational awareness and intelligence information across a secure mobile network, connecting squads and their commanders for real-time decision-making.

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Model	Frequency Range (MHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Typ.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.]	Size (Inch)
DCO Series					
DCO50100-5	500 - 1000	0.5 - 15	+5 @ 34 mA	-100	0.3 x 0.3 x 0.08
DCO6080-3	600 - 800	0 - 3	+3 @ 15 mA	-105	0.3 x 0.3 x 0.08
DCO7075-3	700 - 750	0.5 - 3	+3 @ 12 mA	-108	0.3 x 0.3 x 0.08
DCO80100-5	800 - 1000	0.5 - 8	+5 @ 26 mA	-111	0.3 x 0.3 x 0.08
DCO8190-5	810 - 900	0.5 - 16	+5 @ 34 mA	-118	0.3 x 0.3 x 0.08
DCO100200-5	1000 - 2000	0.5 - 24	+5 @ 36 mA	-95	0.3 x 0.3 x 0.08
DCO1198-8	1195 - 1205	0.5 - 8	+8 @ 30 mA	-115	0.3 x 0.3 x 0.08
DCO170340-5	1700 - 3400	0.5 - 24	+5 @ 29 mA	-90	0.3 x 0.3 x 0.08
DCO200400-5 DCO200400-3	2000 - 4000	0.5 - 18	+5 @ 46 mA +3 @ 46 mA	-90 -89	0.3 x 0.3 x 0.08
DCO300600-5 DCO300600-3	3000 - 6000	0.5 - 18	+5 @ 35 mA +3 @ 35 mA	-80 -78	0.3 x 0.3 x 0.08
DCO400800-5 DCO400800-3	4000 - 8000	0.5 - 18	+5 @ 20 mA +3 @ 20 mA	-78 -76	0.3 x 0.3 x 0.08
DCO432493-5 DCO432493-3	4325 - 4950	0.5 - 11	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 0.08
DCO450900-5 DCO450900-3	4500 - 9000	0.5 - 18	+5 @ 20 mA +3 @ 20 mA	-76 -74	0.3 x 0.3 x 0.08
DCO473542-5 DCO473542-3	4730 - 5420	0.5 - 22	+5 @ 20 mA +3 @ 20 mA	-88 -86	0.3 x 0.3 x 0.08
DCO490517-5 DCO490517-3	4900 - 5175	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 0.08
DCO495550-5 DCO495550-3	4950 - 5500	0.5 - 12	+5 @ 22 mA +3 @ 22 mA	-83 -85	0.3 x 0.3 x 0.08
DCO5001000-5 DCO5001000-3	5000 - 10000	0.5 - 18	+5 @ 20 mA +3 @ 20 mA	-75 -73	0.3 x 0.3 x 0.08
DCO579582-5	5780 - 5880	0.5 - 10	+5 @ 20 mA	-90	0.3 x 0.3 x 0.08
DCO608634-5 DCO608634-3	6080 - 6340	0.5 - 5	+5 @ 20 mA +3 @ 26 mA	-85 -86	0.3 x 0.3 x 0.08
DCO615712-5 DCO615712-3	6150 - 7120	0.5 - 18	+5 @ 22 mA +3 @ 22 mA	-85 -83	0.3 x 0.3 x 0.08

Model	Frequency Range (GHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Typ.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.]	Size (Inch)
DXO Series					
DXO810900-5 DXO810900-3	8.1 - 8.925	0.5 - 15	+5 @ 32 mA +3 @ 32 mA	-82 -80	0.3 x 0.3 x 0.08
DXO900965-5 DXO900965-3	9.0 - 9.65	0.5 - 12	+5 @ 27 mA +3 @ 27 mA	-80 -78	0.3 x 0.3 x 0.08
DXO10701095-5	10.70 - 10.95	0.5 - 15	+5 @ 25 mA	-82	0.3 x 0.3 x 0.08
DXO11441200-5	11.44 - 12.0	0.5 - 15	+5 @ 30 mA	-82	0.3 x 0.3 x 0.08
DXO11751220-5	11.75 - 12.2	0.5 - 15	+5 @ 30 mA	-80	0.3 x 0.3 x 0.08
DXO14851515-5	14.85 - 15.15	0.5 - 15	+5 @ 30 mA	-74	0.3 x 0.3 x 0.08

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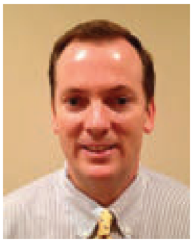
Around the Circuit

Mercury Systems Inc. announced it received $4.6 million in follow-on orders from a leading defense prime contractor for high performance signal processing subsystems for a ship-borne radar application. The orders were booked in the company's fiscal 2014 first quarter and are expected to be shipped within the next 24 months.

Comtech Telecommunications Corp. announced that its Melville, NY-based subsidiary, **Comtech PST Corp.**, received a $1.4 million order for broadband, solid-state, high-power RF microwave amplifier systems from an international OEM. The amplifier systems, which include the latest broadband solid-state switching and transistor technology, provide for very broad frequency coverage and will be utilized as part of communications jamming systems.

The Austrian Ministry of Defence has ordered six Tracker mini unmanned air systems. This contract was won by **Survey Copter**, a wholly-owned subsidiary of Cassidian SAS, responsible for the development and manufacturing of miniature aircraft and helicopter UAVs, in cooperation with the **Kapsch Group**. The Tracker can be deployed for missions including detection, reconnaissance, identification, classification, tracking, over-the-hill targeting, target or axis designation, special force and anti-terrorism action, littoral/border control, force protection, convoy support, dismounted warfighter missions and Military Operations in Urban Terrain (MOUT). Following a pre-programmed and reconfigurable plan in the course of the mission, the Tracker flies entirely automatically.

PEOPLE



▲ Michael E. Clark

Microlease announced the appointment of **Michael E. Clark** as its new chief executive officer for the Americas. Clark joins Microlease from Airvana where he was Airvana LP's senior executive and general manager. Prior to Airvana, Clark spent 22 years in the test & measurement industry, serving in various senior management roles at JDS Uniphase, Agilent Technologies, Acterna, Wandel & Goltermann and Hewlett Packard. Clark has extensive experience in multiple communications markets including wireless and wireline service providers, network equipment manufacturers and major enterprises across the world.

▲ Martin Harris

Altium Ltd. announced the promotion of **Martin Harris** to chief sales officer (CSO). Harris has previously held the role of senior executive vice president, global field operations. As the CSO, he is a key member of Altium's executive team, leading the global sales management team of Altium.

Indium Corp. announced the promotion of two technical managers in the company's Asia-Pacific operations.

▲ Sze Pei Lim

▲ Liyakathali (Liya) Koorithodi

Sze Pei Lim has been promoted to technical manager for Asia-Pacific operations. She is responsible for managing the company's technical teams throughout the Asia-Pacific region. Lim joined Indium Corp. in 2007 as an area technical manager. She earned her bachelor's degree in chemistry from the National University of Singapore and has 17 years of experience in SMT and PCB assembly. **Liyakathali (Liya) Koorithodi** has been promoted to assistant technical manager. He is responsible for all technical support, assisting and providing day-to-day technical support for Indium Corp.'s customers in India. Koorithodi has more than 14 years of experience in electronics assembly manufacturing. He earned a degree in mechanical engineering from the Department of Technical Education, Government of Kerala and is an SMTA-certified SMT process engineer. He earned his Six Sigma Green Belt from Motorola University (TQMI Chennai).

REP APPOINTMENTS

Agile Microwave Technology Inc. announced the appointment of **High-tech Sales** (H-t-S) as its sales representative organization for the MA, CT, NH, ME, RI and VT territories.

As the designated business aviation airtime reseller for Inmarsat's GX Aviation global Ka-Band solution, **Honeywell** has signed an agreement with **ARINC Direct** to bring this connectivity to the business aviation market. GX Aviation is scheduled to be available in early 2015.

Isola Group S.à.r.l. announced that its German subsidiary, **Isola GmbH**, has entered into a distribution agreement with **Holders Technology plc** to sell selected materials in the United Kingdom.

XMA Corp. welcomes **G2 Sales** as its manufacturing representative for FL, GA, AL, NC, SC, TN and MS. G2 Sales has a vast amount of experience selling technical products in the RF, microwave and millimeter-wave related industries.

PLACES

Thales Alenia Space Belgium announced that it will build a new plant in Leuven, which will start operations in the first half of 2014. This strategic new facility reflects Thales Alenia Space's growing role in Belgium, a country that is fully committed to the programs developed by the European Space Agency (ESA). The new facility will initially have a team of about 20 engineers, tasked with developing new avionics products and technologies for satellites and launch vehicles. The facility will work closely with the company's microelectronics center of expertise in Leuven, as well as with Thales Alenia Space's Charleroi plant.

RFMW Ltd. announced the opening of direct sales offices in Russia. With locations in Moscow and St. Petersburg, the new sales organization will support customers in the Russian Federation, Ukraine, Belarus, Armenia, Georgia and Kazakhstan.

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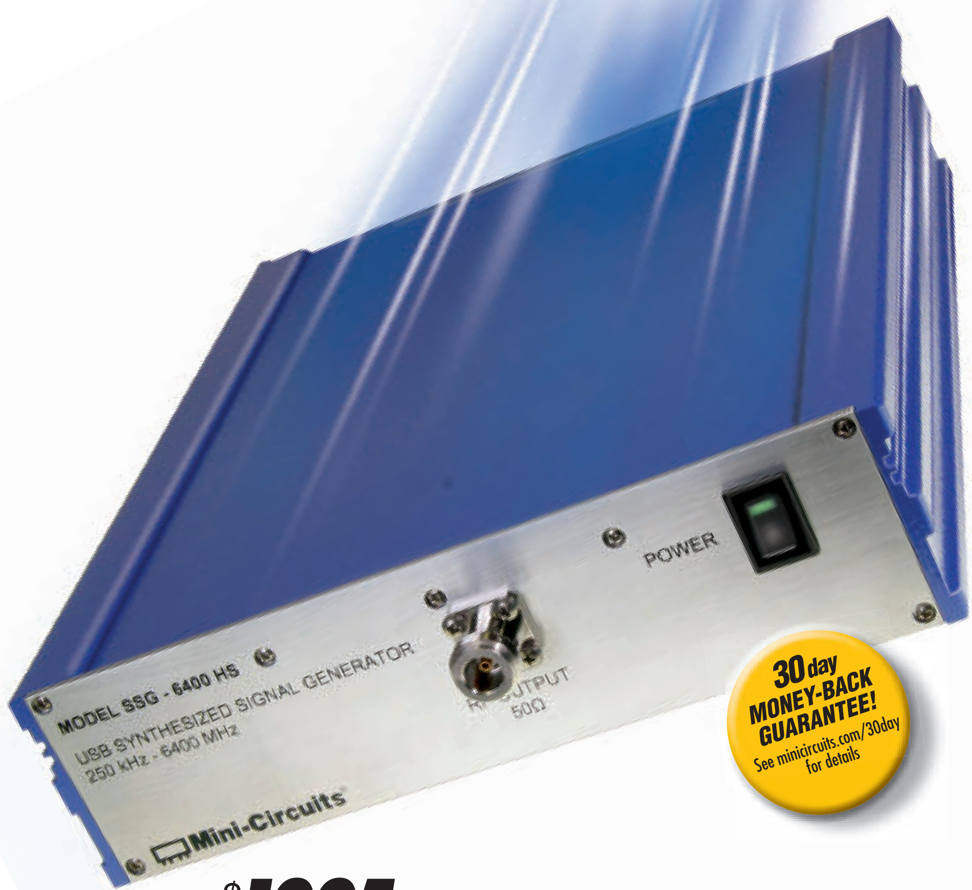

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SSG-6000 *$2,695*
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Hybrid Linac-MR: Image-Guided Radiation Therapy Delivered in Real-Time

Radiation is a proven therapy for treating cancer. However, targeting a radiation beam on organs that move — such as cancers located in the liver, stomach or lungs — can be challenging, especially when the images used to locate a tumor are days, or even weeks, old. Researchers at the Cross Cancer Institute in Edmonton, Canada are using simulation to model the complicated RF fields involved in the process to develop a system in which a tumor can be both imaged and treated simultaneously.

Ever since the benefits of using radiation for treating cancer were first discovered, the challenge has been how to maximize damage to cancerous cells, while simultaneously minimizing the destruction of surrounding healthy tissues and organs. While attempts at leveraging this therapeutic index have led to the advent of a variety of innovative approaches, a central problem still remains — how to accurately determine a tumor's size, shape, location and position in time, and utilize this information in the most effective way possible to treat cancerous cells. Currently, standard radiation therapies are limited by normal shifts in human anatomy. For example, tissues and organs can arrange themselves differently each time a patient climbs onto a treatment table, requiring radiation oncologists to compensate for tumor movement by enlarging treatment areas and lowering radiation doses so as to avoid killing healthy tissues. Many modern treatments depend on computed tomography (CT) imaging, X-rays, ultrasounds or magnetic resonance imaging (MRI) to study tumors, and then use a complex calculation process to determine where the radiation should be directed. It is often days or even weeks between when the first set of images is taken and when radiation is administered, meaning that a tumor's shape or even its location could have changed. This is exaggerated in moving tumors such as those found in the lungs, liver or stomach where normal organ movements cause the tumor to shift drastically. Therefore, in order to ensure that the entire tumor is exposed to radiation, extended regions surrounding the tumor must also be irradiated.

Because of this, the advancement of radiation therapy is intrinsically linked to improvements in medical imaging technology. Over the past few years, the increasing use of MRI for determining a tumor's size, shape and location, coupled with the growing availability of computer-controlled treatment planning and deliv-

Alexandra Foley
COMSOL Inc., Burlington, MA

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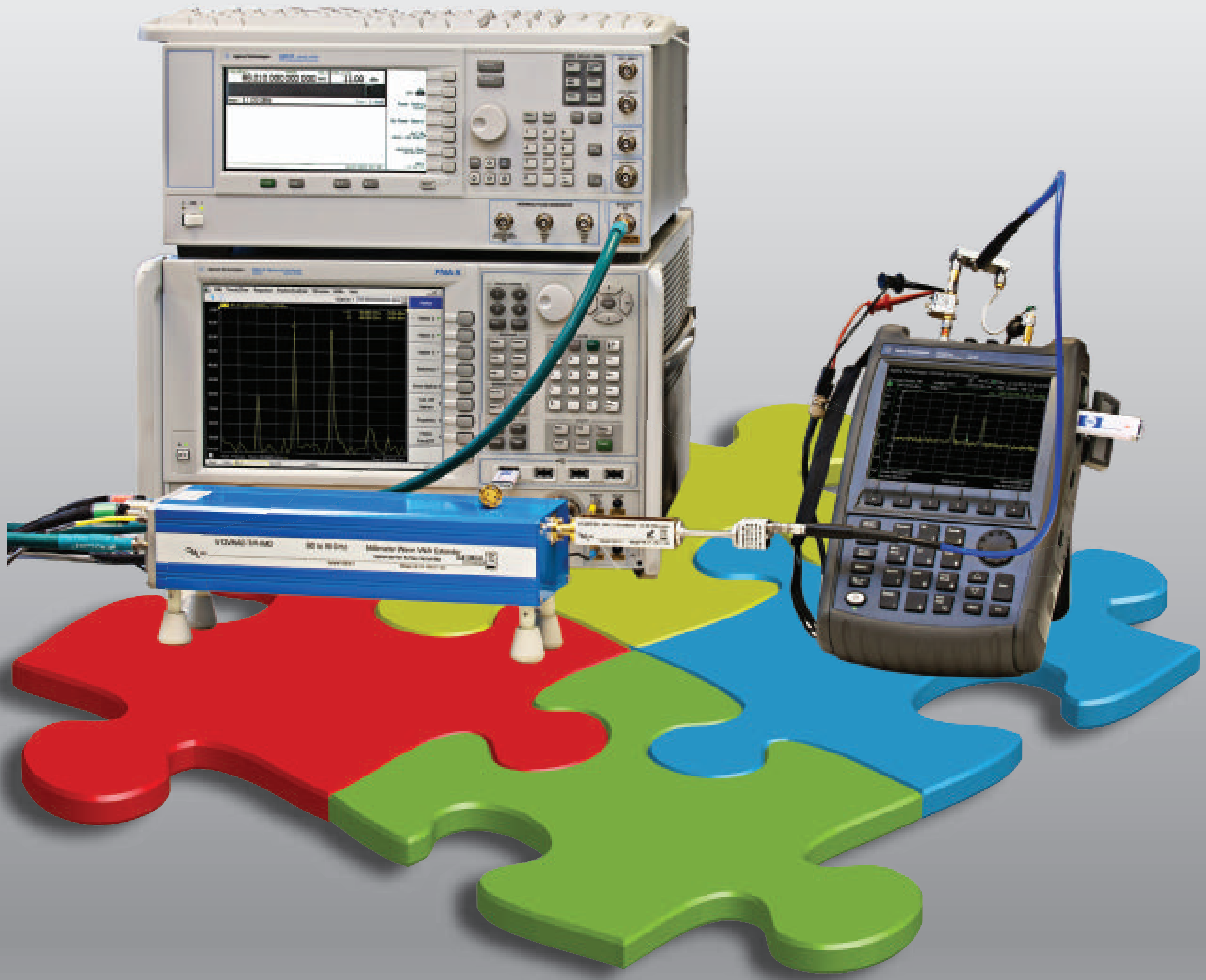

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ery systems, has led to the evolution of radiation treatments that can more accurately target tumors. MRI enables high-contrast 3D images to be taken that provide information not only about the tumor itself, but also about its precise location near vital organs. Computer-controlled treatments then allow for this information to be translated into multiple treatment parameters during irradiation, producing improved dose distributions and more accurate control over treatment areas.

The culmination of these techniques has resulted in image-guided radiation therapy (IGRT), which uses the integration of medical imaging technologies with radiation treatment. In many of these new treatment methods, a linear particle accelerator (linac) is used to generate radiation that can be accurately administered through computer-controlled programs. When combined, these techniques offer the best treatments currently available. However, as of yet, the MRI must be carried out completely independently of radiation treatment due to the electromagnetic interactions that take place between the MR scanners and linac. This means that images can be taken prior to the beginning of a radiation treatment session, but imaging during the actual treatment process is not possible.

A clear improvement to this would be if a patient could be simultaneously imaged and treated in response to accurate 3D images about tumor location on a quantitative scale. If such an ideal treatment system could be developed, a tumor's location could be identified at all times during treatment, allowing for precise irradiation even in moving tumors. This has, up until recent years, been regarded as impossible. Now, however, a team from the Cross Cancer Institute in Edmonton, Canada has found a way to combine the two systems.

CONSIDERATIONS FOR REAL-TIME IMAGE-GUIDED RADIATION THERAPY

Dr. Gino Fallone, from the Department of Medical Physics at the Cross Cancer Institute, first began working on a combination linac and MRI device in 2005. His research group, known as the Linac-MR Project, achieved proof-of-concept in 2008 when they built the first fully operational Linac-MR prototype, containing a 0.2 T biplanar permanent-magnet MRI integrated linac.[1] This Linac-MR images a tumor during radiation treatment, and then uses these images in real time to adjust to changes in tumor position and shape. The Linac-MR, when completed, will be especially important for the treatment of tumors found in organs that move, such as the lungs, liver, stomach and pancreas, for example. This revolutionary approach was dubbed (ART)[2] — Advanced Real-Time Adaptive RadioTherapy by the team.

The first step in designing the Linac-MR was mitigating the electromagnetic interactions that take place between the linac and MR scanner, a process that requires an in-depth understanding of how one system affects the performance of the other. MR scanners emit an RF pulse that interacts with the hydrogen nuclei of a body placed inside a strong magnetic field. This RF pulse causes the nuclei to produce a rotating magnetic field that is then detected by an RF antenna and displayed as a 3D image. In all, MRI uses three different electromagnetic fields: a very strong magnetic field to polarize the hydrogen nuclei, called the static field; a weaker space-time-varying field called the gradient field for image generation; and a weak RF field for manipulation of the hydrogen nuclei to produce measurable signals.

A linac, on the other hand, uses an RF waveguide to create an oscillating electromagnetic (EM) field that accelerates an electron beam toward a target, thereby producing the x-rays used to destroy tumor cells. The EM field generated by the linac interferes with the weak RF signals read and interpreted by the MRI system to construct a 3D image with appropriate soft-tissue contrast, diminishing image quality. In addition, the strong magnetic field produced by MRI to polarize hydrogen molecules impedes the linac's operation by deflecting the electron beam, causing it to miss the target. In order to combine the two devices, Fallone and his team of researchers used the simulation software COMSOL Multiphysics to determine the effects that MRI's magnetic field has on the performance of the linac, and to devise a system of

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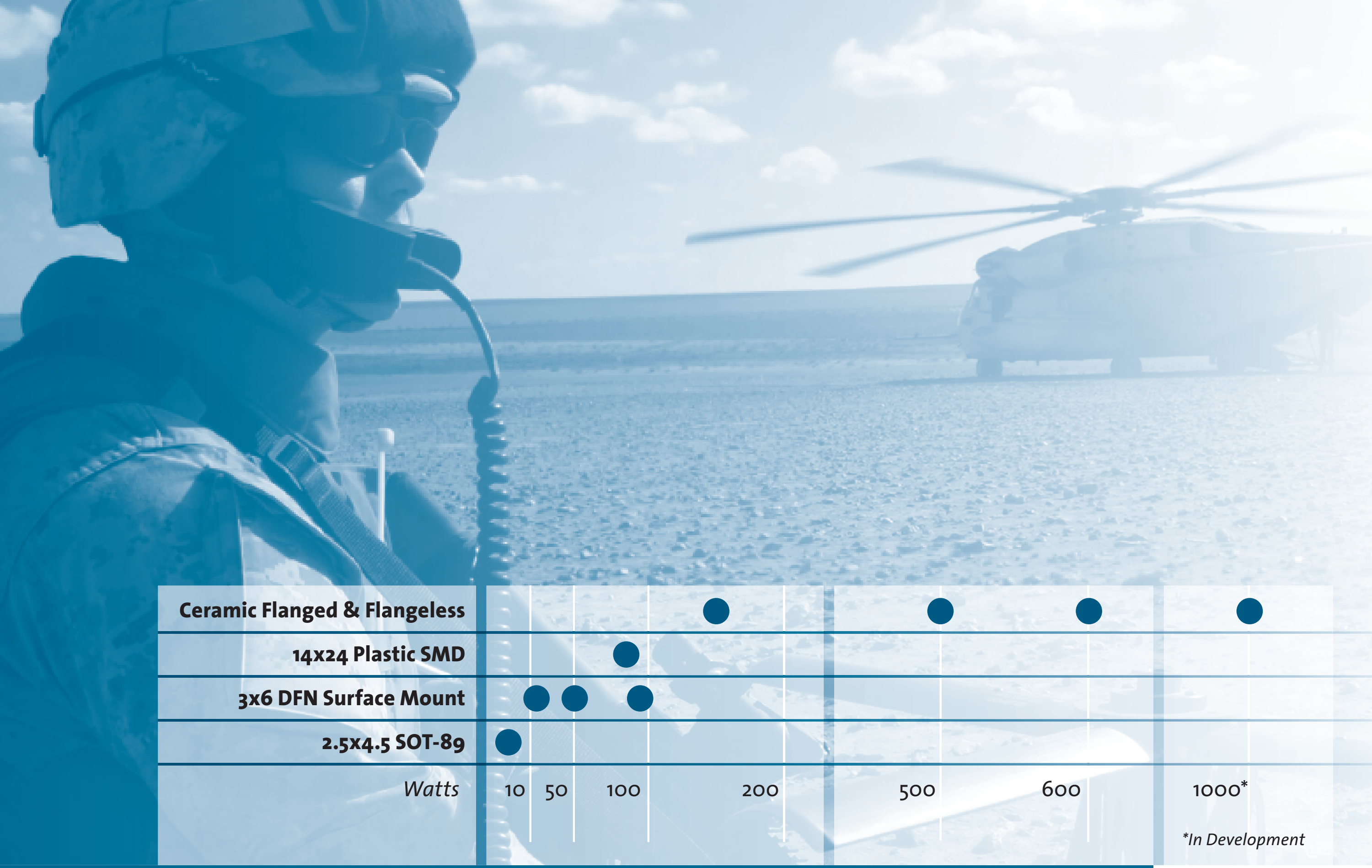

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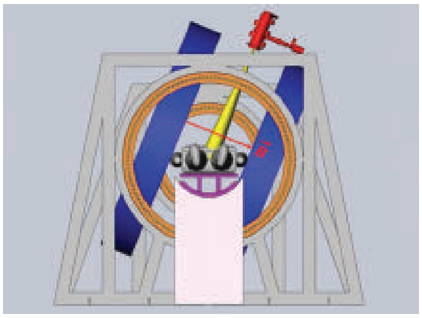
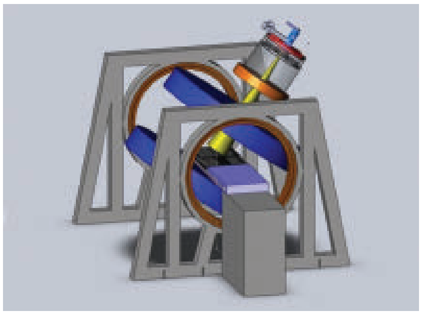


▲ *Fig. 1 Transverse rotating biplanar geometry (electron beam is shown in yellow, and the MRI magnets are shown in blue). Reprinted with permission from Cross Cancer Institute.*



▲ *Fig. 2 Longitudinal rotating biplanar geometry (electron beam is shown in yellow, and the MRI magnets are shown in blue). Reprinted with permission from Cross Cancer Institute.*

shielding the MRI field and the linac from one another.[2]

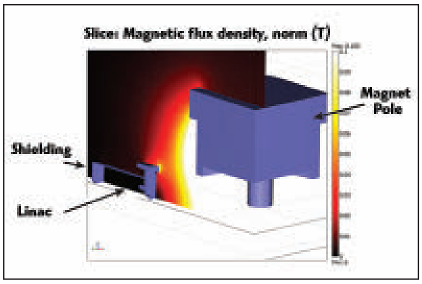
LINAC-MR DEVICE ORIENTATIONS

There were a few different geometries that the team considered when designing the optimal configuration of the Linac-MR device. In addition to the linac and MRI, the Linac-MR also contains a patient treatment table as well as a gantry on which the linac and MR scanner is housed. Simulation and experiments were performed to investigate the optimal relative position of the linac and MRI device. To do this, a simulation was set up in which the linac system was rotated around the MR scanner. Fallone and his team found that mounting the linac and the biplanar magnet of the MRI system onto the same gantry would allow them to move together and reduce distortion to the MR images.[3,4,5] This unified configuration is referred to as the rotating biplanar geometry.

The team explored two different configurations of this geometry; the transverse and longitudinal directions as shown in ***Figures 1*** and ***2***. In the transverse geometry, the radiation beam could pass unimpeded through the open side of the MRI system (see Figure 1), but a hole was required for the beam to pass without interacting in the magnet poles in the longitudinal geometry (see Figure 2). Currently, both geometries are being pursued as each one has its clinical advantage.

METHODS FOR SHIELDING

One of the earliest projects conducted by the team was to establish a means of shielding the linac from MRI's strong static field, and MRI from the EM field generated by the linac. Because the linac's tolerance to magnetic



▲ *Fig. 3 Quarter section cutaway of passive shielding for a perpendicular Linac-MR orientation (magnetic field lines perpendicular to electron trajectories).*

fields was unknown at that time (this was later investigated by this group), the aim was to shield the linac down to 0.5 gauss, the magnitude of the Earth's magnetic field. To accomplish this, the team used a ferromagnetic shielding wall to concentrate the magnetic flux lines produced by MRI, preventing them from affecting the electron trajectories within the linac.[5,6,7]

The initial dimensions of the steel plate in the shielding wall were set to a thickness of 5 cm and dimensions of 2000 × 2000 cm. Using COMSOL Multiphysics, the team was able to verify the tolerances of the linac to the magnetic field and reduce the shield to a radius of 30 cm and a thickness of 6 cm (see ***Figure 3***). The new shield was more than three times lighter than the original, much more practical from an engineering design point of view. This new shield also dramatically reduced MRI's field inhomogeneities — by more than three times — which is important in producing a distortion-free MR image. And in addition to the optimized passive shielding arrangement that was devised, they also were able to develop an optimal active shielding solution that provided the same level of shielding for the linac but with an even further reduction in MRI field inhomogeneities.

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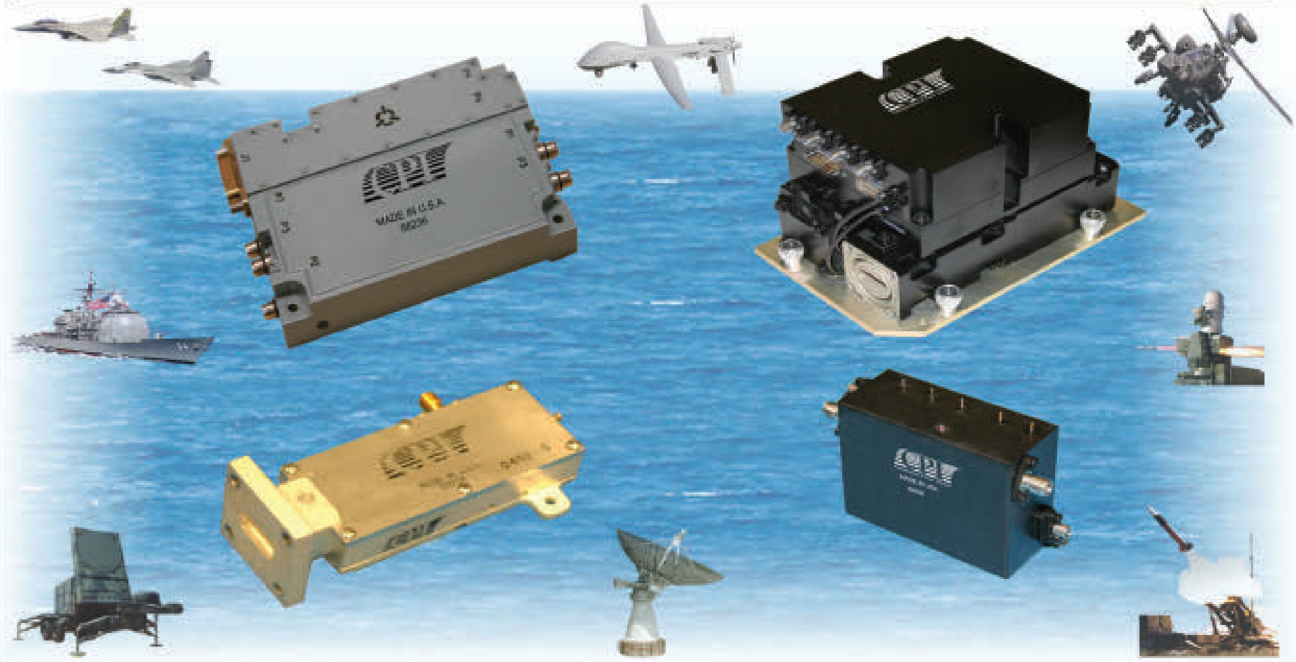

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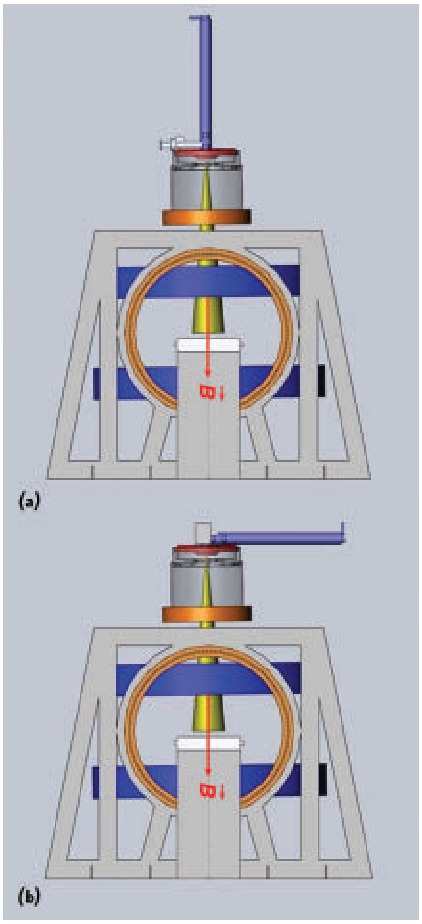
As a complementary investigation to the simulations performed on the transverse geometry, analyses were performed to determine the linac's tolerance for the longitudinal Linac-MR geometry. Both passive and active shielding were optimized, resulting in no increase in MRI image distortion and a fully functional radiation beam.

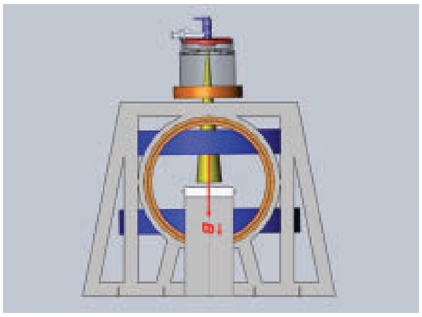
OPTIMIZATIONS THAT FIT THE STANDARD TREATMENT ROOM

Initially, the prototype Linac-MR was designed with a 6 MeV waveguide; however, to treat the full range of cancer sites, a higher electron beam energy is needed to penetrate into tissues deep within the body. To produce higher x-ray energies of 10 MeV, a long (1.5 m) waveguide is needed to accelerate the particles (see ***Figure 4a***). However, a longer waveguide would require buncher coils, solenoid coils and positioning coils along its length to prevent the deflection of the electron beam from the waveguide during treatment. In addition, due to the waveguide's length, it would need to be positioned horizontally to the treatment table in order to fit into a standard-sized treatment room (See ***Figure 4b***).[8] This horizontal orientation of the waveguide would require the use of bend magnets to redirect the electron beam toward the patient, and the Lorentz forces introduced by the MR's magnet would further deflect the electron beam out of the waveguide and require more shielding.[2]

Instead of using either of these orientations for the long 10 MeV waveguide, the team instead designed a shorter 10 MeV waveguide by optimizing it using simulation.[2] They wanted the Linac-MR to generate a 10 MeV electron beam because it would allow the Linac-MR to treat the full range of cancers that necessitate the use of many different beam energies. Given the current resizing options, that would have meant using a waveguide that measured 1.5 m, too long for the system needs and requiring too much shielding. The team estimated that the shortest 10 MeV waveguide that could be designed using conventional S-Band techniques was 70 cm, but by performing additional simulations, they found that they could reduce the length of the waveguide to 30 cm (see ***Figure 5***).



▲ *Fig. 4 A long 10 MeV waveguide cannot be positioned vertically above the treatment table because it would be too large to house in a standard treatment room (a). Positioning the waveguide parallel to the treatment table introduces interactions that are difficult to shield from MRI (b). Reprinted with permission from Cross Cancer Institute.*



▲ *Fig. 5 Orientation of the short 10 MeV waveguide in relation to the treatment table. Reprinted with permission from Cross Cancer Institute.*

To date, no one has attempted to design such a linac. According to Dr. Stephen Steciw, Department of Medical Physics at the Cross Cancer Institute, the goal of designing a new S-Band linac is to use the same technologies currently available in the market, but to use them smarter. The team uses simulation software to push the current capabilities of existing technologies further by optimizing

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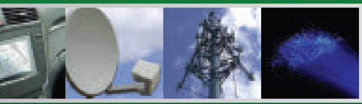

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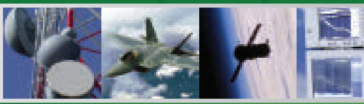

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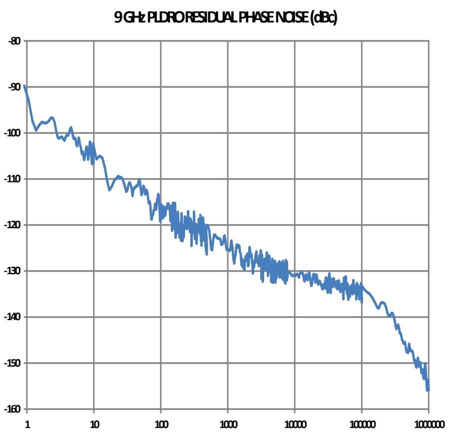

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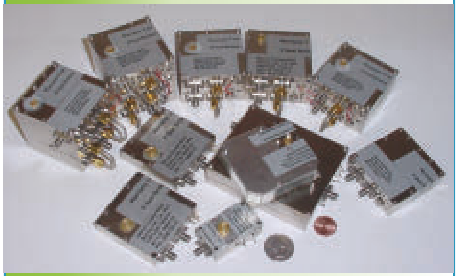

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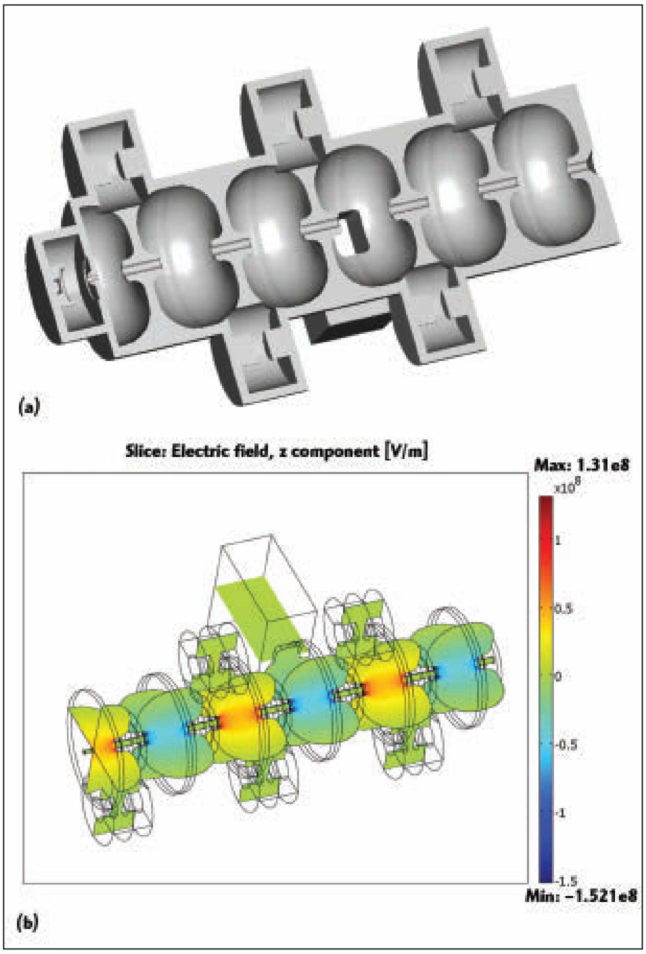
them to improve their performance.

To begin, the research team used a benchmark model of a single energy Varian 600C (6 MeV) S-Band waveguide produced by a former graduate student of the group, Dr. Joel St. Aubin, to analyze the effects of increasing the field strength to produce 10 MeV electrons. A significant concern when increasing the input power to the waveguide is electric breakdown. If the RF fields in the waveguide increase beyond the threshold determined by the waveguide geometry and operating frequency, electric arcing will occur within the waveguide, absorbing the RF energy and damaging the device. Using simulation, the team was able to determine that current S-Band technologies only use roughly 40 percent of the breakdown limit, allowing plenty of room for improvements to be made for a stronger waveguide.[2]

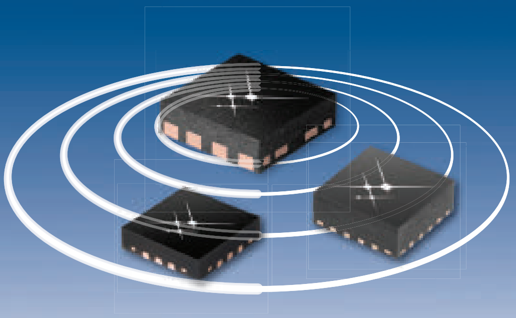


▲ *Fig. 6 Cutaway view of the Linac system waveguide with RF cavities (a). Electromagnetic field distribution in a short 10 MeV waveguide (b).*

COMSOL Multiphysics was used by a graduate student Devin Baillie, member of the team, to adjust the resonance frequency of the model and to calculate in 3D the RF fields that exist within the waveguide. This analysis was then used to determine the highest strength of the power source that could be used in the waveguide. The benchmark model, the Varian 6 MeV waveguide, uses a 2.5 MW magnetron power source. Using COMSOL to recalculate the RF fields within the waveguide, the team determined that a 7.5 MW klystron power source could be used instead, without the risk of causing electric breakdown.

The waveguide is composed of a number of RF cavities through which the electron beam is directed (see ***Figure 6***). From previous work done by the group, they knew that the RF fields in the first half of the accelerating cavity, where the electrons enter the waveguide, are critical for electron capture within the waveguide and have a strong influence on the final energy spectrum. They determined that these RF fields could be reduced by optimizing the position of the first coupling cavity, thereby allowing for a stronger power source to be used. Results obtained from the model showed that, even with a threefold increase in input power needed to generate a 10 MeV waveguide (from 6 to 10 MeV), the peak surface fields of the waveguide are below the threshold limit, meaning that electric breakdown will not interfere with the operation of the accelerator (see ***Figure 7***).[2]

With this shortened waveguide, the Linac-MR device is small enough that it can be fit into a standard-size radiation therapy treatment room. This factor was of the utmost importance to the success of the project, because it will enable the device to be easily



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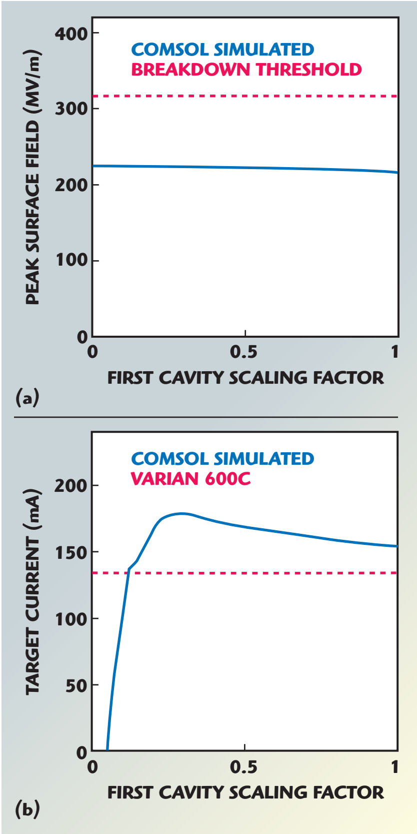
installed in hospitals and treatment centers around the globe. Many radiation treatment rooms are housed in the basement, meaning that it would be next to impossible to expand the room to contain a larger device. Rebuilding the treatment rooms would be too costly to be implemented on a large scale. With a short 10 MeV waveguide, the Linac-MR is not only able to treat a wider variety of cancer types, but it can be easily set up in a typical treatment center as well.

REAL-TIME TUMOR TRACKING

Even with the ability to successfully shield a short 10 MeV waveguide, a system still needed to be developed to compensate for the motion that occurs during system delay as images are acquired and processed by the MRI and computer-controlled system, and as radiation beam modifiers move into place to deliver radiation therapy. This is especially important for tumors located in the lungs, liver or stomach, since it is impossible to prevent movement from occurring in tumors located in these areas.



▲ *Fig. 7 The maximum field magnitude (solid blue) compared with the breakdown threshold (dotted red), as the first cavity fields are scaled (a). The current in the electron beam striking the target simulated (10 MeV) waveguide (solid blue) compared with that of the unmodified (6 MeV) waveguide (dotted red) (b).*

This was accomplished using a system that could predict the future position of the tumor in space and time using a motion-prediction software and an algorithm developed by the team.[9,10] The program works by taking several images per second during treatment, and then auto-contouring the images using an in-house software that determines the tumor's shape and position. By tracking the past movements of the tumor, the system then predicts from this data where the tumor will be a few seconds in advance.

The accuracy of the motion-prediction software was determined using an MR tractable 'phantom' that was representative of a tumor. 'Phantom' tumor movements were tested in two different patterns: sine, representing periodic motion; and modified cosine, signifying lung tumor motion. Dosing

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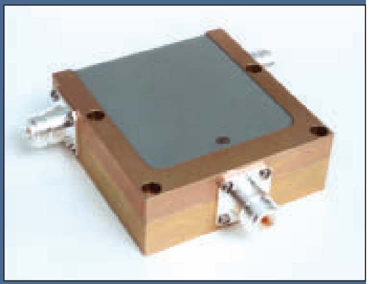

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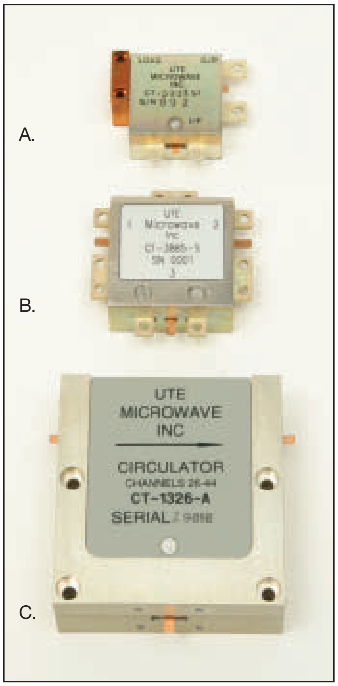

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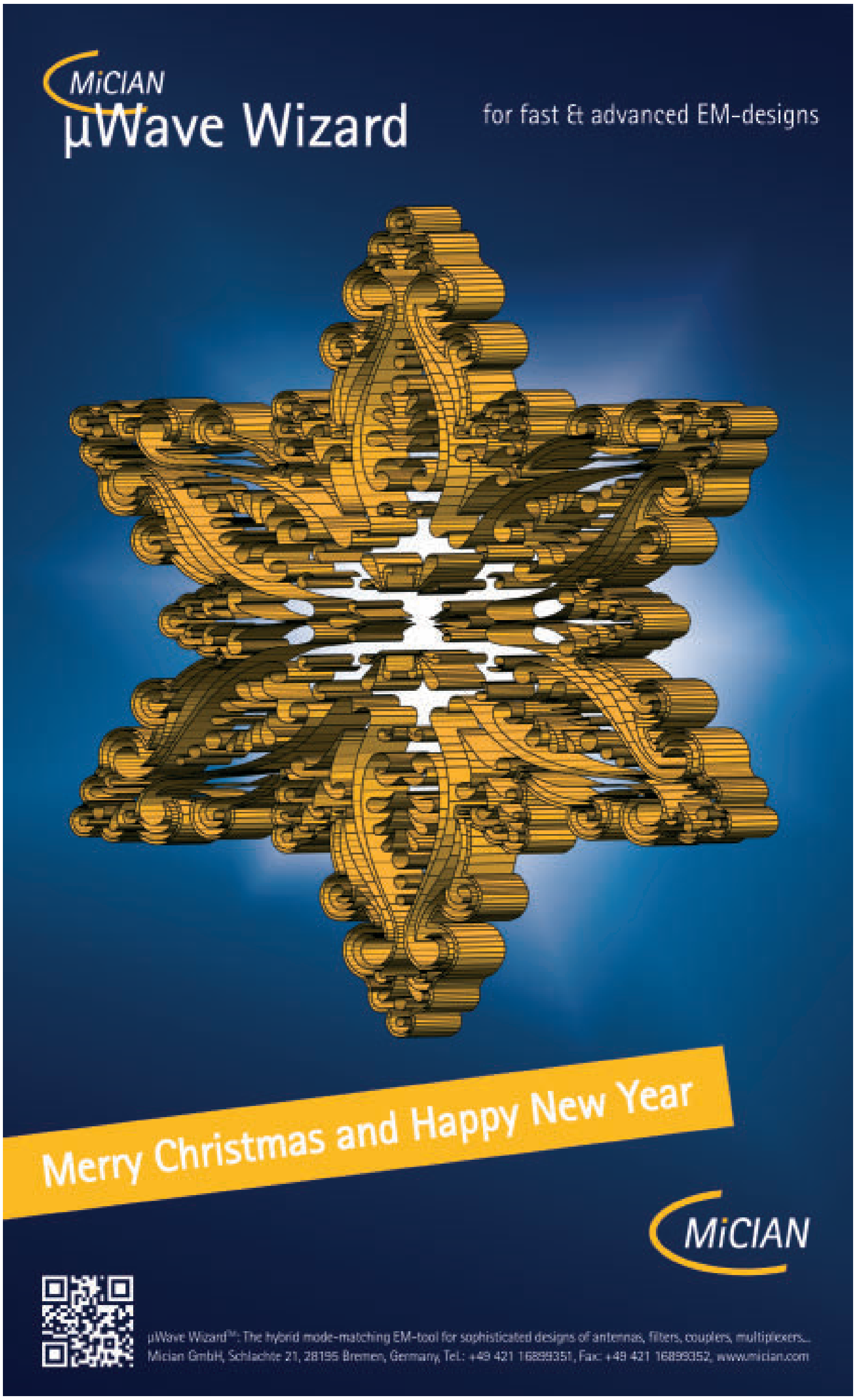
Contact us for more information on our extensive product line and current catalog. We accept Visa, MC, Amex film inserted inside the tumor phantom measured the tumor's exposure to radiation and determined the accuracy of the software's predicted future tumor position. Their algorithm, when used in both the sine and modified cosine trials, demonstrated a dose profile in the phantom that closely matched dose profiles in static targets. The ability to deliver a highly conformal dose to a target in motion was confirmed.

CONCLUSION

The Linac-MR is an enormous breakthrough for radiation treatment. In addition to improving the accuracy of radiation treatments for stationary tumors, it will also mean that certain types of tumors that are difficult to treat with radiation — such as those found in the liver, stomach and pancreas — can now include radiation as a treatment option. The prospects for mobile tumors are also drastically improved, since the Linac-MR can administer adequate doses to these moving tumors with sufficient accuracy to preserve surrounding healthy tissues. The Linac-MR prototype is currently undergoing its final tests, and the team is preparing the documentation required to seek governmental approval for the device to be used in clinical trials. The first real-time image-guide radiation treatment device, the Linac-MR, is expected to be in use as early as 2016. ■



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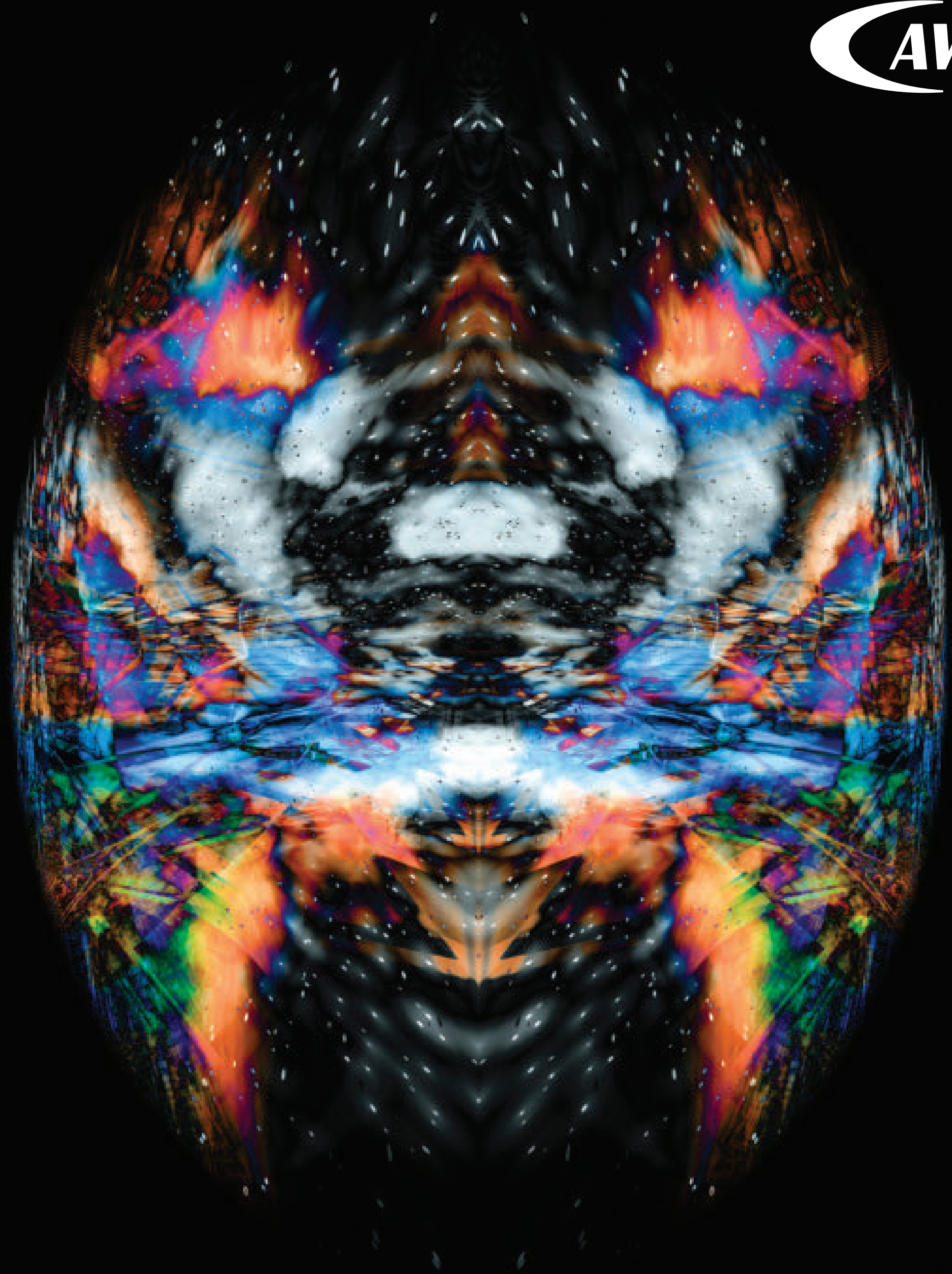

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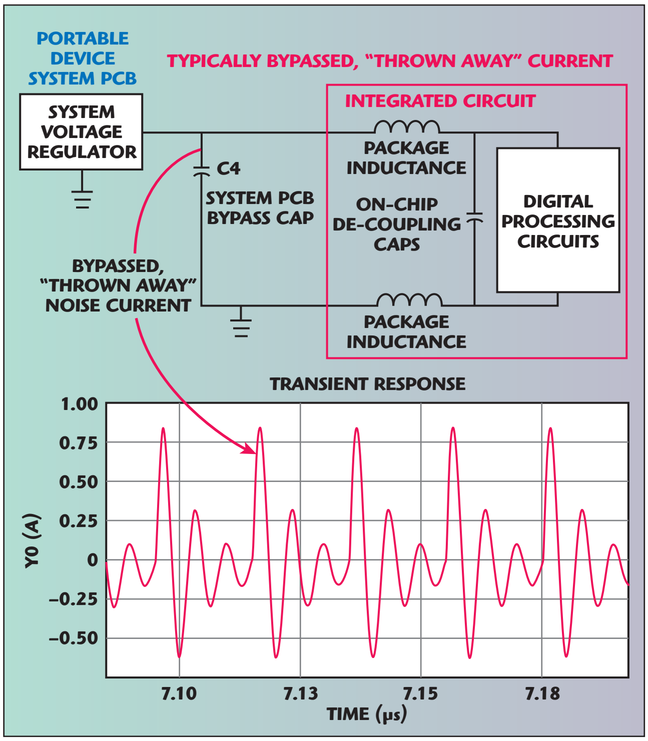
Tapping into a New RF Energy Source Found in Digital Processing Circuits

All electronic systems that use digital signal processing circuits (DSP) generate noise currents as an undesired by-product of their function. These noise current impulses are too high in frequency for conventional regulators to supply directly, thus bypass capacitors are utilized in conjunction with system voltage regulators to supply these locally needed high frequency currents.



▲ *Fig. 1 Reservoir current in typical bypass capacitors.*

The added bypass capacitors also function to provide a local high frequency current reservoir for local logic, reducing supply voltage noise by bypassing the digitally generated, high frequency noise currents to system ground. This bypassing action shunts the high frequency noise currents away from the supply line, as shown in ***Figure 1***, ultimately causing a "throw away" DC power drain (i.e., DC recharging of the bypass capacitors due to the losses in the system) on system power sources, batteries and capacitors.

Figure 1 shows typical reservoir current flowing (the "transient repsonse" waveform) as the result of active digital circuits and a typical system bypass cap (C4). Current spikes up to 1 A are shown. The "integrated circuit" in the figure can be any IC in any system that has some amount of digital activity on board. Power draw due to these digitally derived noise cur-

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rents and losses can be greater than 50 percent of the total device and system power consumption. They are especially significant in portable devices, such as smart phones and portable computing devices, laptops and iPads, medical devices, ultra-low power systems powered by low capacity energy harvesting devices and the like. This form of digital power drain tends to increase as the device is utilized more heavily and application complexity increases in digitally driven systems.

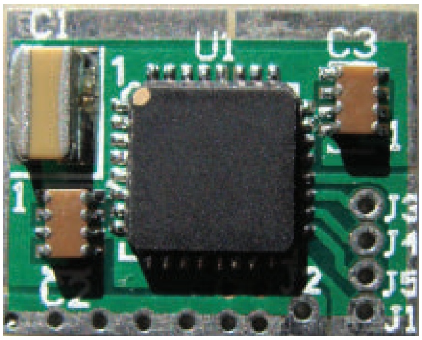
To reduce this power drain, the conventional design wisdom is to use digital strategies in design so as to periodically deactivate power hungry digital circuits (some form of "burst mode" processing), minimize digital supply voltages, or "process shrink" the design to a lower gate length manufacturing process node. The strategies above can be thought of as power saving "defensive" actions, the designer striving to reduce switching circuit power drain as much as possible. Utilizing the above strategies generally requires some form of design rework on the digital circuits in order to accomplish the desired power reduction, which adds to time to market and cost.

It should be noted that no matter what "defensive" choices designers make in attempting to reduce digital power drain, a certain magnitude of "thrown away" current and power always remains when switching circuits are active. So long as designers use electron-based transistor devices in design, this type of energy waste will be present. This form of power drain can be thought of as a previously unknown energy source embedded in switching systems, considered unreachable and unusable, until now.

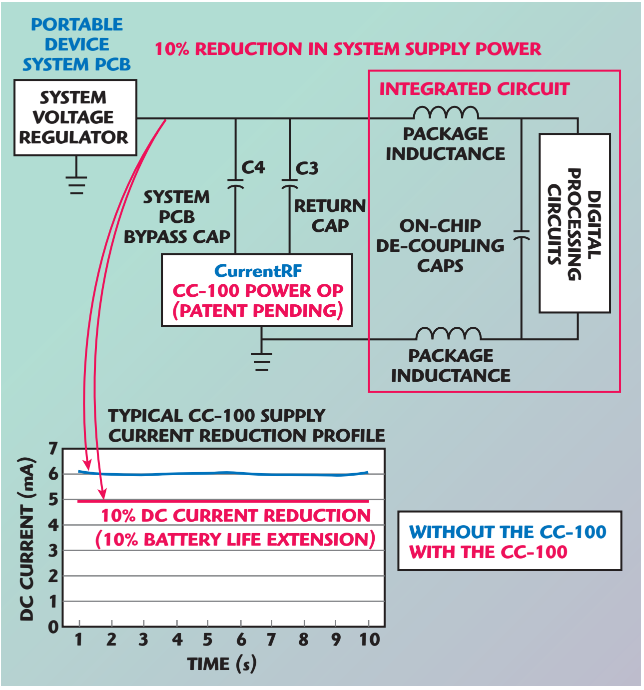
A methodology and a design has been developed that can reduce the aforementioned digital power drain, tapping into this "hidden" source of wasted power, without the need for costly digital design rework. The methodology and design is intended to be an "add on" to existing digital and system designs, at the IC, PCB and system levels of integration. Targeting digital "thrown away" currents, the methodology and design intercepts and recycles these currents back into a given system. The implementation of the methodology is small and inexpensive enough to be integrated into existing ICs, PCBs and systems, drawing no operational power of its own.

POWER OPTIMIZER IC

The Power Optimizer IC (PowerOp) shown in ***Figure 2*** (patent pending) is central to the real world realization of the mentioned methodology, a "proof of concept" device that fulfills the earlier mentioned needs and requirements. The IC functions



▲ *Fig. 2 The CC-100 Power Optimizer.*



▲ *Fig. 3 Typical application.*

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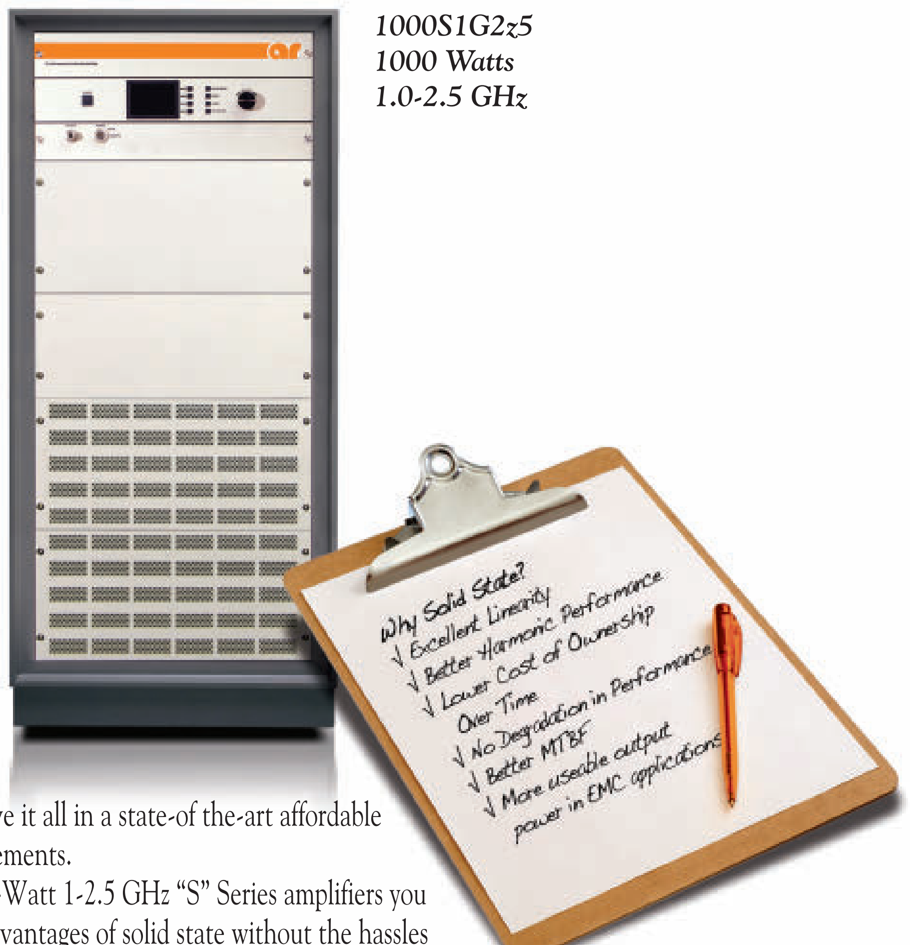

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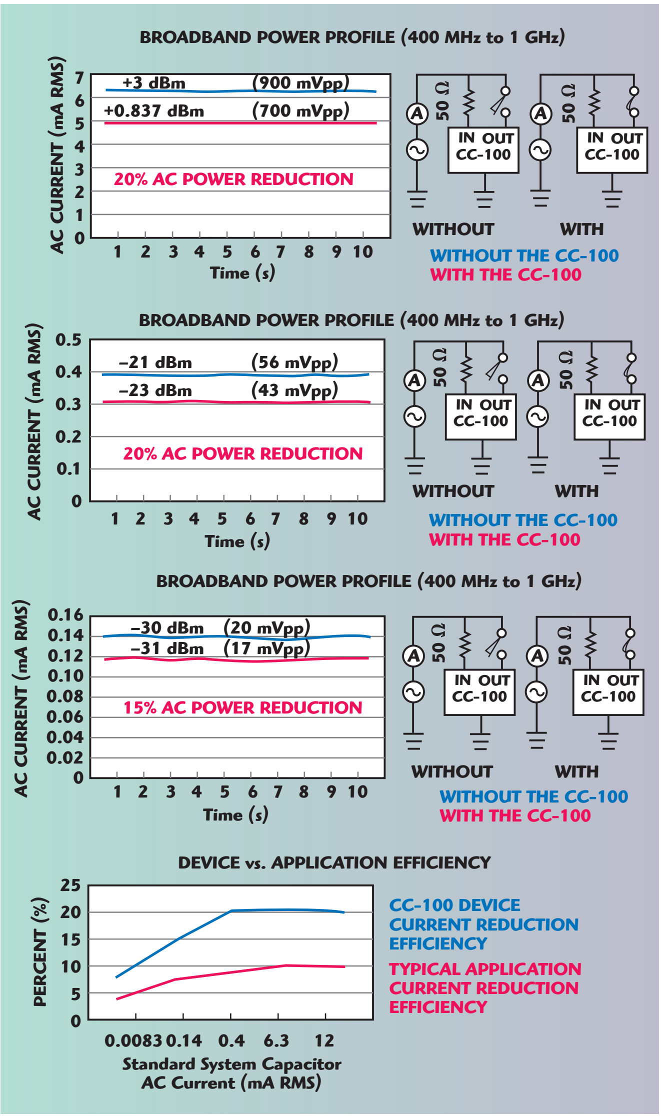
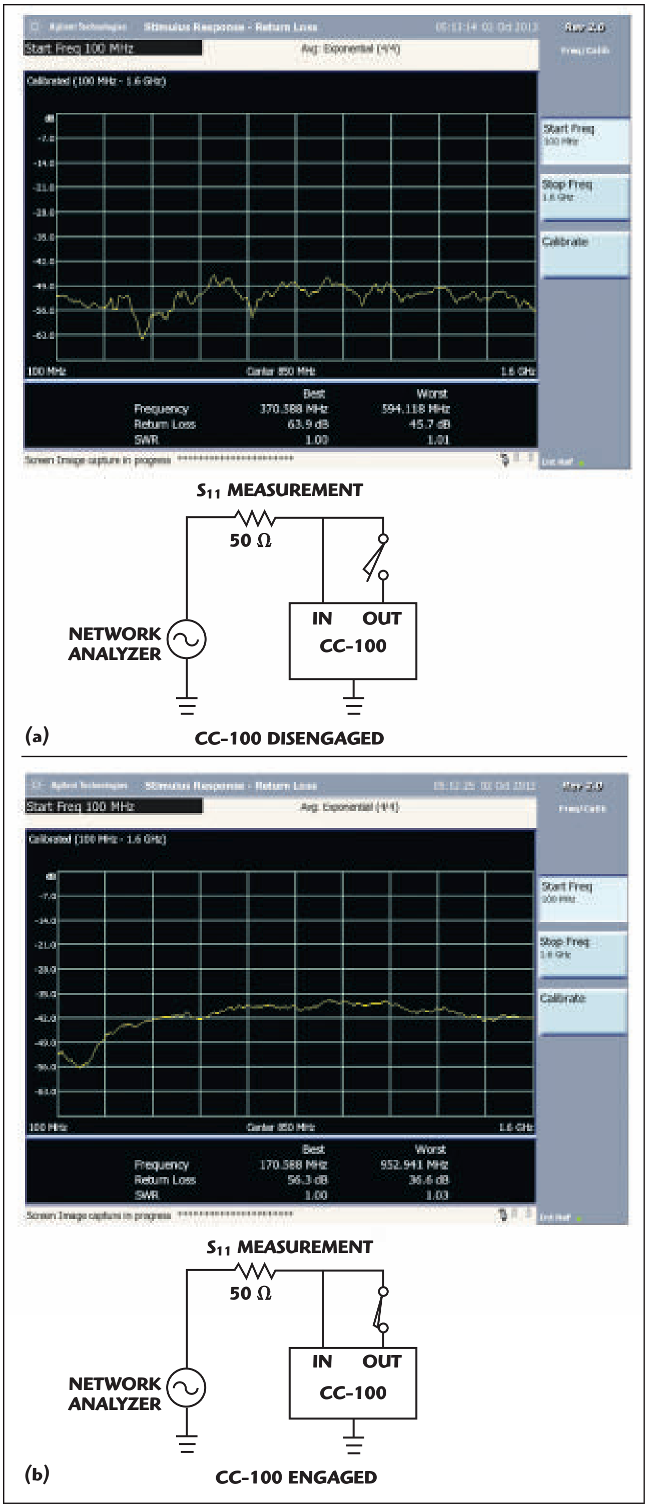


▲ *Fig. 4 Power Optimizer characterization plots.*

▲ *Fig. 5 CC-100 embedded in a USB connector.*

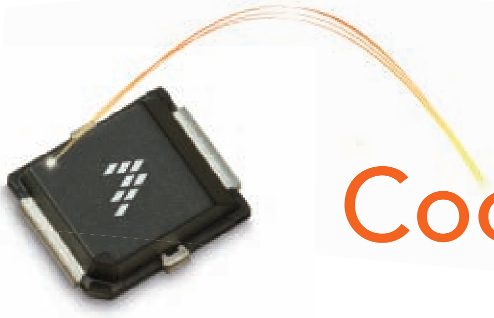


▲ *Fig. 6 S_{11} with Power Optimizer disengaged (a) and engaged (b).*

to intercept "thrown away," digitally generated currents, recycling them back into the system, reducing overall digital system power draw. This current recycling has been laboratory tested and shown to improve system battery life in portable devices by as much as 10 to 20 percent.

The "proof of concept," production ready device, inserted in series with the ground side of a major system board bypass capacitor, has an ultra-low input impedance small enough so as not to interfere with the normal function of a PCB bypass capacitor. The output impedance of the device is high enough to force, with the inclusion of an appropriately sized return capacitor, "thrown away" currents back into the system.

Figure 3 shows the same system as in Figure 1, only this time the device is inserted in series with the ground path of the system decoupling path and a current return cap (C3) is included for the device return path. The system bypass cap (C4) is the same cap as in Figure 1. The Power Optimizer IC, intercepting these "thrown away," digitally generated noise currents, recycles previously wasted cur-



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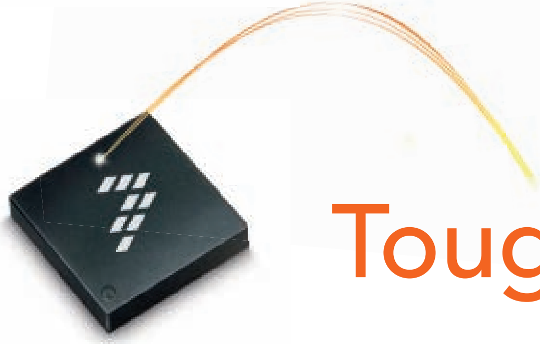

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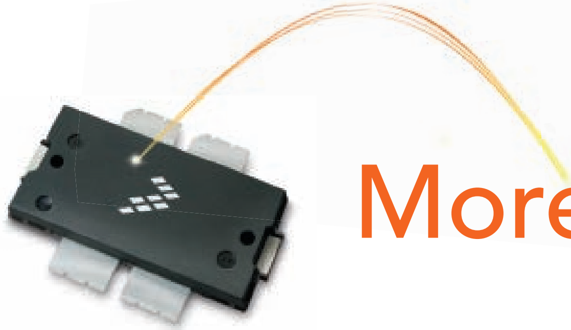

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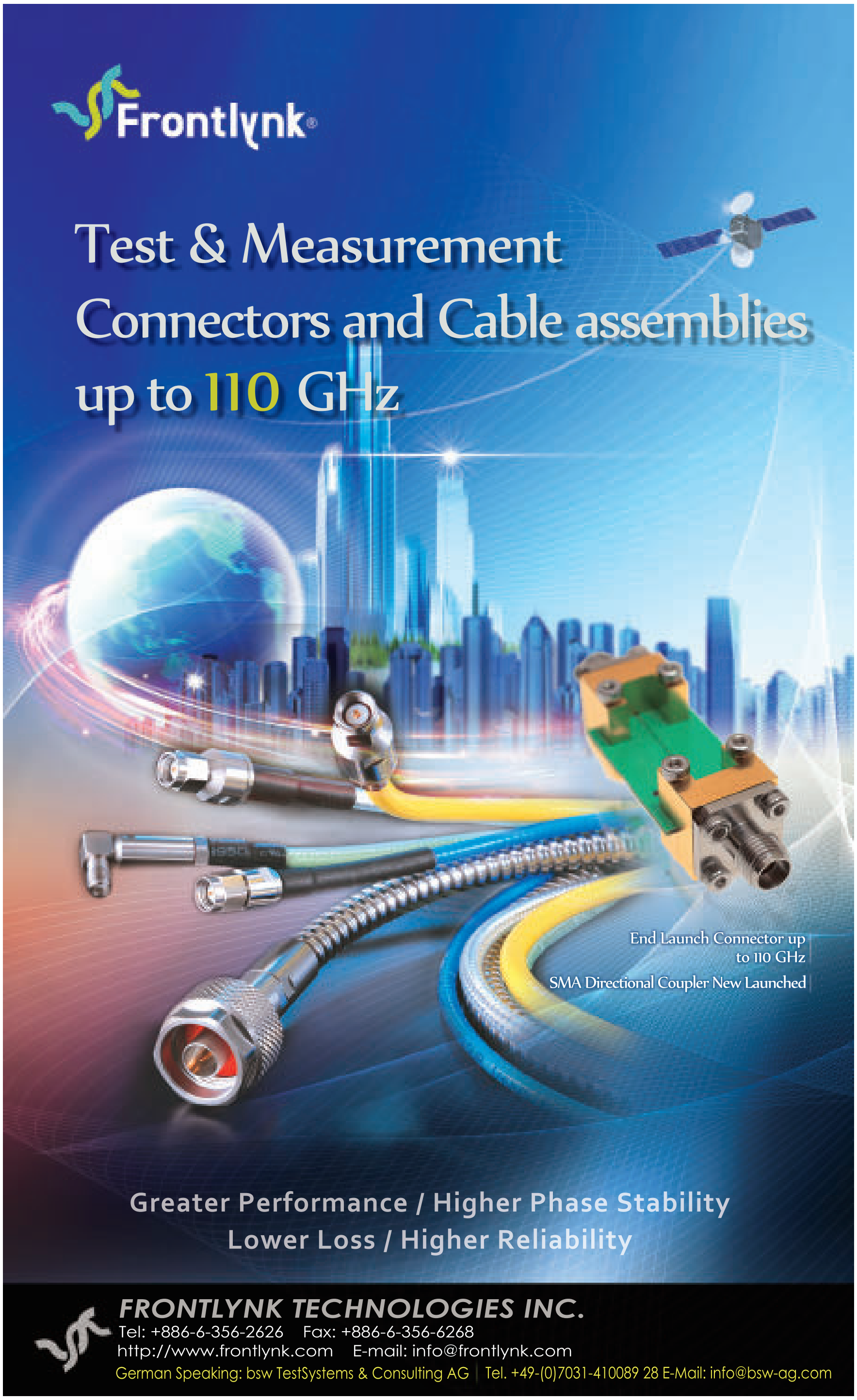
rents back into the system. This wasted current recycled (the "transient response" waveform in the Figure 1 case) is shown to improve system battery life (see current draw reduction — the "red" plot in Figure 3) in the system by as much as 10 percent.

Characterization data plots in ***Figure 4*** for the device were taken utilizing a Wireless Telecom Group, JV9000 VCC noise generator, a Hewlett Packard 8860C signal generator, and a Hewlett Packard 8569B spectrum analyzer. The characterization data in Figure 4 was taken with a 50 Ω impedance matching resistor in series with the device "in" terminal and a switch connecting and disconnecting the "out" terminal from the generator side of the input 50 Ω impedance matching resistor. The 50 Ω resistor was included in the test setup to facilitate test system impedance matching and is not needed for the device operation. All power data was taken for 10 consecutive seconds, averaged from the accumulated 10 raw data points, then averaged across various single frequency points across the 400 MHz to 1 GHz bandwidth of the CC-100 device output.



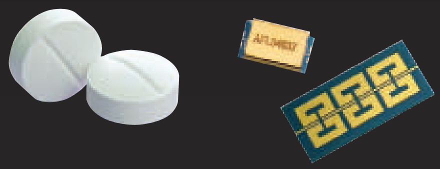
With the acquired Figure 4 power data, the RMS current values and peak to peak voltage values were computed for each of the plots, allowing the gathered data to be related to the main device application shown in Figure 3. Where possible, the AC RMS current values in the Figure 4 plots were checked against actual current measurements utilizing a super-cap powered, Digital Linear Feedback Shift Register (the "Digital Processing Circuits" referred to in Figures 1 and 3), that applied controlled, repeatable, pseudo-random induced VDD noise to the DUT. Currents were then computed by utilizing the equations Q = CV and Q/t = I, the test procedure designed to accurately measure the voltage discharge rate of the super caps in the test system. An Agilent AT-34411A data logging multi-meter was utilized to measure DC voltage values, Vi-Vf, while timing the discharge rate. The delta charge, Q = C(Vi-Vf) was then computed and divided by the elapsed time (Q/t = I). The test and analysis was done with the device in the test circuit and without the device (five times each, and averaged), the delta current and current/power savings computed.

CORRELATION OF TEST RESULTS

Correlation with a scaling factor of 0.5 was discovered to exist between the RMS current data gathered for the device tests in the Figure 4 plots and the RMS current data (Figure 3) obtained with the super cap powered, pseudo random Digital Linear Feedback Shift Register, VDD noise generator applications test circuit. This 0.5 correlation factor was expected and is due to the varying nature and characteristics of the noise injected into the device. Symmetrical, random noise was injected in the device tests (the Figure 4 power plots), both voltage and current being allowed to vary. Non-symmetrical injected noise was injected in the application tests (Figure 3), with the voltage held constant by the regulator action in the system, thus allowing only the current to vary.

The device was found to respond differently to various types of injected

All these pain relievers shown actual size.



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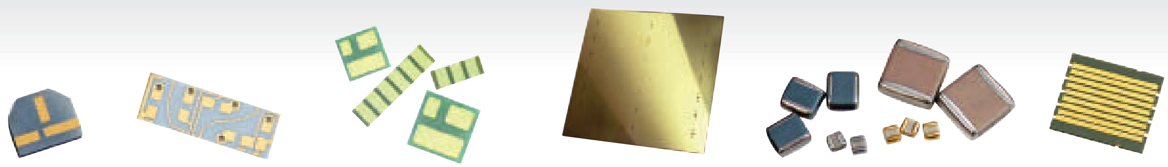

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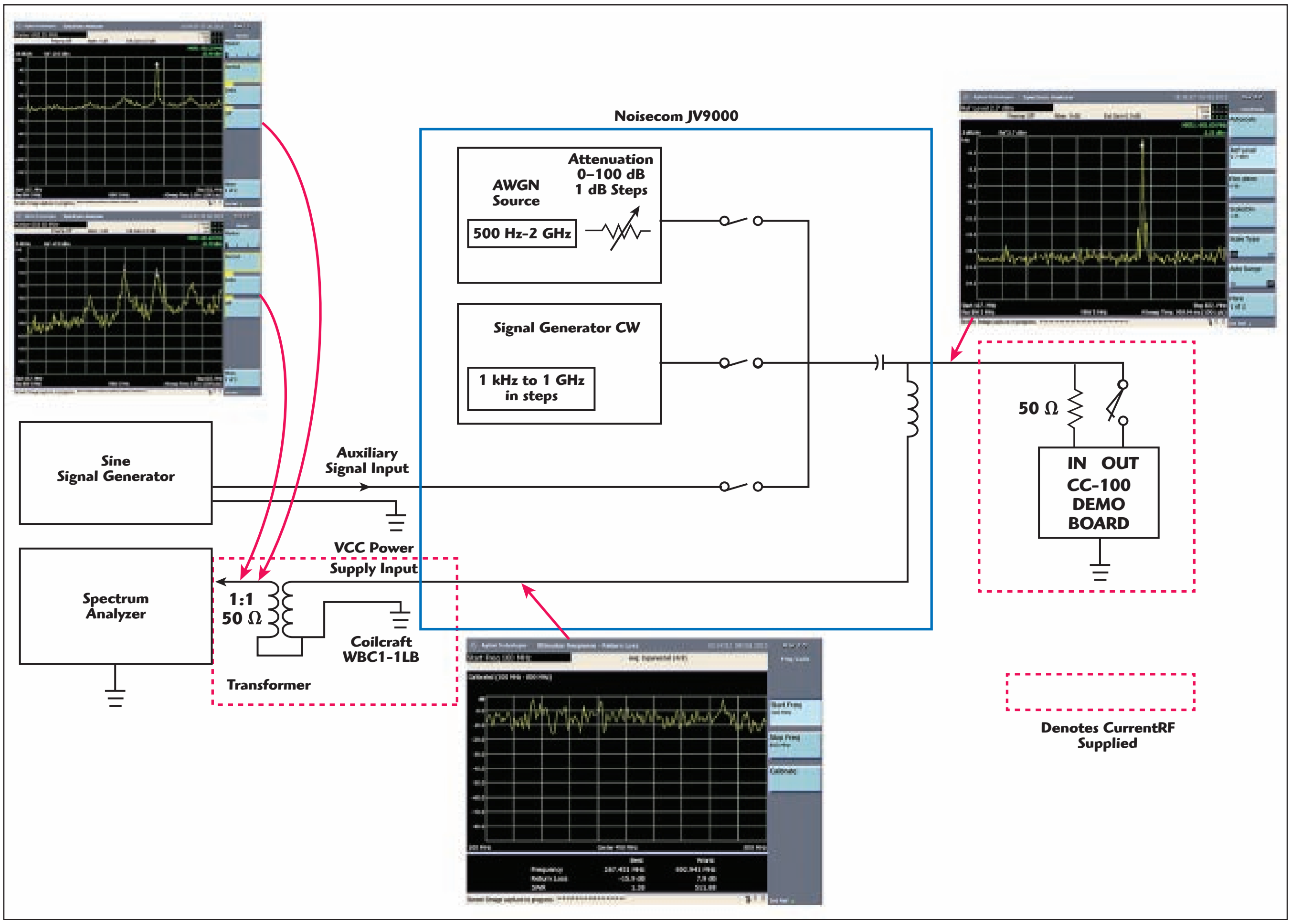
noise. This delta in performance is graphically displayed in the last plot of Figure 4. What the data in Figures 3 and 4 means commercially, in terms of battery Watt-hours (Wh) is that this methodology and design effectively reduces the current load on portable device batteries, extending the effective time between needed battery recharges by up to 20 percent.

As an example, the DELL M5Y0X laptop battery, which is rated at 97 Wh, with this methodology and design being utilized, will cause the battery discharge rate to decrease and cause the



▲ *Fig. 7 CC-100 test characterization setup with the JV9000.*

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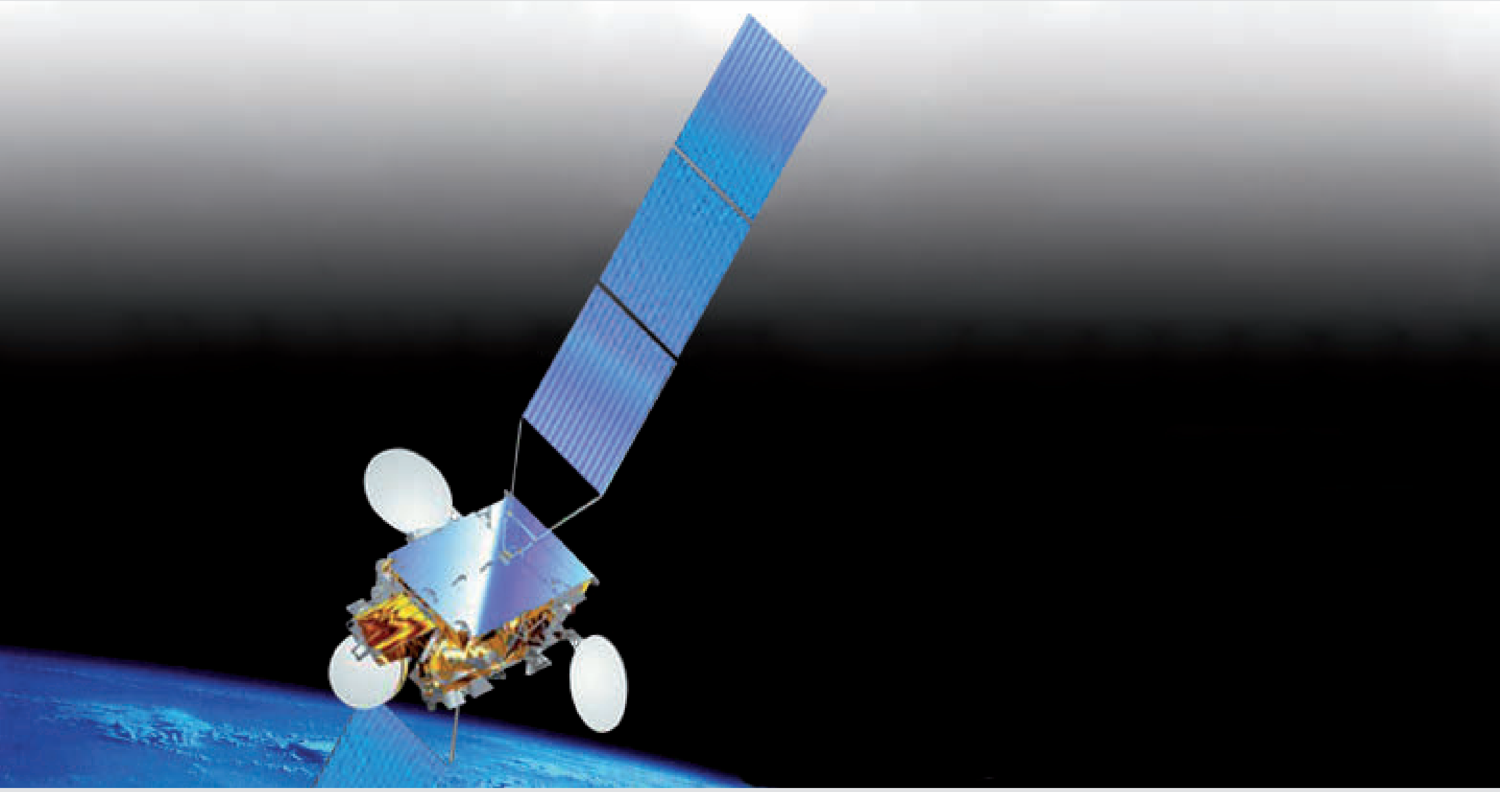

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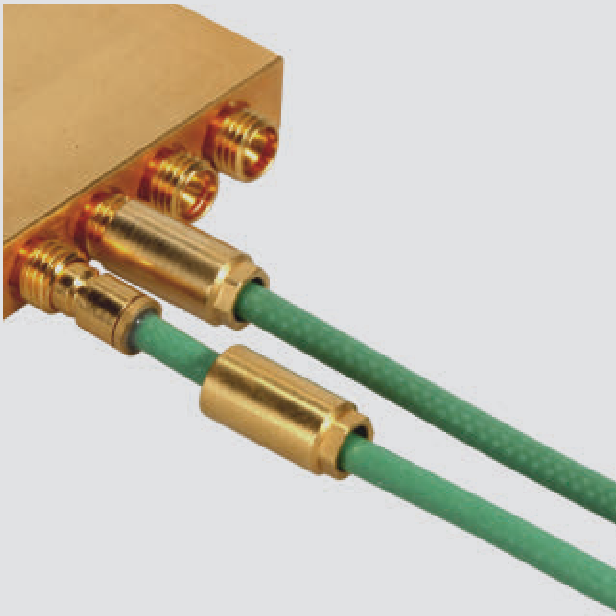

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system to operate as if the battery capacity was increased to 116 Wh. Systems utilizing Power Optimizer technology internally could be designed to fit a smaller form factor, since the battery capacity requirements are reduced, or handle more intense processing applications with the same performance in battery discharge rates.

The device has been packaged as shown in ***Figure 5*** (patent pending) and used externally (no system re-design needed) in systems and devices with I/O ports like USB or Firewire in laptops, SDIO, or any portable device with port access to device internal power. The magnitude of the total power reduction utilizing the solution in this manner is dependent of I/O port activity, be it user mouse and keyboard activity or data transfers (SerDes) and such to and from the I/O port. Tests show a typical 10 to 20 percent battery life extension with an active USB I/O port with the Power Optmizer utilized in this fashion.

RF POWER INTEGRITY/STABILITY

A natural byproduct of the Power Optimizer current recycling is the device's effect on power grid stability. System bypass capacitors, added to the system for impulse noise reduction, also function as AC terminations over frequency for system power grids. If the impedance of the system power grid and the impedance of the bypass caps in the system match over frequency, the power grid network will respond in a critically damped fashion over frequency to applied current impulses.

It is generally difficult, however, to obtain power grid-terminator matching over frequency, due to the tolerances and parasitics of and in the system components made commercially available for such systems. The S_{11} loss plots in ***Figure 6*** graphically display this phenomenon. Figure 6a shows the wideband S_{11} of the device. With a series 50 Ω resistor placed at the input of the device, the overall VSWR of the device input is quite good, varying from nearly perfect, a VSWR of 1.0, to a worst case VSWR of 1.01. This plot shows that the low input impedance of the device is negligible to the total input resistance, and does not show much variation over the input bandwidth of the part. However, narrowband spectral peaks and dips remain in the Figure 6a plot, indicative of imperfections in the matching of the power grid on the device evaluation board, test system cabling and connectors.

Compensating and optimizing for such mismatches in power grid and system impedances can lead to higher system component costs, longer design/optimization cycles and possible system design rework. What is desired is a methodology and design that can compensate for the underdamped mismatch effects created by the imperfections found in system components made available for system builds.

This methodology and design compensates for the aforementioned effects of component mismatches without the need for costly system design optimization/rework. Acting much like a negative feedback loop, the IC

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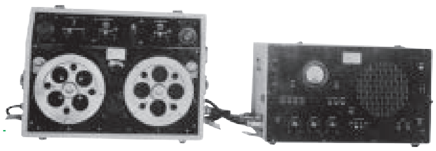

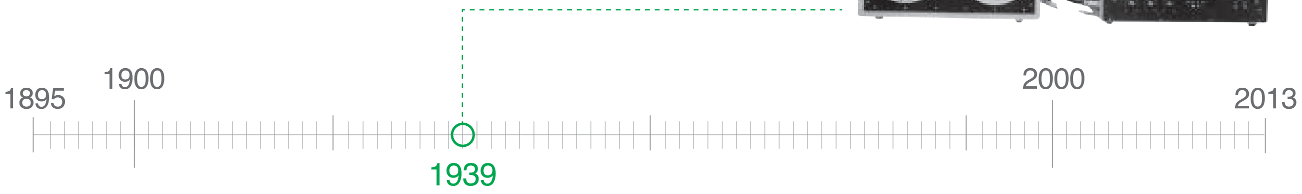

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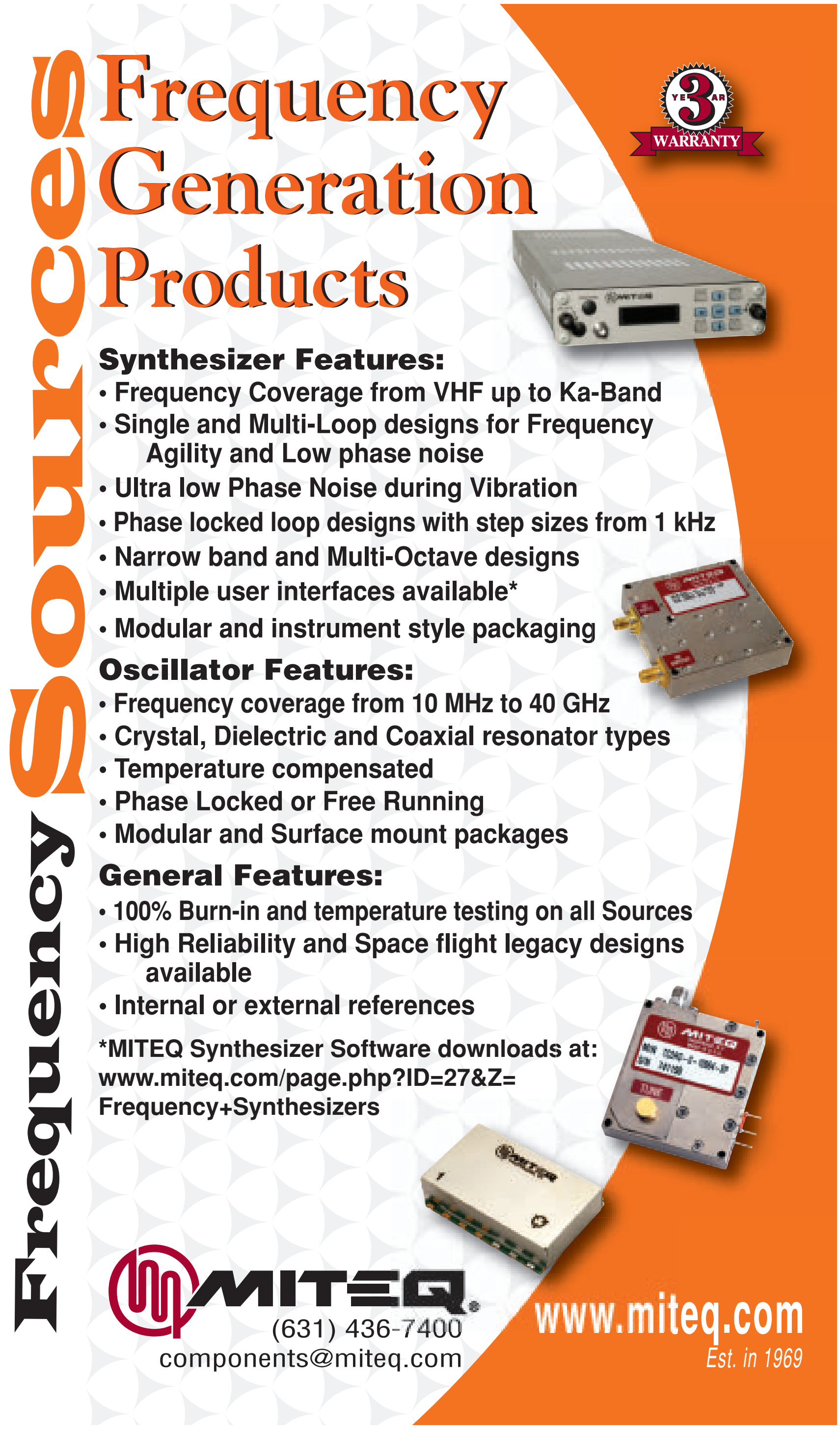
central to this methodology targets the "thrown away" currents that are the result of system transient activity, intercepting and recycling these "thrown away" currents back into the system, critically damping the power grid in a broadband fashion.

Figure 6b shows the S_{11} spectral results of the device's negative feedback and power grid compensation. The Figure 6b plot demonstrates an increase in overall "returned" current (a 10 dB decrease in return loss, a slightly higher worst case VSWR of 1.03 vs. 1.01), but much reduced spectral peaks and dips, with respect to the Figure 6a plot. This return loss and VSWR decrease is not due to typical load mismatch effects, but is the result of Power Optimizer action, returning current to the system for reuse. Thus, in Figure 6b, the network analyzer power detectors show the device current return and negative feedback compensating for the imperfections present in the power grid on the Power Optimizer evaluation board, test system cabling, connectors, etc. This compensation aids in power reduction, transient suppression and overall power grid stability.



A WALK AROUND THE LOOP

The Power Optimizer was designed to possess a broad spectral response to induced power line noise. ***Figure 7*** is a Power Optimizer device test characterization setup that utilizes the capabilities of the Noisecom JV9000, a sine generator, a spectrum analyzer, an impedance matching transformer and the evaluation board. The device evaluation board is set up in such a manner so as to allow the device output to be engaged or disengaged from the test system for "with" or "without" the Power Optimizer.

The JV9000 unit in the test system acts as a controllable, variable amplitude and frequency noise source that emulates the noise produced by digital switching activity in CMOS circuits. The unit possesses its own variable amplitude white noise source, carrier wave generator, inputs for an external sine wave generator, and a DC supply port.

In the device characterization setup in Figure 7, the DC supply port is utilized as a signal monitor port, outputting the results of device performance to an impedance matching transformer, and the output of that is fed to a spectrum analyzer for analysis. The DC supply port on the JV9000 was designed for VCC biasing, not for signal monitoring, as the port is not impedance matched (see the S_{11} plot of the DC supply port in the lower middle of Figure 7) to a 50 Ω environment and attenuates the JV9000 output signal by roughly 30 dB. The impedance mismatch of the 50 Ω environment of the WBC1-1LB Coilcraft transformer to the unmatched DC supply port impedance creates reflective behavior (see Figure 7) between the output of the JV9000, the input of the device, and the input of the WBC1-1LB transformer. The reflective behavior of the JV9000 DC supply port; however, provides an excellent frequency domain test for the device's capability of compensating, in a broadband fashion, power grid impedance mismatches.

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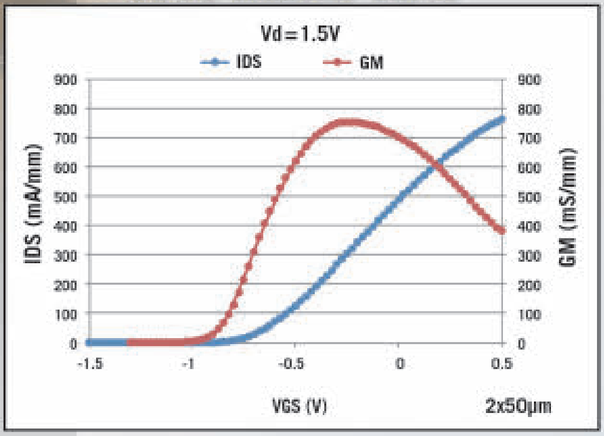
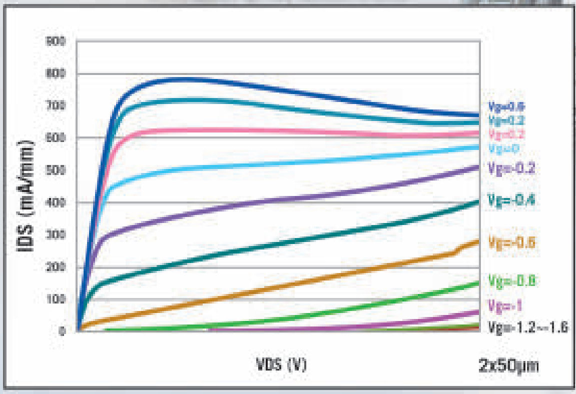
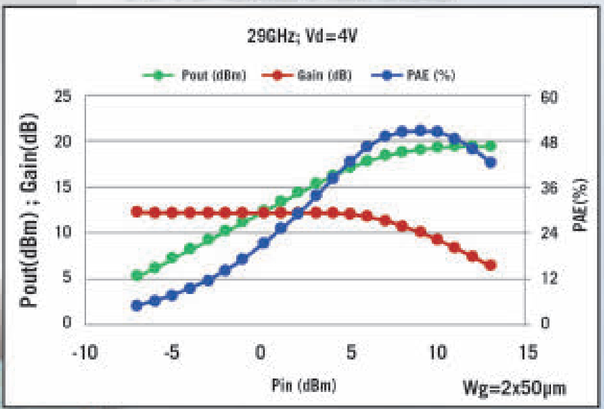


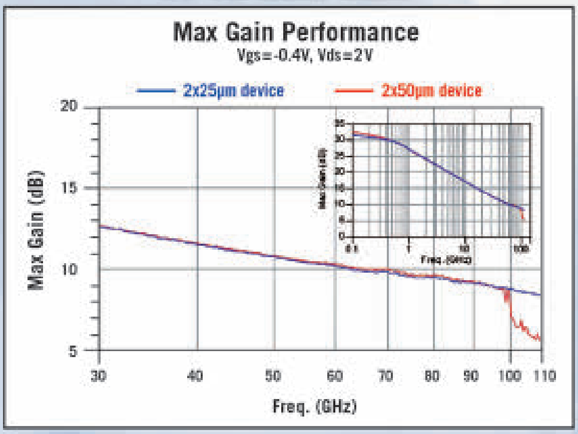
PP10 I-V Curves



PP10 Load Pull Data



PP10 Max Gain



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In Figure 7, the frequency plot shown at the output of the JV9000 displays the spectral characteristics and frequencies applied to the device. The output signal, terminated into a 50 Ω input of a spectrum analyzer, shows a flat –19 dBm JV9000 maximum injected noise floor and a +2 dBm injected 600 MHz sine wave tone superimposed in the unit on the JV9000 output. Given the JV9000 spectrum applied to the output disengaged device, the two frequency plots at the end of the DC supply port and Coilcraft transformer shows the impedance mismatched, reflective spectrum fed to the spectrum analyzer, with and without the 600 MHz injected tone (upper left corner of Figure 7).

POWER OPTIMIZER COMPENSATION PERFORMANCE

Figure 8 (on page 84) shows the spectral results of the Power Optimizer with and without the device's output engaged in the Figure 7 test system. The two disengaged plots show the spectrum seen at the spectrum analyzer input with the device disengaged. Peaking and reflection in the spectrum is observed, with major peaks in the noise only spectrum at 400 and 600 MHz at approximately –51 dBm levels, and the injected 600 MHz tone applied to the device at a –24 dBm level. The plots in Figure 8, with the device engaged, show reduced spectral peaking and reflection, the major peaks at 400 and 600 MHz at approximately –54 dBm, and the injected 600 MHz tone applied to the device reduced to –28 dBm.

Thus, a 3 to 4 dB reduction in spectral reflection and peaking is shown in the device, JV9000 driven tests, yielding a smoother, flatter spectrum, with the device compensating for system termination mismatches and consequent signal reflection on impedance mismatched nodes. The JV9000 tests correlate well to the S_{11} measurements taken and displayed in Figure 6, showing the Power Optimizer capability in compensating for system and power grid mismatches.

CONCLUSION

The Power Optimizer IC is central in the realization of system power reduction and power grid stabilization. A "proof of concept," production ready device has been developed that saves system power and fulfills system power integrity needs and requirements. Due to the interception of "thrown away," transient generated currents and consequent current mode recycling, the data presented shows that the IC damps the system power grid while reducing overall transient system power draw.

The implementation of the power reduction and power grid compensation methodology is process node and digital processing mode "agnostic," in that it reduces overall digital system power up to 20 percent beyond what can be achieved by conventional power reduction methods alone, damping system power grids. It works in any process technology and in tandem with other power reduction and power integrity design/optimization efforts, and has been shown to be effective at all levels of system transient power draw.

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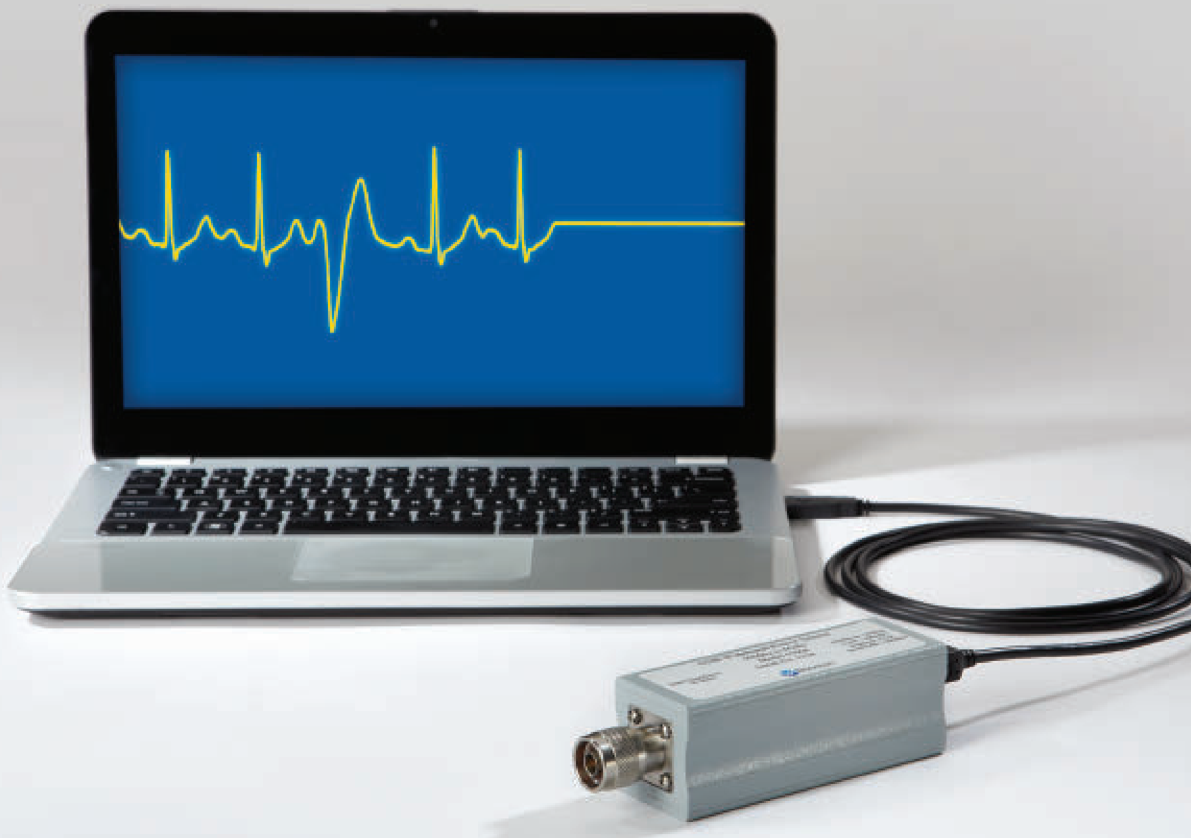

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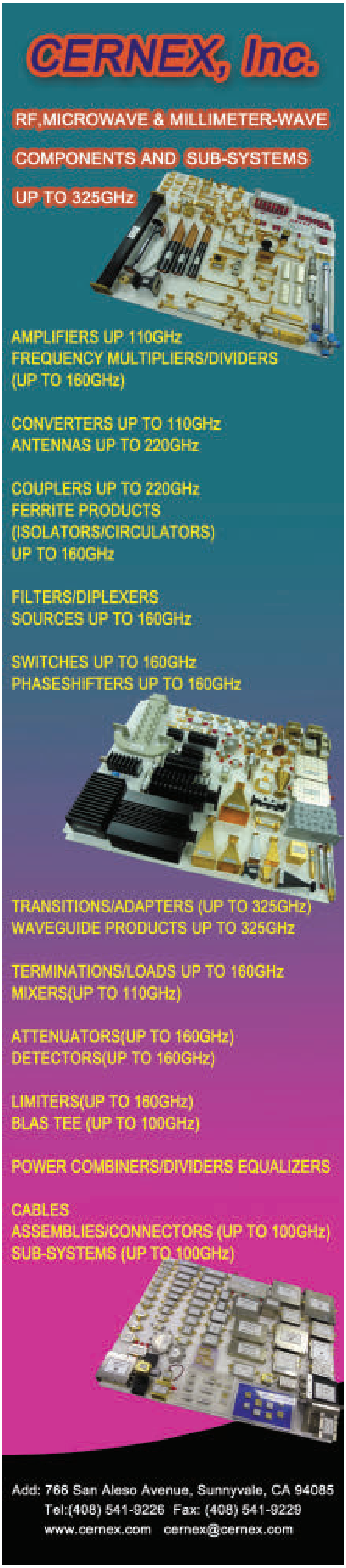

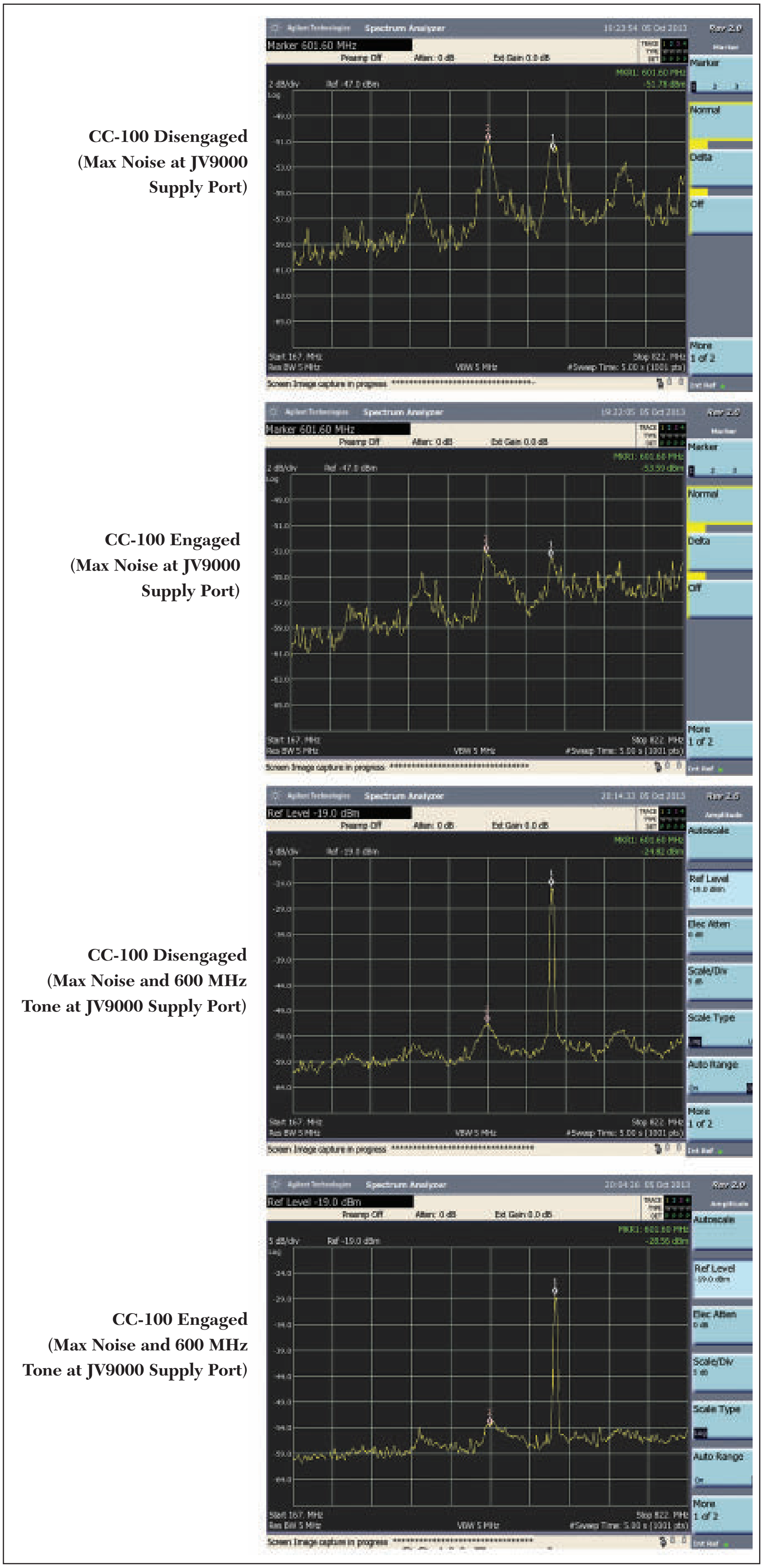

▲ *Fig. 8 CC-100 DUT test results with the JV9000.*

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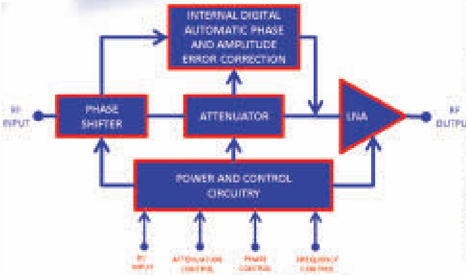
RF Input Power	+5dM CW, 1.0 Watt max
Insertion Loss	11.0dB max
VSWR	1.6:1 max (50 ohm system)
Attenuation vs Frequency	±1.5dB typ
Phase vs Frequency	±10.0 degrees typ
Control Logic	2x12 BITs (I & Q), TTL Compatible
Control Slopes	Linear
Switching Speed	500 nSec max
Temperature Coefficient	±0.035 dB/°C & ±0.17 Deg/°C
Power Supply	±12V to ±15V @ 100mA max
RF Connectors	SMA Female Input and Output
Power/ Logic Connectors	DC-37P, Sub Miniature D Multi-Pin
Size	5.0" x 5.0" x 1.0"

2.0GHz to 18.0GHz I/Q Modulator
Model No: PIQ-2G18G-360-16-CD-1

Frequency Range	2.0 to 18.0GHz
Dynamic Range	16dB & 360 degrees
RF Input Power	+10dBm CW, 1.0 Watt max
Insertion Loss	16.0dB max
VSWR	2.2:1 max (50 OHM System)
Attenuation vs Frequency	±3.5dB typ
Phase vs Frequency	±20.0 degrees typ
Control Logic	2x12 BITs (I & Q), TTL Compatible
Control Slopes	Linear
Switching Speed	500 nSec max
Temperature Coefficient	±0.035 dB/°C & ±0.17 Deg/°C
Power Supply	±12V to ±15V @ 100mA max
RF Connectors	SMA Female Input and Output
Power/ Logic Connectors	DC-37P, Sub Miniature D Multi-Pin
Size	4.25" x 3.5" x 1.0"

85MHz to 18GHz I/Q Modulator
Model No: PIQ-85M18G-360/20-CD-2



Frequency Range	85MHz to 18.0GHz		
Phase Range	360° Nominal in 1, 2, or Up To 4 Bands		
Attenuation Control Range	20dB min.		
Attenuation Resolution	0.1dB max.		
Insertion Loss	-3dB ± 4dB		
Amplitude Variation	±4dB (85MHz to 18GHz)		
Amplitude Variation, Narrow Band	±0.5dB across any 50MHz (100MHz to 500MHz) ±0.5dB across any 100MHz (500MHz to 18GHz)		
Phase Variation, Narrow Band	±2° over any 50MHz (100MHz to 500MHz) ±2° over any 100MHz (500MHz to 18GHz)		
Phase Resolution	0.8° max.		
Return Loss (Input / Output)	10dB min.		
Input Power, Operating Max.	+7dBm		
RF Input Power (CW) Damage Threshold	+30dBm CW max.		
Control Type - Frequency Control Setting (Optional) - Phase Shift Setting - Attenuator Setting	 8-Bit TTL for 100MHz Bands & More Accuracy 9-Bit TTL 8-Bit TTL		
Band Switching	1 Band: 85MHz to 18GHz	2 Bands: 85MHz to 14GHz 14GHz to 18GHz	4 Bands: 85MHz to 4GHz 4GHz to 8GHz 8GHz to 12GHz 12GHz to 18GHz
Switching Speed	3usec typ.		
Power Supplies	+15V (1.15A) -15V (95mA) +5V (1mA)		
Size	6.0" x 3.0" x 1.0" (Smaller Sizes Available)		
RF Connectors	SMA (F)		
Digital / Power Connector	MDM-37PH003P or Equivalent Mating Connector Provided		

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Performance Over Time

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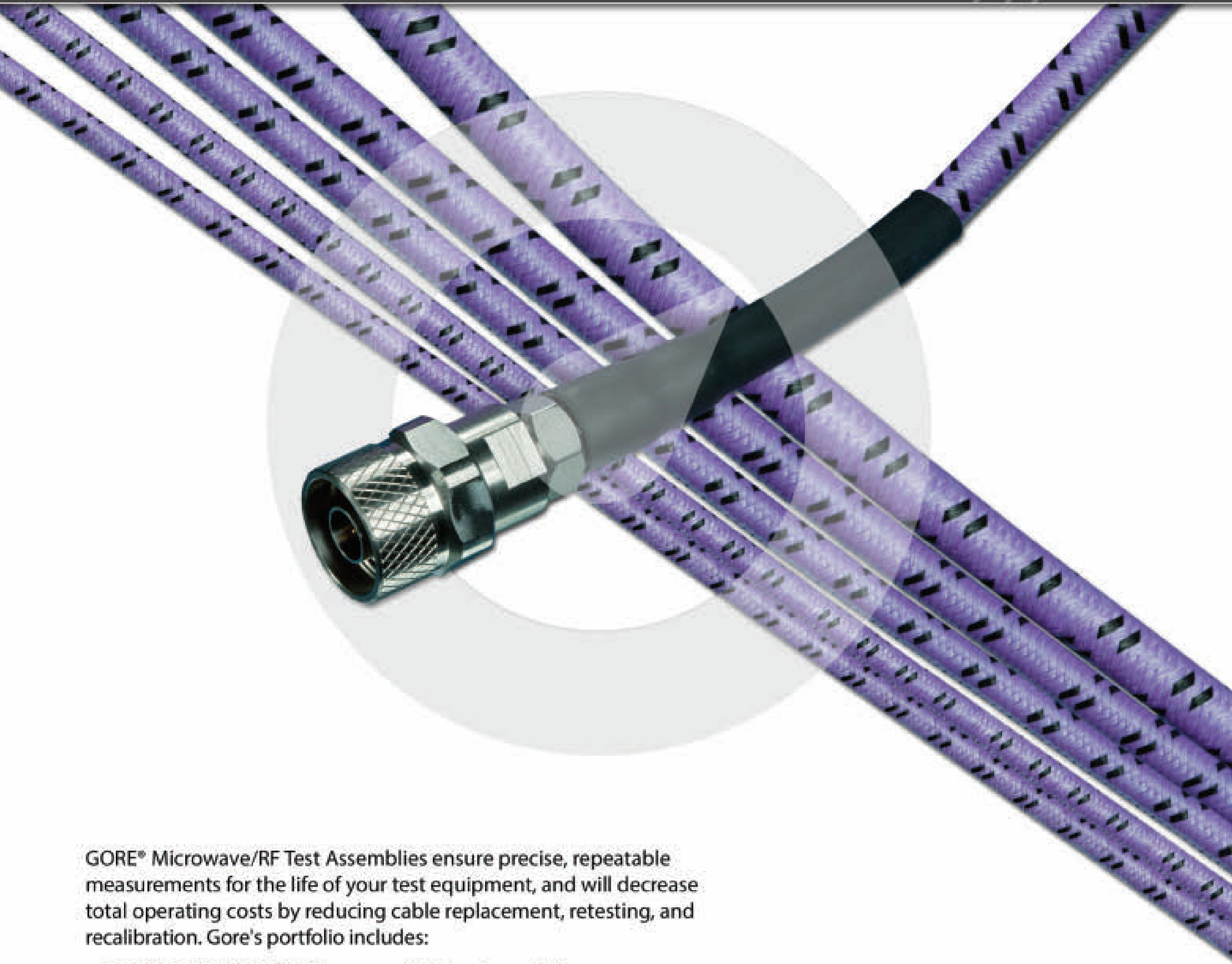

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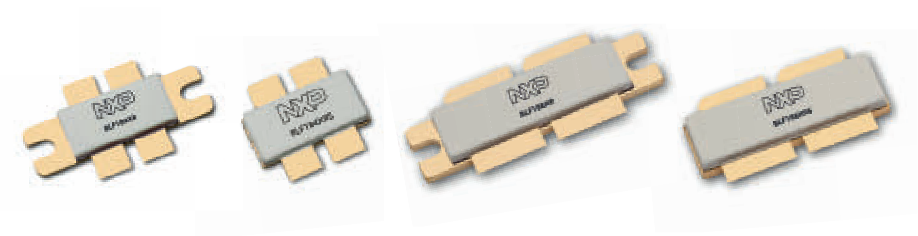

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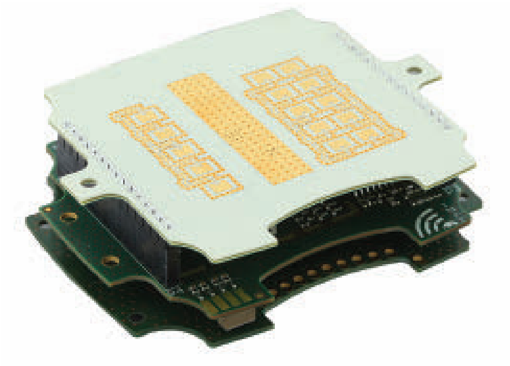

24 GHz FMCW Multi-Channel Radar Module

Radar technology has become more and more important for the civil market. The widespread use of automotive radar modules, for example, is a testimony to this. There are numerous applications where radar is an interesting solution. The most prominent feature of radar is robustness against weather and light conditions. Distance is measured directly without the difficulties associated with optical systems. By adding multi-channel capabilities, it is possible to detect the angle of a target. Modern radar thus enables the user to obtain a real-time 2D scan of the vicinity.

▲ *Fig. 1 Hexacopter UAV equipped with a radar/gimbal combination for target tracking.*

Such a system may be used in various industrial processes, but also opens the way to novel applications: In security systems, it is possible to extend the typical motion detector with the capability to tell where an intruder is. Hence, one is able to build smarter automated solutions, where an image of the intruder is directly presented to the alerted personnel. IMST has developed a special signal-processing firmware for detecting human beings that supplies the exact position of the intruder to the user. First field tests show accuracies as good as 30 cm in a 50 m distance for an 80 degree surveillance sector using a single module.

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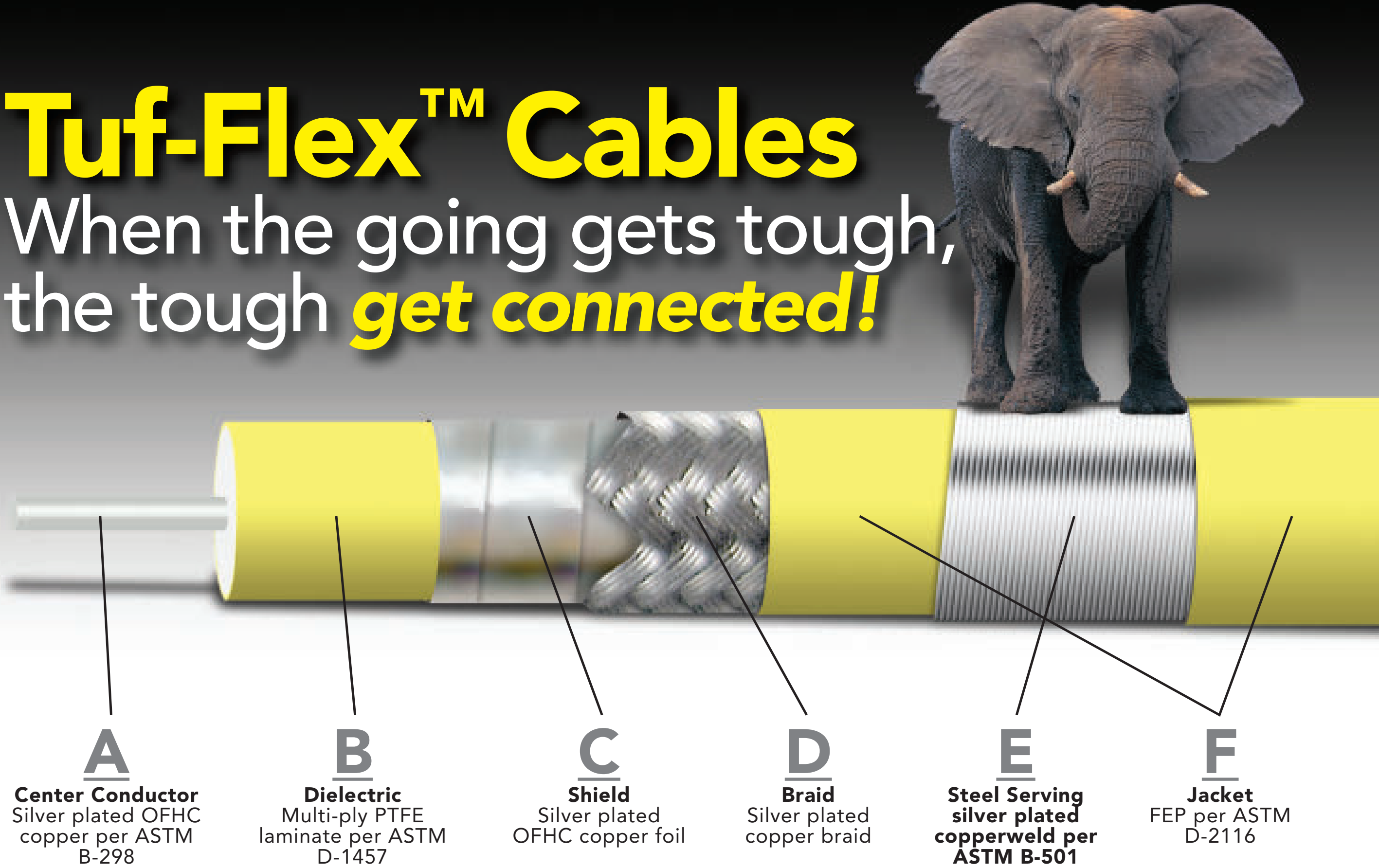

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160	1.20	1.3
200	1.22	1.3
225	1.28	1.3

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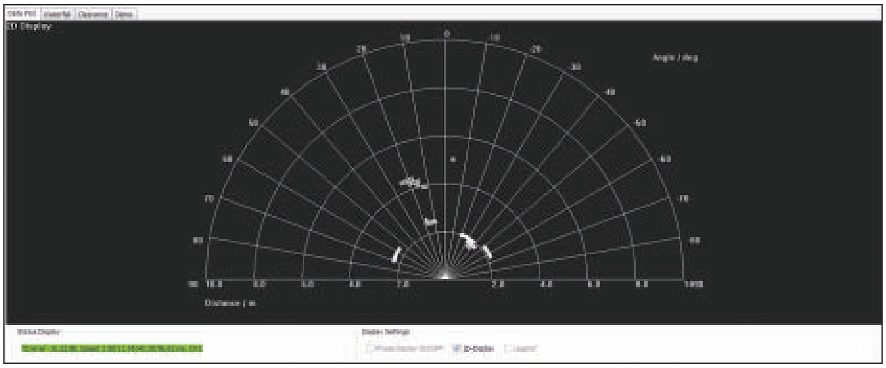
▲ *Fig. 2 Developer Kit Software: System configuration menu and data visualization.*



▲ *Fig. 3 The 2D angular view of the radar showing targets.*

▲ *Fig. 4 Housed version of the radar module.*

Unmanned aerial vehicles (UAV) for civil applications, as shown in ***Figure 1***, are an emerging field for microwave technology. These systems have an inherent need for collision protection and radar is the perfect solution for this challenge. The IMST radar is very light (only 42 grams without housing). This is ideal for a direct integration into the UAV and four modules are sufficient to realize a full 360 degree protection. Besides collision protection, it is also possible to link the radar directly to the flight control. In such a configuration, a closed-loop control of the distance to a target is achieved, e.g., holding a target within the camera focus. IMST provides these control boards, as well as 5.8 GHz WiFi connections for in-flight supervision of the radar raw data.

The basis for these solutions is a flexible and configurable hardware. On the RF side, the system features bandwidths of up to 2 GHz and an adjustable EIRP of 15 to 30 dBm, full IQ demodulation and a PLL stabilized signal generation. The antenna features large opening angles in azimuth of 80 degrees and supports angle detection in this plane of view. In elevation, a smaller beam width of 24 degrees is used.

The heart of the system is a digital signal controller. Here, various RF waveforms may be generated. Typical waveforms range from saw-tooth ramps (up and up-down ramps) to FSK/Doppler signals – whatever suits the application best. The system digitalizes the IQ signals and performs a frequency (distance) analysis. Depending on the user's choice, this raw data is transmitted to a host or is further processed within the controller. IMST's standard module features tracking algorithms with numerous configuration options. In this case, a target list is transferred to the host. For the host connection, an SPI interface is available. The user has full control over all options and complete access to the radar data, making it a unique choice on the market.

For an easy entry into the world of radar, IMST provides a radar developer kit including versatile PC software. The kit comes with an SPI-to-USB adapter to enable plug-and-play operation of the radar. The user may experiment with bandwidth and ramp duration settings as well as several options concerning signal processing. The most important feature is a live view of the radar data (see ***Figures 2*** and ***3***). Here, time-domain samples or processed frequency data with magnitude/phase information can be plotted. In addition, the data may be exported to .csv style files for offline processing. Tracking algorithms can be configured and their results visualized giving the user the opportunity to optimize the settings for his or her specific application. The package comes with example codes helping you to realize your own connectivity. The IMST radar developer kit is the first solution on the market that provides such an easy approach to radar solutions.

A standalone version of this radar is also available (see ***Figure 4***). This version features a housing for operating the radar outdoors, without the need to integrate it in a host system. The system comes with CE approval and operates within the ISM band so it may be used without special license.

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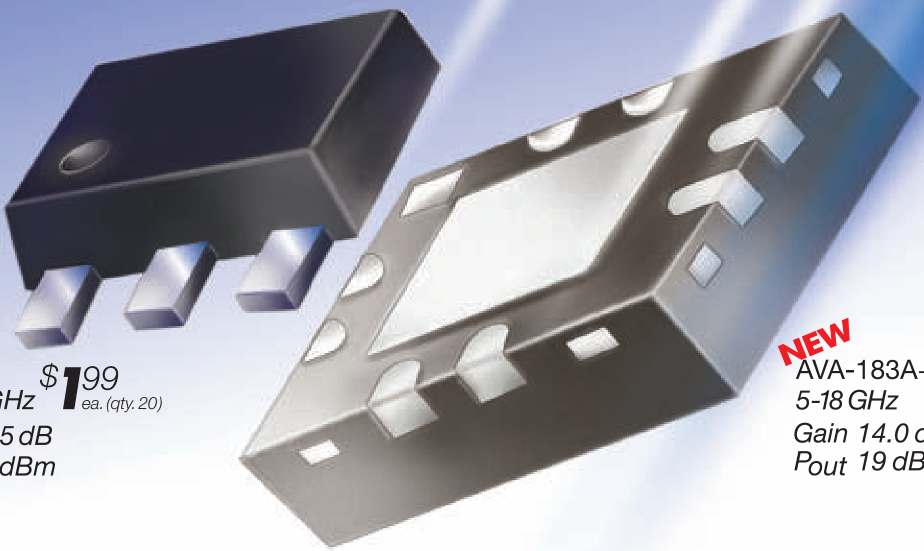

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Low Cost Signal Analysis

With capabilities that rival high-end lab equipment and at a fraction of the price, ThinkRF's WSA5000 is a platform for all signal analysis applications. Modern wireless signals continue to become more complex while T&M budgets continue to shrink. This has created the need for high performance, low cost signal analysis. Typically, affordable spectrum analyzers have narrow bandwidths of around 10 MHz. This makes analyzing time-varying, wideband signals greater than 10 MHz in bandwidth impossible without a sweep over several frequency bands. Sweeps can yield inaccurate results and are not an adequate solution to measuring complex modern signals.

Normally, measuring sophisticated waveforms requires a wideband vector or real-time signal analyzer which can cost as much as $50,000 to $100,000. Furthermore, typical lab analyzers often weigh as much as 50 pounds and consume about 500 W of power, which makes them unsuitable for field applications. To meet this demand for portable, high performance, low cost, real-time spectrum analysis, ThinkRF has developed the WSA5000 – a powerful software-defined signal analysis platform.

SPECIFICATIONS

The WSA5000 was built with specifications that would allow it to be a truly universal solution to the majority of signal analysis applications. Many commercial waveforms are limited to a top frequency of 6 GHz but there are a number of applications that operate at higher frequencies. The WSA5000 was designed with a frequency range of 100 kHz to 20 GHz in order to facilitate those applications. Also, bandwidths of commercial wireless systems are steadily increasing to accommodate the demand for larger data rates. With this in mind, the device is built to have up to 100 MHz of instantaneous bandwidth. Some applications require the ability to quickly sweep across a number of frequencies. Scan speed for the WSA5000

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Fig. 1 ThinkRF's WSA5000 Back Panel with I,Q outputs and inputs, Gigabit Ethernet, GPIO and USB console.

– which determines how fast the device can jump from analyzing one set of frequencies to another set – is 200 GHz/s. A dynamic range between 70 to 80 dB is sufficient for many applications but in certain instances (like measurements for characterizing IP3) a dynamic range of around 100 dB is needed. The WSA5000 was designed with that in mind and so it has a 100 dB dynamic range.

Beyond technical requirements, many signal analysis applications have other considerations such as size, power consumption and price. The majority of devices currently on the market fall into to two size categories: very large or very small. The very large are usually used in lab environments and are not moved often whereas the very small are most commonly used for fieldwork. The WSA5000, which has the technical capabilities of lab equipment, is barely larger than a book and has less than half the power requirement of the average laptop – only 18 W. Lastly, price can be a prohibitive factor for many applications looking to reduce costs. This device starts at $3500.

DESIGN

In order to achieve powerful specifications at such an aggressive price, ThinkRF needed to use new design techniques. The device was built using a combination of the three most common receiver architectures: super-heterodyne, homodyne (direct conversion) and direct digitization. While a super-heterodyne architecture is much better suited to real-time analysis, homodyne is better for applications that require a wide instantaneous bandwidth. The WSA5000's architecture consists of a super-heterodyne front end with a back end that utilizes an I/Q mixer similar to that in a direct-conversion architecture. By building a device that allows the user to switch between these architectures, ThinkRF created a platform that meets the needs of most signal analysis applications.

Depending on the frequency of the signals being analyzed, one of three receiver signal processing paths is selected. Signals in the frequency range 100 kHz to 50 MHz are directly digitized, while all other signals are translated to the frequencies of the first IF block via one of the other two signal processing paths. The IF block consists of a bank of multiple SAW filters and any one SAW filter in this bank is selected depending on the frequency of the input signal. The output of the SAW filter feeds the I/Q mixer. Depending on the mode of operation, i.e., super-heterodyne or homodyne, either one or both outputs are utilized to process either 50 or 100 MHz instantaneously.

OPEN PLATFORM

Beyond creating a powerful, low cost device, ThinkRF wanted to design a platform that would be open and customizable. This was accomplished through a combination of hardware and software. The hardware was designed so it could not only be used as a stand-alone device but also as a powerful RF front end that can be attached to an external digitizer. As a front end, the WSA5000 is capable of reaching 400 MHz of instantaneous bandwidth. Furthermore, the device has a high-speed Gigabit Ethernet port to allow for large-scale deployments that can be remotely monitored (see ***Figure 1***).

The application development environment for the WSA5000 was built in the Python language. Python is easy to use and develop for, has a rich environment of diverse libraries, is used by the scientific community and is free. The framework ThinkRF developed, called pyRF, and the spectrum analyzer application are freely available and under a flexible open-source BSD license. This means users can customize and/or commercialize the spectrum analyzer application for their own purposes (see ***Figure 2***).

ALL APPLICATIONS

The WSA5000 is a device that solves the problem of high performance, low cost signal analysis and does so in a form factor that is about the size of a paperback. It was built with specifications that fill the needs of most applications and can be effectively deployed in a variety of environments, such as in the lab, at a production facility or in the field. This combination of high-end specifications, small form factor and low price makes the WSA5000 the only solution suitable for most signal analysis applications.

ThinkRF,
Ottawa, Canada
(613) 369-5104,
sales@thinkrf.com,
www.thinkrf.com.

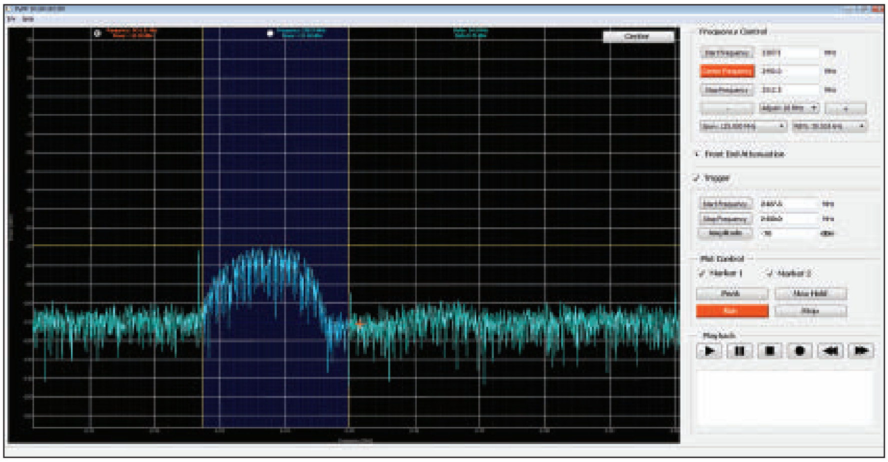

Fig. 2 Spectrum Analyzer Application featuring playback and trigger mode.

USB/ETHERNET

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USB Control Switch Matrices

Model	# Switches (SPDT)	IL (dB)	VSWR (:1)	Isolation (dB)	RF P_{MAX} (W)	Price $ (Qty. 1-9)
USB-1SPDT-A18	1	0.25	1.2	85	10	385.00
USB-2SPDT-A18	2	0.25	1.2	85	10	685.00
USB-3SPDT-A18	3	0.25	1.2	85	10	980.00
USB-4SPDT-A18	4	0.25	1.2	85	10	1180.00
USB-8SPDT-A18	8	0.25	1.2	85	10	2495.00
NEW USB-1SP4T-A18	1 (SP4T)	0.25	1.2	85	2	795.00

NEW USB and Ethernet Control Switch Matrices

Model	# Switches (SPDT)	IL (dB)	VSWR (:1)	Isolation (dB)	RF P_{MAX} (W)	Price $ (Qty. 1-9)
RC-1SPDT-A18	1	0.25	1.2	85	10	485.00
RC-2SPDT-A18	2	0.25	1.2	85	10	785.00
RC-3SPDT-A18	3	0.25	1.2	85	10	1080.00
RC-4SPDT-A18	4	0.25	1.2	85	10	1280.00
RC-8SPDT-A18	8	0.25	1.2	85	10	2595.00
RC-1SP4T-A18	1 (SP4T)	0.25	1.2	85	2	895.00

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*The mechanical switches within each model are offered with an optional 10 year extended warranty. Agreement required. See data sheets on our website for terms and conditions. Switches protected by US patents 5,272,458; 6,650,210; 6,414,577; 7,633,361; 7,843,289; and additional patents pending.

†See data sheet for a full list of compatible software

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521 rev org

Power Analysis Solutions for R&S Oscilloscopes

Rohde & Schwarz has added power analysis options and a new differential wideband probe to its portfolio of analysis solutions for clocked power supplies. Developers can use the R&S RTO-K31 or R&S RTM-K31 option to automatically perform all major quality analyses and conveniently document the measurement results. The new R&S RT-ZD10 probe is particularly suitable for the characterization of switching power supplies with high clock frequencies.

The R&S RTO-K31 and R&S RTM-K31 power analysis options provide users with specialized measurement functions for automatically testing the quality of all segments of today's switching power supplies – including the main voltage quality of the input range, the safe operating area (SOA) of the switching transistor as well as the magnitude and spectrum of the output ripple. A measurement wizard guides the user through all measuring steps and provides diagrams illustrating where to connect current probes and other probes to the device under test.

The R&S RT-ZF20 power deskew fixture allows automatic delay correction between the signals of the current probe and the voltage probe. The handy documentation feature helps users manage the measurement results and save the measurement documentation in RTF or PDF format.

Advanced switching power supplies have increasingly-higher clock frequencies. The R&S RT-ZD10 active differential wideband probe is especially useful for characterizing such power supplies. The probe combines a high bandwidth of 1 GHz and a large input voltage range of 70 V DC or 46 V AC (peak). The common mode and differential offset compensation can be set separately from each other to increase the flexibility of the measurement.

VENDORVIEW

Rohde & Schwarz,
Munich, Germany
+49 89 4129 12345,
www.rohde-schwarz.com.

Ceramic ISM Bandpass Filter

Integrated Microwave Corp. now offers the 928103, a 914.5 MHz ISM bandpass filter. This filter is designed to reject interference to and from adjacent radio services, like the cellular radio band. This high-Q ceramic filter is designed using eight resonators that exhibit high Q (over 1000). The result is a compact filter that handles over 10 W CW, and has low insertion loss (5 dB max) considering its bandwidth. Elliptic function steepens the high-side and low-side rejection adjacent to the passband. Inductive coupling allows high-power operation and accommodates peak powers of over 200 W.

Large 12 mm Integrated Microwave ceramic resonators enable the construction of filters that approximate the performance and loss of cavity filters, but are far smaller. The filter measures 3.82 × 0.5 × 0.95 inches. The filter is designed for thru-hole mount that allows a relatively large filter to be soldered onto a host board without jeopardizing the reflow schedule used for smaller SMT components. The filter-on-board approach reduces cost and improves performance by getting rid of cables and connectors. When a system needs continuous out-of-band protection, many other filter technologies cannot compete with passive ceramic filtering. Ceramic filters protect from the passband all the way down to DC, and from the passband up to 3× the center frequency. Ceramic filters can also offer static protection by shunting DC to ground and are frequently the best option for connecting an LNA to an antenna. Other ceramic filter models are available from 280 MHz to over 10 GHz.

VENDORVIEW

Integrated Microwave Corp.,
San Diego, CA
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sales@imcsd.com, www.imcsd.com.


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Reliant Switch™ for Better RF Testing

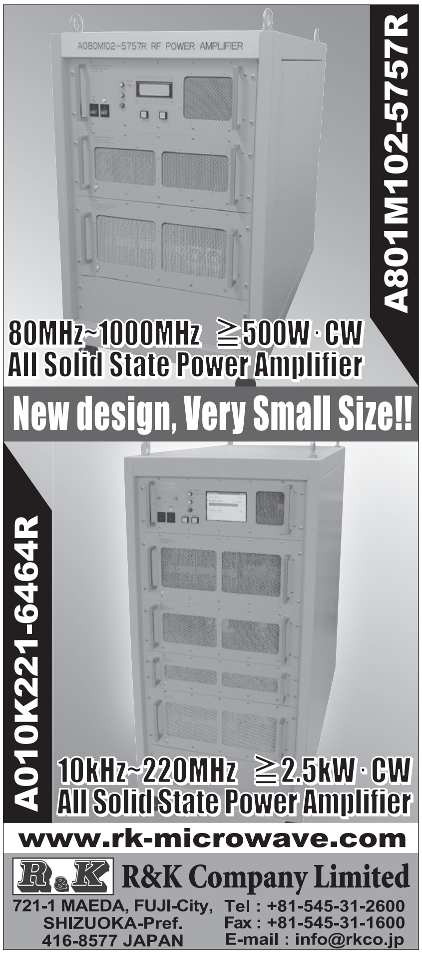
Today, RF and wireless devices are equipped with many signal paths between input and output ports that need to undergo rigorous and complex testing. Therefore the use of coaxial switches is essential, allowing the user to easily switch between I/O ports and avoiding the cumbersome task of having to disconnect and re-connect RF cables. Repeatability between port-to-port testing and repeated tests across different DUTs is critical, making that the life of a RF switch and its reliability imperative.

Dow-Key Microwave has launched a new product line that meets all these critical features. The Reliant Switch™ is a 1×6 bidirectional coaxial switch with an operating frequency from DC to 26. 5 GHz, which covers the typical 6 GHz test range and beyond for high-speed testing. This switch is designed with a high isolation of 100 dB (up to 4 GHz) to maintain RF consistency between port-to-port testing. Moreover, the switch can sustain a guaranteed insertion loss repeatability of 0.03 dB across the entire frequency band. The Reliant Switch™ has an extended life cycle where each position can switch a minimum of 5 million cycles, which is a 5× improvement from a typical multi-position switch.

To meet a variety of test & measurement setups and signal switching configurations, the Reliant Switch™ is offered with latching actuators, position indicators, SMA connectors and with 50 Ω, 2 W terminated ports. The switch can operate both in break-before-make (cold-switching) or make-before-break (hot-switching) applications and has a switching speed of 15 ms. A variety of control options are available, including controlling the switch with +24 V DC coil voltage, or using TTL or CAN bus logic. For more sophisticated control solutions, the CAN bus interface can be converted to Ethernet or GPIB with RS-232 and USB controls by externally adding a Dow-Key designed controller board.

VENDORVIEW

Dow-Key Microwave,
Ventura, CA
(805) 650-0260,
askdk@dowkey.com,
www.dowkey.com.



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New Website

VENDORVIEW

AR RF/Microwave Instrumentation has made numerous changes to enhance both its corporate and RF/Microwave Instrumentation website by giving them a more modern look and feel, while offering easier navigation and more comprehensive information. The menu system and flash spotlights have been re-designed to work with various touch screen tablets and mobile devices and enhanced streamlining of code makes the menus much more search engine friendly and easier to read. Please check out the newly re-designed AR RF/Microwave Instrumentation website at www.arww-rfmicro.com/html/00000.asp or the corporate website at the link below.

AR RF/Microwave Instrumentation
www.arworld.us

Customer-Centered Website

Microwave Development Laboratories (MDL) has collected tools and tailored its website to ease the way for its customers. This world leader in waveguide components provides handy programs to help its customers, including a free reflectometer calculator and a rigid waveguide sliderule. Visitors to the site can access a growing number of computer drawings and models that can be plugged into a favorite computer-aided-design (CAD) program to speed simulations. A custom search function makes finding components fast and easy.

Microwave Development Laboratories
www.mdllab.com

EZ Sample Online System

VENDORVIEW

EZ Sample is Mini-Circuits' new online free sample request system for surface mount parts. Choose the part or parts best fit for your project from over 1000 available SMT models guaranteed in stock, and the company will ship your free samples directly to you within a few days. Mini-Circuits is even paying for shipping charges to make sure you get what you need to make an informed decision at no cost. It's an offer you can't refuse.

Mini-Circuits
www.minicircuits.com

Online Cascade Analysis Calculator

VENDORVIEW

Custom MMIC introduced a new online, easy-to-use, cascade analysis calculator that lets you choose between input or output specifications for each component in your system. Designed to analyze up to ten stages, this new calculator offers a simple yet powerful way to analyze multi-component systems for their cascaded gain, noise figure, compression point and linearity. The calculator lets you choose between input or output specifications for each component in a line-up — and go straight from datasheet to analysis without any questions.

Custom MMIC
www.custommmic.com

Redesigned Website

Microwave Solutions Inc. turned 29 in August and would like to say "Thank You" to its customers. In conjunction, MSI launched a re-designed website featuring more products, specifications and capabilities. Please visit its website and contact one of its sales reps for more information.

Microwave Solutions Inc.
www.microwavesolutions.com

New Website

Peregrine Semiconductor announced the launch of its new website. The new site includes information on the company's UltraCMOS® technology – a patented, advanced form of SOI. With products that deliver best-in-class performance and monolithic integration, Peregrine is the trusted choice for market leaders in automotive, broadband, industrial, Internet of Things, military, mobile devices, smartphones, space, test-and-measurement equipment and wireless infrastructure.

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www.psemi.com

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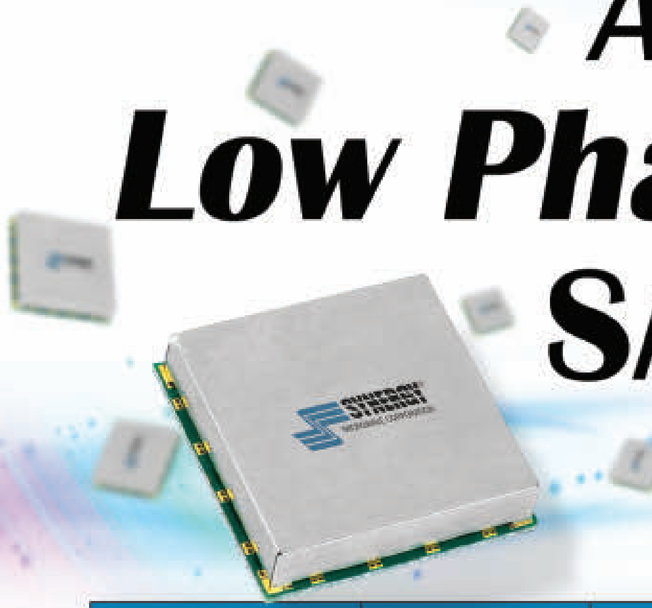

RoHS

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Model	Frequency (MHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Max.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.]
HFSO640-5	640	0.5 - 12	+5 @ 35 mA	-151
HFSO745R84-5	745.84	0.5 - 12	+5 @ 35 mA	-147
HFSO776R82-5	776.82	0.5 - 12	+5 @ 35 mA	-146
HFSO800-5	800	0.5 - 12	+5 @ 30 mA	-146
HFSO914R8-5	914.8	0.5 - 12	+5 @ 35 mA	-139
HFSO1000-5	1000	0.5 - 12	+5 @ 35 mA	-141
HFSO1000-12	1000	0.5 - 12	+12 @ 35 mA	-141

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Rogers Corp.
www.rogerscorp.com

New Website

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SAGE Millimeter Inc. announced the launch of its new website. The new site includes the company's high performance microwave and millimeterwave components and subassemblies for commercial and military system applications, including antennas, amplifiers, frequency converters, control devices, ferrite devices, oscillators, subassemblies & modules, test equipment & modules and waveguide passive components. Also, now on the site is the new "What's New" page which will be updated monthly with new product releases.

Sage Millimeter Inc.
www.sagemillimeter.com

Interactive Website

VENDORVIEW

Werlatone®'s fully interactive website features detailed product search functions and new landing pages highlighting the company's truly custom designs and absorptive filters. Visit the site for additional product lines in the near future. Werlatone is a leading supplier of high power, broadband RF coaxial components. The company's Mismatch Tolerant® directional couplers and combiners/dividers are designed to operate continuously, at rated power, into high load VSWR conditions without damage.

Werlatone
www.werlatone.com

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Components

Miniature Step-Up Transformers

Coilcraft's new 6 × 6 × 3.5 mm LPR6235 Series coupled inductors can be used as step-up or flyback transformers in DC-DC converters or as autotransformers. They are ideal for voltage step-up in energy harvesting applications. They feature an excellent coupling coefficient (k = 0.95) and are available with five turns ratios from 1:10 to 1:100 for a variety of voltage step-up and step-down applications. They offer 300 V winding-to-winding isolation.

Coilcraft CPS,
www.coilcraft.com.

Cable Assemblies

RFMW announced immediate delivery of selected, one meter cable assemblies from Florida RF Labs Inc. The Lab-Flex® family of cable assemblies boasts six different cable types supporting applications to 65 GHz. They are extremely well-suited for high frequency test applications and high-density interconnects where insertion loss and stability over temperature are concerns. Florida RF Lab-Flex assemblies offer > 90 dB of shielding effectiveness and a wide range of connectors including, but not limited to, 7/16, TNC, SMA, 2.4mm, 2.92mm and 1.86mm interfaces in various configurations.

VENDORVIEW

Florida RF Labs Inc.,
distributed by RFMW Ltd.,
www.emc-rflabs.com.

PIN Diode Switch

Model SA-50-0JK is a 4.385 to 4.885 GHz, SP32T reflective PIN diode switch. This subassembly consists of two SP16T switches, one SPDT switch and a power/logic connector all mounted together on a single plate. It exhibits an insertion loss less than 3 dB, a VSWR less than 1.5:1 in 50 Ω and a minimum isolation of 60 dB. This SP32T switch is capable of handling 10 W CW, hot switching, 200 W peak, a 5 percent duty cycle and a 1 µSec pulse width.

G.T. Microwave,
www.gtmicrowave.com.

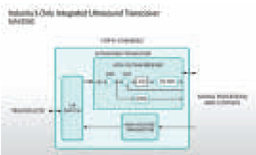
Power Receiver

Linear Technology introduced the LTC4120, a first for the company in the wireless battery charging space. The LTC4120 combines a wireless power receiver with a constant-current/constant-voltage battery charger, functioning as the receive circuit component in a complete wireless power transfer system comprised of transmit circuitry, transmit coil, receive coil and receive circuitry. The LTC4120 works reliably with Linear Technology's simple discrete resonant transmitter reference design or with advanced off-the-shelf transmitters designed and manufactured by PowerbyProxi.

VENDORVIEW

Linear Technology Corp.,
www.linear.com.

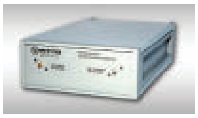
Ultrasound Transceiver



Ultrasound designers can now reduce form factor and improve image quality and reliability with the MAX2082 octal ultrasound transceiver. It integrates eight channels of 3-level 200 V pulsers and T/R switches, an octal ADC, octal LNA, octal VGA, CW mixers, anti-aliasing filters and coupling capacitors into a small package requiring less than 10 square inches for an entire 128-channel solution. This is 40 percent of the space required for conventional solutions and is especially beneficial for portable systems.

Maxim Integrated Products Inc.,
www.maximintegrated.com.

Block Converters



MITEQ's LNB Series of low noise block converters supply RF down conversion from 18 to 40 GHz to IF frequencies of 2 to 16 GHz, well within the range of your existing 18 GHz equipment. The LNB series, with its 4 dB noise figure and internal LO, permits processing of very low level input signals. Currently MITEQ offers either an 18 to 26 or 26 to 40 GHz model. This unit is housed in a half rack case.

MITEQ Inc.,
www.miteq.com.

Broadband Capacitor

Passive Plus has its broadband capacitor – the 0402BB104 – intended primarily for coupling RF signals or bypassing them to ground over extraordinarily large RF bandwidths – that now has 25 V. The PPI 0402BB104 is a 100 nF capacitor and offers resonance-free, low loss operation from 16 KHz (-3 dB point) to > 35 GHz at 25 V with an insertion loss of <1.2 dB.

Passive Plus Inc.,
www.passiveplus.com.

Circulator

Renaissance has released a new S-Band 2.5 kW peak power drop-in circulator operating from 2.9 to 3.3 GHz. With insertion loss of less than 0.6 dB and return loss and isolation over 19 dB, the circulator is ideal to duplex an antenna with HPA and a receiver. This circulator has been customized to withstand 250 W of forward and 150 W of reverse power at the same instance without arcing or corona failures.

VENDORVIEW

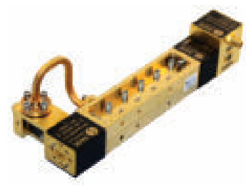
Renaissance Electronics & Communications LLC/HXI LLC,
www.rec-usa.com.

N Connectors

The RFN-1006-49I features a solderless captive pin and the RFN-1006-4I features a crimp pin. Both connectors are compatible for high performance cables. Combination hex/knurl coupling nuts allow for tightening by hand or wrench. White Bronze (tri-metal) plating eliminates tarnishing while providing improved electrical performance and reduced PIM (Passive Intermodulation). Exceptional VSWR of less than 1.10 to 1 up to 3 GHz and less than 1.20 to 1 up to 8 GHz is achieved through an enhanced impedance matching design.

RF Industries,
www.rfindustries.com.

Mono-Static Doppler Sensor



Model SSM-94313-S1 is a 94 GHz mono-static Doppler sensor designed and manufactured for speed measurement. The module is offered with WR-10 waveguide interface for various antenna integrations. The sensor operates from +10 V DC/200 mA DC supplier and transmits 13 dBm power at 94 GHz. The conversion loss of the sensor is about 9 dB and IF bandwidth is up to 4 GHz. The Doppler sensors in other frequency bands from 26.5 to 110 GHz or with I/Q output are also available.

VENDORVIEW

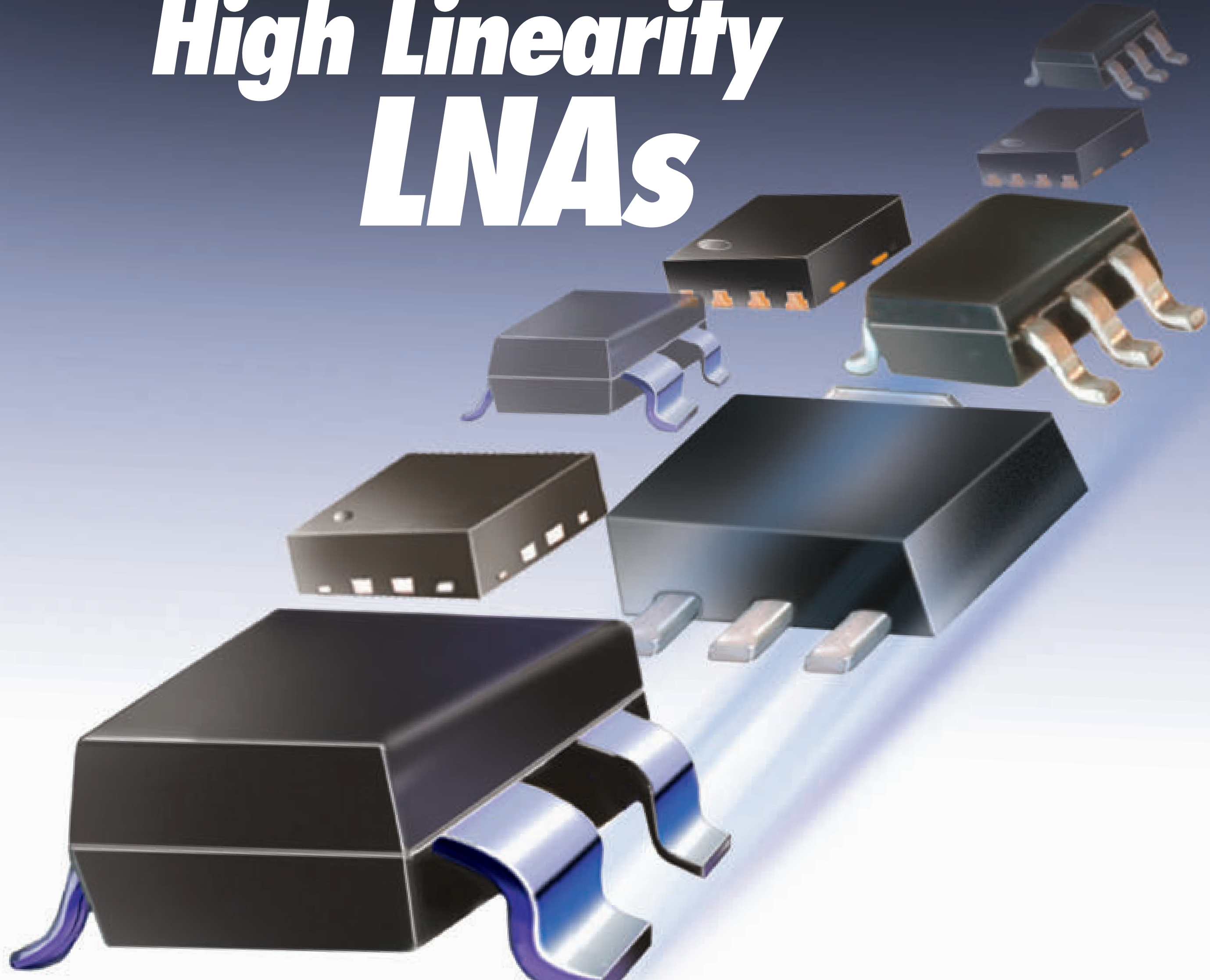
Sage Millimeter Inc.,
www.sagemillimeter.com.

E-Band Mixer

Spacek Labs model M80-5X2B is an E-Band mixer covering the two radio bands of 71 to 76 GHz and 81 to 86 GHz. The mixer includes an integrated LO doubler, so that the customer need only supply a 39 GHz source with +16 dBm of power. Spacek Labs can also supply a phase-locked source with the assembly. The conversion loss over the band is 6 dB typical and 10 dB maximum, with an IF frequency range of 2 to 8 GHz.

Spacek Labs Inc.,
www.spaceklabs.com.

High Linearity LNAs



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Model	Freq. (MHz)	Gain (dB)	NF (dB)	IP3 (dBm)	P_{out} (dBm)	Current (mA)	Price $ (qty. 20)
PMA2-162LN+	700-1600	22.7	**0.5**	**30**	20	55	2.87
PMA-5452+	50-6000	14.0	**0.7**	**34**	18	40	1.49
PSA4-5043+	50-4000	18.4	**0.75**	**34**	19	33 (3V) 58 (5V)	2.50
PMA-5455+	50-6000	14.0	**0.8**	**33**	19	40	1.49
PMA-5451+	50-6000	13.7	**0.8**	**31**	17	30	1.49
PMA2-252LN+	1500-2500	15-19	**0.8**	**30**	18	25-55 (3V) 37-80 (4V)	2.87
PMA-545G3+	700-1000	31.3	**0.9**	**33**	22	158	4.95
PMA-5454+	50-6000	13.5	**0.9**	**28**	15	20	1.49

Model	Freq. (MHz)	Gain (dB)	NF (dB)	IP3 (dBm)	P_{out} (dBm)	Current (mA)	Price $ (qty. 20)
PGA-103+	50-4000	11.0	**0.9**	**43**	22	60 (3V) 97 (5V)	1.99
PMA-5453+	50-6000	14.3	**0.7**	**37**	20	60	1.49
PSA-5453+	50-4000	14.7	**1.0**	**37**	19	60	1.49
PMA-5456+	50-6000	14.4	**0.8**	**36**	22	60	1.49
PMA-545+	50-6000	14.2	**0.8**	**36**	20	80	1.49
PSA-545+	50-4000	14.9	**1.0**	**36**	20	80	1.49
PMA-545G1+	400-2200	31.3	**1.0**	**34**	22	158	4.95
PMA-545G2+	1100-1600	30.4	**1.0**	**34**	22	158	4.95
PSA-5455+	50-4000	14.4	**1.0**	**32**	19	40	1.49

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New Products

Connectors

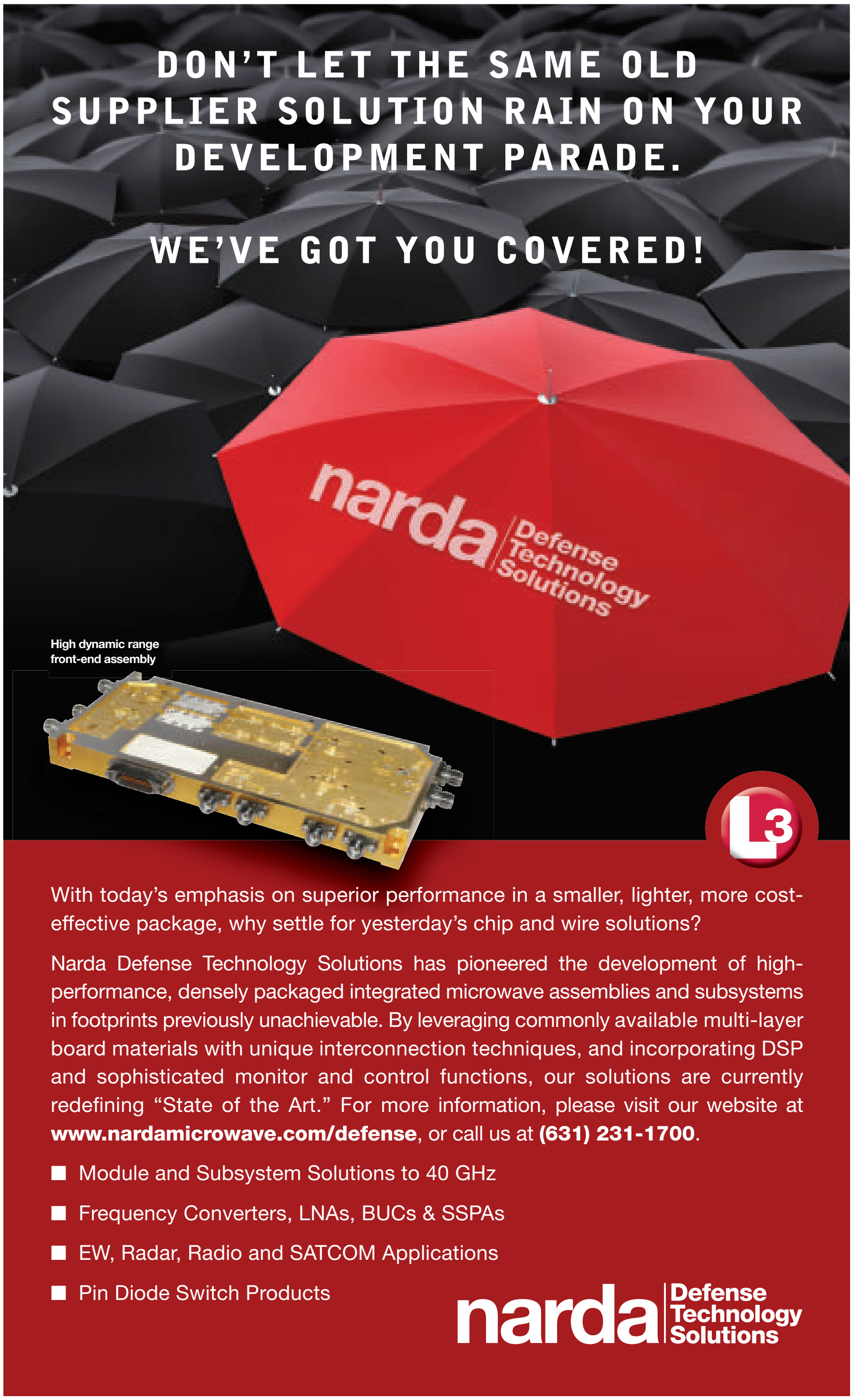
SV Microwave has released a new SMP/SMPM style line of connectors, the QuarterBack® series. The line utilizes a quarter turn bayonet style coupling nut with a locking feature for standard SMP/SMPM interfaces. The QuarterBack connectors are ideal for high vibration and test applications that require a large number of mating cycles. Visit the company's website or email marketing@svmicro.com for more information.

SV Microwave,
www.svmicro.com.

Power Splitter

The DPK1100S is a low loss, 16-way power divider with multi-decade frequency coverage from 10 to 1000 MHz with typically less than 2 dB of insertion loss. This high performance model is available in a connectorized package with either SMA female or type N connectors (DPK1100N). Other typical features of this model are isolation better than 20 dB across the band, typical phase unbalance of 6° and amplitude unbalance of 0.7 dB.

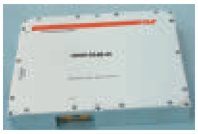
Synergy Microwave Corp.,
www.synergymwave.com.



Amplifiers

Solid State Power Amplifier

Model 30HM1G6AB-45 is a compact, wideband, Class AB hybrid solid state power amplifier module that instantaneously covers 1 to 6 GHz. It operates from a single DC voltage and provides 48 dB of typical gain with excellent gain flatness, noise figure and low intermodulation distortion. It is a 50 Ω, cascadable building block and can be used for both military and commercial applications.



VENDORVIEW

AR RF/Microwave Instrumentation,
www.arworld.us.

Solid State Power Amplifier

Comtech PST has announced the release of a solid state Class AB linear amplifier which operates over the full 6 to 18 GHz frequency band and delivers a minimum of 20 W. The amplifier uses the latest Gallium Nitride (GaN) technology and is packaged in a standard rack mountable enclosure measuring 19" × 22" × 3.5".

Comtech PST,
www.comtechpst.com.

Low Noise Amplifier

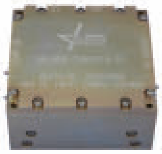
PMI Model No. PE2-15-8G20G-4R0-20-SFF is an 8 to 20 GHz low noise amplifier that provides 12 dB minimum of gain with a typical gain flatness of ±1.25 dB. The noise figure is 4 dB typical and offers an OP1dB of 20 dBm typical. The operating voltage is +11 to +15 V DC and the current draw is 225 mA nominal. The unit is supplied with removable SMA(F) connectors in PMI's standard PE2 housing.

VENDORVIEW

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

Wideband Amplifiers

QuinStar Technologies Inc. introduced the QPW-71803014-S1 E-Band power amplifiers. The QPW model of E-Band amplifiers come with some of the widest industry frequency ranges, such as 71 to 86 GHz, a gain of 30 dB and output power available up to +30 dBm depending on the frequency range and bandwidth. The wide bandwidth of these amplifiers makes them ideally suited for broadband MMW communications systems and other broad spectrum systems applications.



QuinStar Technologies Inc.,
www.quinstar.com.

Variable Gain Amplifiers

Skyworks Solutions introduced five highly linear, active bias, low noise variable gain amplifiers for LTE and WCDMA infrastruc-

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The Exhibition (7th – 9th October 2014)

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- 5,000 key visitors from around the globe
- 1,700 - 2,000 conference delegates
- In excess of 250 international exhibitors (including Asia and US as well as Europe)

The Conferences:

- European Microwave Integrated Circuits Conference (EuMIC) 6th – 7th October 2014
- European Microwave Conference (EuMC) 6th – 9th October 2014
- European Radar Conference (EuRAD) 8th – 10th October 2014
- Plus Workshops and Short Courses (From 5th October 2014)
- In addition EuMW 2014 will include the 'Defence, Security and Space Forum'.

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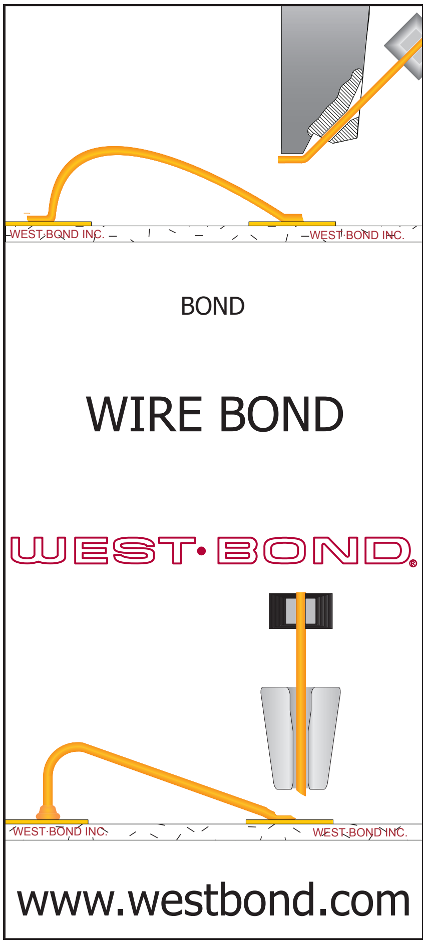


New Products

ture systems. The SKY65369-11 (832 to 862 MHz), SKY65370-11 (814 to 849 MHz), SKY65371-11 (880 to 915 MHz), SKY65373-11 (1710 to 1785 MHz) and SKY65374-11 (1850 to 1915 MHz) receive modules are fully integrated, high performance devices that combine several discrete components into a single, easy-to-use solution.

VENDORVIEW

Skyworks Solutions Inc.,
www.skyworksinc.com.

Materials

Flux Coating

Indium Corp. introduced a high-reliability, low-voiding flux coating for solder preforms. LV1000 reduces false failures while increasing productivity, throughput yields and component performance. This new halide-free (ROL0) material is especially suited for assembly processes in which the components don't allow for proper outgassing of volatized flux. LV1000 provides a durable, level, clear coating that does not clog pick and place equipment, even in automated assembly processes.

Indium Corp.,
www.indium.com.

Semiconductors

MMIC PHEMPT

Eclipse Microdevices' EMD1706 is a GaAs MMIC PHEMPT distributed general purpose driver amplifier. This MMIC is ideal for applications that require a typical P1dB output power of +23 dBm up to 20 GHz, while requiring only 130 mA from a +8 V supply. Gain flatness of this device is less than 0.8 dB from DC to 22 GHz. The EMD1706 comes in a small RoHS compliant 4 mm QFN leadless package and has excellent RF and thermal properties ideal for commercial and industrial applications.

Eclipse Microdevices Inc.,
www.eclipsemicrowave.com.

HEMT

IGN2729M250C is an internally pre-matched, GaN HEMT. This part is designed for S-Band radar applications operating over the 2.7 to 2.9 GHz instantaneous frequency band. Under 300 µs/10 percent pulse conditions it supplies a minimum of 250 W of peak output power with 10 dB gain typically. This device is rated for 250 W, 10 percent duty cycle operation (PAVG = 25 W). Specified operation is with Class AB bias.

Integra Technologies Inc.,
www.integratech.com

HEMT

Richardson RFPD Inc. introduced a new 50 V GaN on SiC RF power high-electron-mobility transistor (HEMT) from Microsemi Corp. The 0912GN-650V is internally-matched and ca-pable of providing over 17 dB gain, 650 W of pulsed RF output power at 128 µs pulse width and 10 percent duty factor across the 960 to 1215 MHz band. It features gold metallization and eutectic attach for outstanding reliability and ruggedness and was specifically designed for use in broadband avionics data link applications.

Microsemi Corp.,
distributed by Richardson RFPD Inc.,
www.microsemi.com.

Source

High Precision TCXO

The TX7-705M-SQ-WT is a new oscillator in a 5 × 7 mm SMD package that exhibits highly stable behavior in the extended operating temperature range from -40° to +85°C, and beyond (e.g., from -55° to +90°C). These TCXOs cover the frequency range from 10 to 52 MHz. The oscillator is available for a power supply of 3.3 V and has a clipped sinewave as output signal form and Tri-state function.

QuartzCom AG,
www.quartzcom.com.

Software

Signaling Tester Software

Anritsu introduced software enhancements to its MD8430A signaling tester that make it the first LTE network simulator to support Time Division Duplex LTE (TD-LTE) carrier aggregation (CA) test functionality. Coupled with existing Frequency Division Duplex (FDD) LTE CA test capability, as well as leading-edge LTE-Advanced functions, including enhanced Inter-Cell Interference Coordination (eICIC) and advanced beamforming functionality, the MD8430A is the industry's leading platform for device testing from development to certification and carrier acceptance.

VENDORVIEW

Anritsu Co.,
www.anritsu.com.

Test Equipment

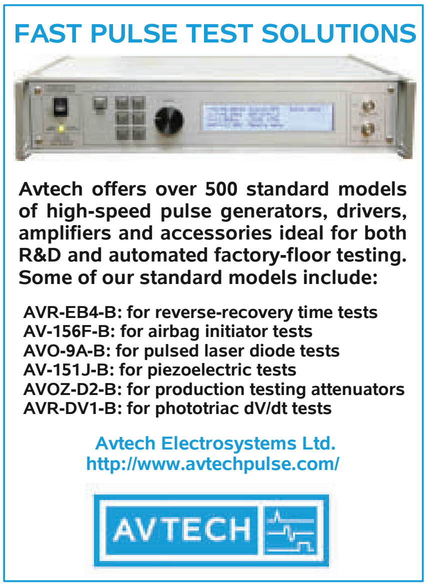
Power Sensor

Mini-Circuits' PWR-4RMS power sensor delivers highly accurate, true RMS measurements of signals employing advanced modulation schemes such as QPSK, 256 QAM, MSK and DQPSK, for example in LTE, DECT, GSM, PWT and other systems. The PWR-4RMS is also ideal for multi-tone and CW measurements, whether centered on a single frequency or sweeping and hopping across its entire 50 MHz to 4 GHz range, with high speed (as fast as 30 ms), resolution down to 0.01 dB, and averaging of up to 999 separate measurements.

VENDORVIEW

Mini-Circuits,
www.minicircuits.com.

MICRO-ADS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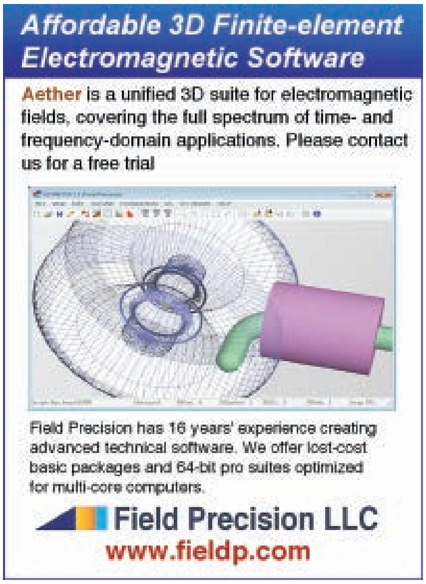
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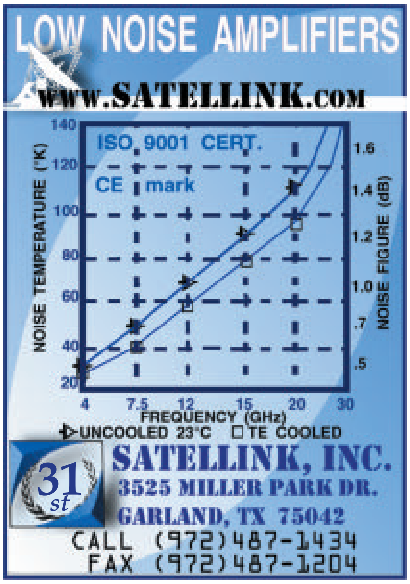
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NEW: RFIC 2014 Calls for 2-Page Industrial Submissions

The **2014 IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2014)** will be held in Tampa, FL, on 1-3 June 2014. For the latest information, please visit: **rfic-ieee.org.**
New for RFIC 2014: 2-page INDUSTRIAL papers are welcome for 10-minutes oral and special poster/demo session.

Electronic Paper Submission/Communication: Technical papers must be submitted via the RFIC 2014 website at **rfic-ieee.org.** Hard copies will not be accepted. Complete information on how and when to submit a paper is posted on the RFIC website.

Technical Areas: The conference will solicit papers describing original work in RFIC design, system engineering, system simulation, design methodology, RFIC circuits, fabrication, testing, and packaging to support RF applications in areas such as, but not limited to:

- **Wireless Mobile ICs:** 3G/4G/LTE, WCDMA, TD-SCDMA, HSPA, WiMax, Mobile TV.
- **Wireless Connectivity:** WLAN, 802.11xx, Bluetooth, FM, GPS, UWB, Wireless HD.
- **Low Power Transceivers:** RFID, NFC, Zigbee, WPAN, WBAN, Biomedical, Sensor Nodes.
- **RF Front-End Circuits:** RF and mm-wave LNAs, Mixers, VGAs, phase shifters, RF switches, & Integrated FEM.
- **Mixed-Signal RF & Analog Baseband Circuits:** RF and BB Converters (ADC/DAC), Sub-sampling/Over-sampling Circuits, and all analog baseband circuits including filters and modulators.
- **Reconfigurable and Tunable Front-Ends:** SDR/Cognitive Radio, Wideband/Multi-band Front-Ends, Digital RF circuits/architectures, RF BIST, and reconfigurable data converters.
- **Large-Signal Circuits:** Power Amplifiers (RF & mm-Wave), Drivers, Advanced TX circuits, Linearization.
- **VCOs and Frequency Multipliers:** RF and mm-Wave VCOs, Frequency Multipliers.
- **Frequency Generation Circuits:** PLLs, Synthesizers, ADPLL, DDS, Frequency Dividers.
- **Modeling and CAD:** Active/Passive Devices, Packaging, EM Simulation, Co-Simulation.
- **Device Technologies:** CMOS, SOI, SiGe, GaAs, MEMS, Integrated Passives, Reliability, Characterization, Testing.
- **mm-Wave SOCs:** mm-wave SOC and SIP systems above 20GHz for data, video, and imaging apps, beam steering applications.
- **High-Speed Data Transceivers:** Wireline, Wireless, Optical Transceivers, CDRs for High-Speed Data links.

RFIC Program: The conference starts on Sunday, 1 June 2014 with workshops, followed by our plenary talks and reception. Monday, 2 June 2014 and Tuesday, 3 June 2014 will be comprised of presentations of contributed papers and special lunch-time panel sessions.

New 2-page Industrial Session in 2014! RFIC invites 2-page short-format ORIGINAL INDUSTRIAL paper submissions on all the areas listed above. While traditional 4-page industrial papers are encouraged for detailed discussions, the new 2-page industrial briefs are welcome to report the latest, state-of-the-art RF IC designs. The 2-page industrial short papers do not require the die photos and detailed schematics, however, will be reviewed upon the same technical criteria. The accepted industrial briefs will be presented in a 10-minutes short slot. In addition, these industrial papers will be invited for presentation at a special poster/demo session during the popular evening RFIC Reception on Sunday, June 1, 2014, which will offer a venue for the industry to showcase their newest RF IC designs to both the attendees and the press. The 4-page submissions would be reviewed and invited for special issues in IEEE Transactions on Microwave Theory and Techniques, and IEEE Journal of Solid State Circuits. 2-page industry briefs will not be reviewed for special issue invitations.

Radio Wireless Week

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Join us for the 9th annual IEEE Radio Wireless Week (RWW) in Newport Beach, California from 19- 22 January 2014. This exciting week includes the IEEE Radio and Wireless Symposium (RWS) and the IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF). Join us to learn about the latest in the wireless technologies and networks with colleagues while enjoying the beautiful ocean view of southern California.

RWW: ***IEEE Radio Wireless Week***
RWS: ***IEEE Radio and Wireless Symposium***
PAWR: ***IEEE Topical Meeting on Power Amplifiers for Wireless and Radio Applications***
SiRF: ***IEEE Topical Meeting on Silicon Monolithic Integrated Circuits on RF Systems***
BioWireleSS: ***IEEE Topical Conference on Biomedical Wireless Technologies, Networks, and Sensing Systems***
WiSNet: ***IEEE Topical Meeting on Wireless Sensors and Sensor Networks***

Highlights

Technical Oral Sessions - Mon/Wed, 20-22 Jan., 2014
Interactive Poster Sessions - Mon/Wed, 20-22 Jan., 2014
Student Paper Competition Finals - Mon, 20 Jan., 2014
Demo Session - Tue, 21 Jan., 2014
Plenary Talk - "THz imaging for Biomedical Applications"
Workshops
Power Amplifier, Radar Systems/Biomedical Radar, RF Energy Harvesting, etc.
Panel Sessions
Future of Wireless Communications, Emerging PA Breakthrough, THz Wireless Communications, etc.
Distinguished Lecturer Talks
Monday morning Distinguished Lecturer session featuring four prominent speakers. For more information, Advance Program will be available at http://www.radiowirelessweek.org/

Exhibits and Sponsorship Opportunity

This year's Exhibit will offer tabletops and full 10×10 exhibits. The exhibition will operate on Monday and Tuseday, with a special offer for Sunday Set-ups. WirelessApps talks and Demo Sessions will also be held in the Exhibition area. Rental fees for 2014 are $1200 per tabletop booth space and $1500 per 10×10 booth space. Sponsors at the $3000 level and above will be offered one free 10×10 booth space. In 2011, 2012 and 2013 the exhibition was SOLD OUT so please book early in order to insure premium exhibit space. For more about exhibits and sponsorship, visit http://www.radiowirelessweek.org/exhibits/

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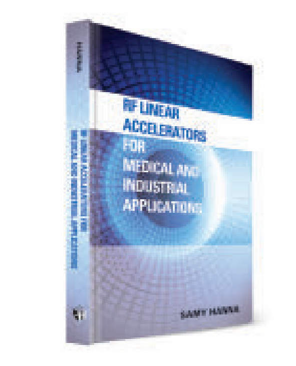

RF Linear Accelerators for Medical and Industrial Applications

Samy Hanna

RF Linear Accelerators for Medical and Industrial Applications offers a clear overview of medical and industrial accelerators including details of the manufacturing process for producing accelerators. Using minimal mathematics, it includes thorough explanations of the basic concepts surrounding the operation of accelerators. It has well illustrated discussions designed to educate the reader on how to use accelerator-based systems in a safer, more productive and more reliable manner.

The book focuses mostly on RF linear accelerators (linac) as discussed in a special report of this issue. In addition to discussing the underlining operation of linacs, it also describes the RF systems needed to run them, so this book is very appropriate for *Microwave Journal* readers. Other types of accelerators are also covered briefly. The various types of medical and industrial applications for accelerators are reviewed in each section, providing an interesting look into how they are used in practice.

The book covers commonly encountered real-world manufacturing issues and potential sources of defects to help you avoid costly production problems. From principles of operation and the role of accelerators in cancer radiation therapy, to manufacturing techniques and future trends in accelerator design and applications, this is an easy-to-comprehend book that provides a nice overview but does not go very deep into the details. Therefore it is appropriate for most anyone who is interested in learning more about the subject but would not necessarily be an in-depth reference for industry experts.

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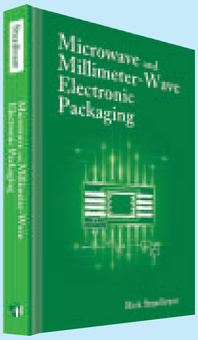

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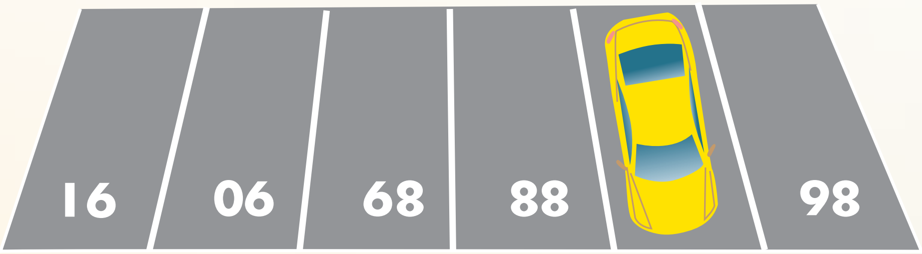
Question:

What number spot is the car parked in?



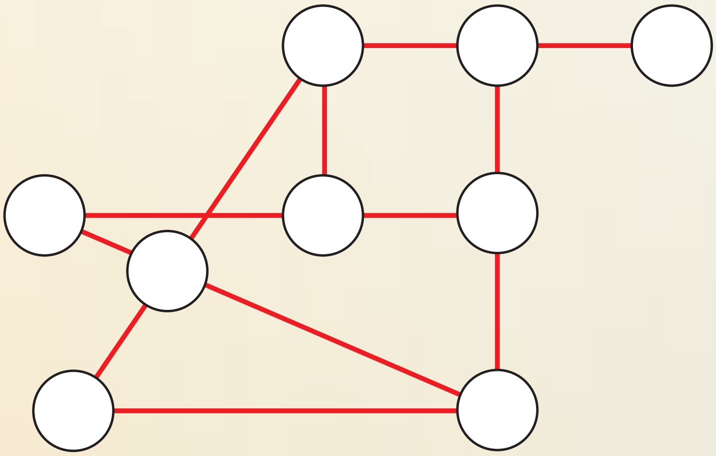
2013

A. The year 2013 uses four different digits. When did this last happen?

B. The digits in 2013 form a sequence (0, 1, 2, 3). When did this ***last*** happen (not necessarily the same digits)?

C. The digits in 2013 form a sequence (0, 1, 2, 3). When will this ***next*** happen (not necessarily the same digits)?

Place all of the digits from 1 to 9 into the circles so that the sum of the numbers in each straight line is the same.



Can you circle exactly four of these numbers such that the total is twelve?

1	6	1
6	1	6
1	6	1
6	1	6

What is represented?

SCHEME

SCHEME SCHEME

SCHEME SCHEME SCHEME

SCHEME SCHEME SCHEME SCHEME

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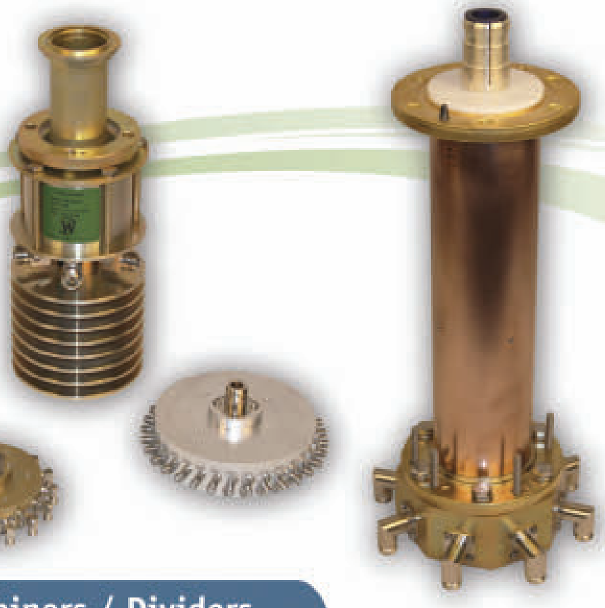

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D8454	8-Way	370-450	10,000	0.25	1.30:1	3 1/8" EIA, N Female
D9710	8-Way	1000-2500	2,000	0.3	1.40:1	1 5/8" EIA, N Female
D9529	8-Way	2305-2360	1,000	0.2	1.15:1	7/16 Female, N Female
D9528	8-Way	2305-2360	2,000	0.2	1.15:1	7/8" EIA, N Female
D5320	12-Way	470-860	500	0.3	1.30:1	All N Female
D9194	16-Way	2305-2360	1,000	0.2	1.15:1	7/16 Female, SMA
D9527	16-Way	2305-2360	2,000	0.2	1.15:1	7/8" EIA, N Female
D9706	16-Way	2700-3500	6,000	0.35	1.35:1	Waveguide, N Female
D6857	32-Way	1200-1400	4,000	0.5	1.35:1	1 5/8" EIA, TNC

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