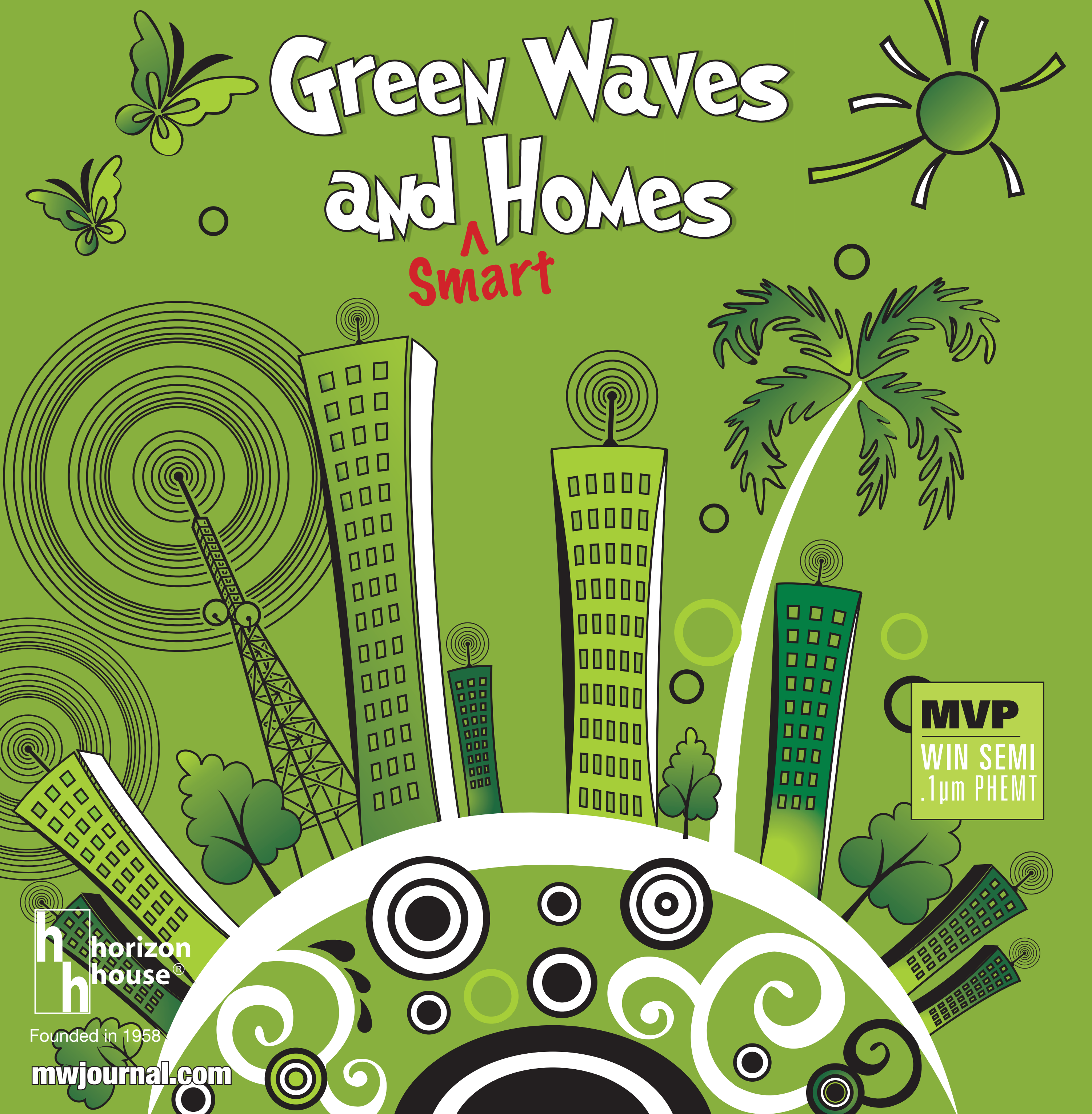
Vol. 53 • No. 12

December 2010

Microwave Journal

Green Waves and Smart Homes



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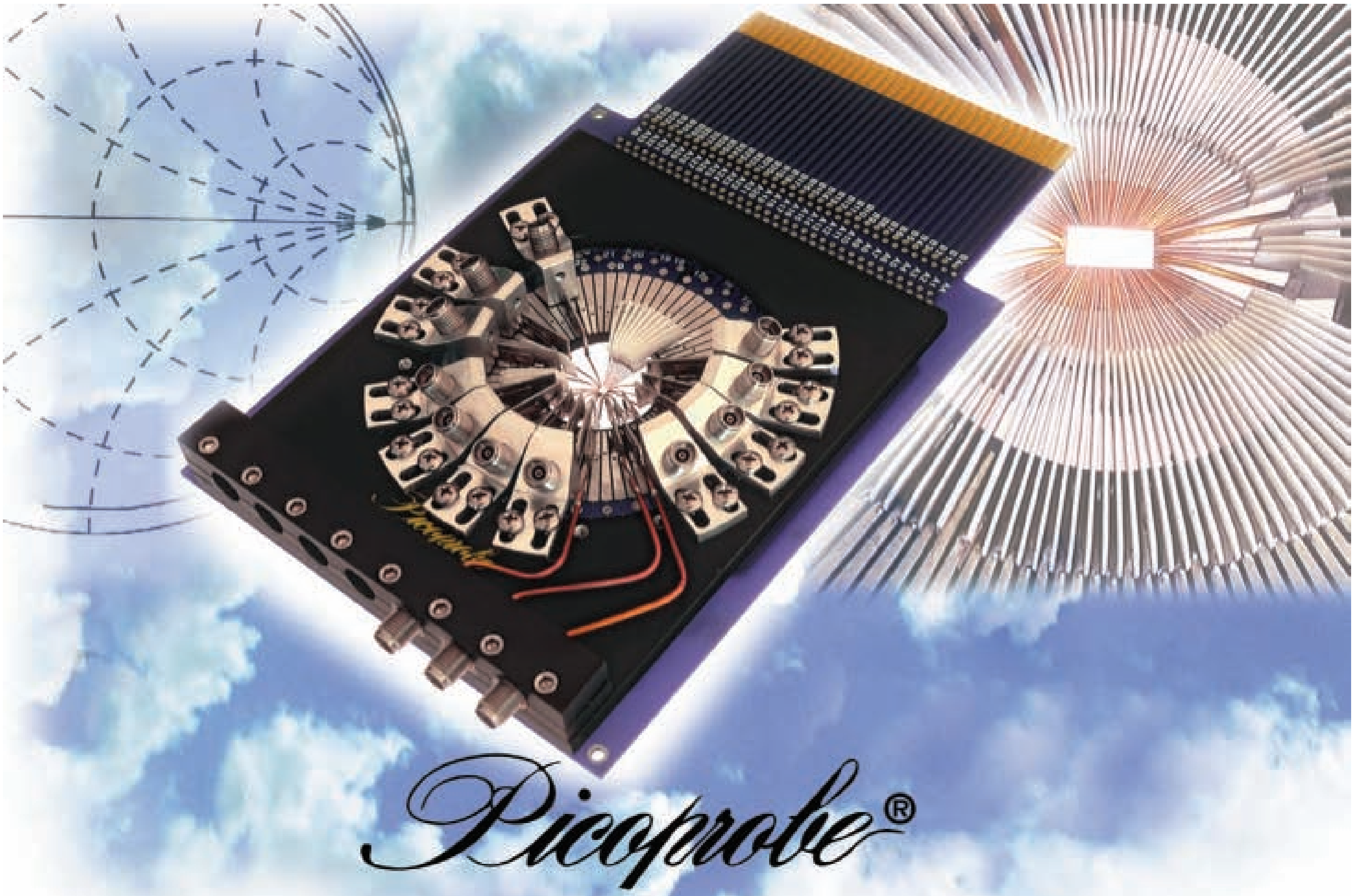

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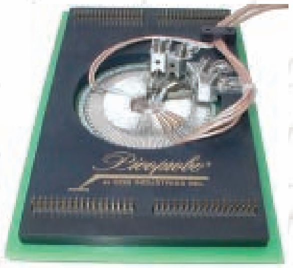

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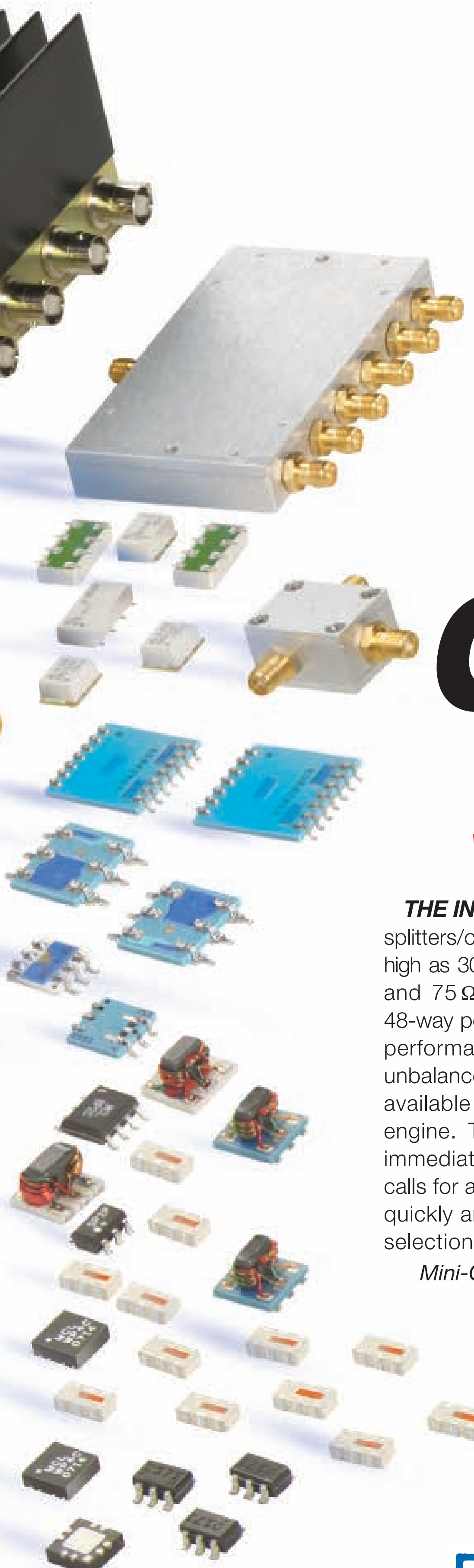


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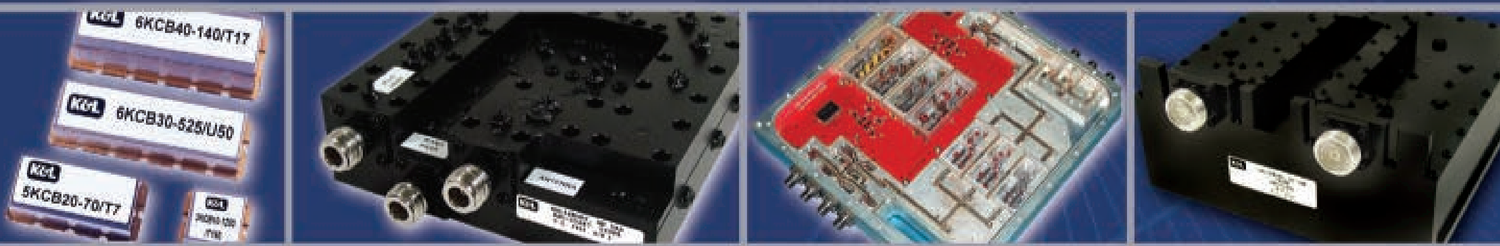
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Microwave Journal

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NOTE FROM THE EDITOR

COVER FEATURE

MVP: MOST VALUABLE PRODUCT

TECHNICAL FEATURES

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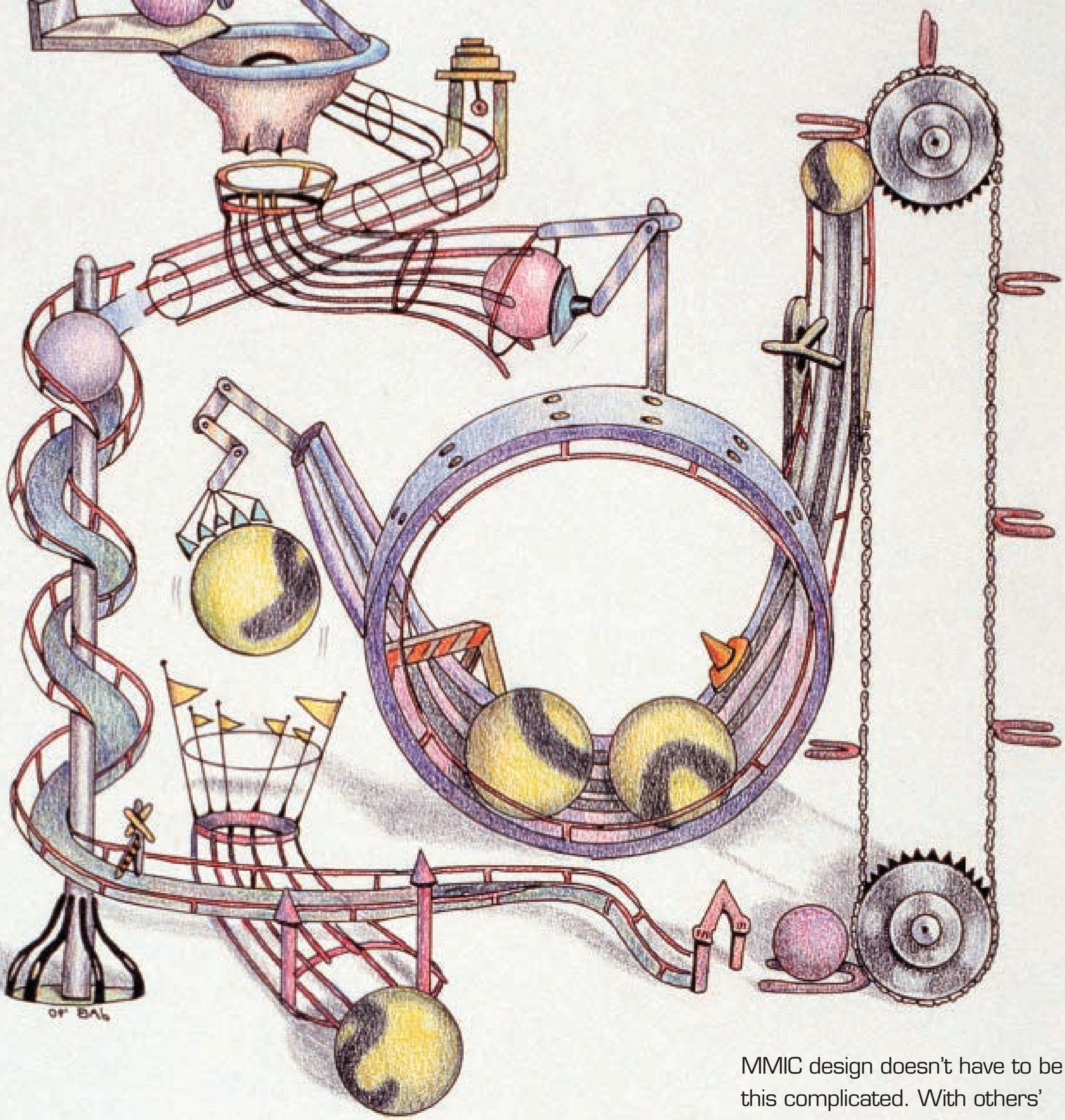

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Guest Speaker **Dr. Philippe Masson**, Advanced Magnet Labs

Executive Interview

Nik Chavannes, Director of Software Development, **Schmid & Partner Engineering AG (SPEAG)**, expands on the company's spin-off from the Swiss Federal Institute of Technology and outlines its development of software tools and instrumentation for industrial, scientific and medical applications.

Expert Advice

Leonard Pelletier, Application Support Manager at **Freescale**, talks about the number one cause for most RF performance issues—an inadequate back side RF grounding connection of the device with the associated PCB ground plane.

Online Technical Papers

What's the Best Wireless Transport Option of Uncompressed HDTV Video?
Dave Russell, HXI/Renaissance

The Cost and Performance Benefits of 80 GHz Links Compared to Short-haul 18 to 38 GHz Frequency Band Products
White Paper, BridgeWave Communications

New Generation of TCXOs Equals Accuracy and Precision of OCXOs
Robert Gubser and David Kenny, Pletronics Inc.

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THE YEAR THAT WAS...

DAVID VYE, *MICROWAVE JOURNAL* EDITOR

Twenty-ten, what was that all about? Throughout much of this year, forecasters puzzled over the direction of the economy. Was it heading for a double-dip recession or on its way to being stuck in a jobless recovery for the next decade? Elsewhere, a few optimists claimed to see the green shoots of resurging economic growth. Either way, predictions of a speedy recovery were far and few between. With such uncertainty about the future, what can be said about the health of the microwave industry in this tenth year of the third millennium?

Remember the tale of four blind men who felt their way around an elephant in order to understand what it was? Each one touched a separate part of the animal, such as the trunk or tail. After comparing notes they learned that they were in complete disagreement over the nature of the beast they could not see.

"And so these men of Hindustan
Disputed loud and long,
Each in his own opinion
Exceeding stiff and strong,
Though each was partly in the right
And all were in the wrong."

If we were to reverse engineer this parable—replacing the elephant with the general economy—which body part should we assign to the microwave industry? Let's look at some metrics.

The strong recovery of the wireless communications market, especially for smartphones and supporting networks, provided double digit growth for leading RFIC/MMIC front-end and related test equipment manufacturers. The financial reports and product/technology innovations of these touchstone microwave companies in 2010 projected the image of an industry that was sturdy under pressure.

RFIC manufacturers responded with technology that addressed multi-band, multi-mode phone requirements, while improving linearity and efficiency (see September cover), test manufacturers responded with equipment that was faster and more accurate (phase noise, dynamic range, etc.), supporting nonlinear device characterization (see March cover) and MIMO-enabled network validation (see August cover). Meanwhile, network expansion in emerging markets helped fuel growth for passive component, cable and connector manufacturers. Clearly the microwave industry helped other markets move forward.

The abundance of applications enabled by high-frequency electronics, including mobile Internet, Wireless HD, M2M, low power RF Smart Grid, medical microwaves and RF plasma lighting—to name a few on the commercial side—suggests that we are an industry supporting mammoth-sized markets.

A review of the most popular online *Microwave Journal* news items for any given month shows interest evenly split between defense-related items (contract wins, mergers and market reports, i.e. GaN and radar) and commercial ones (Femto-cells, LTE and mobile phones/networks), suggesting an industry that is broad.

Sturdy, supportive, forward moving and broad—perhaps the high-frequency electronics industry is one leg of the general economy.

As the war on terror shifted focus from Iraq to Afghanistan and beyond, many companies pursued the defense and aerospace markets. Ad-hoc personal communications, UAV command and control, surveillance and IED counter-measures all helped drive defense R&D spending (see January, August Supplement and October cover stories), which in turn helped the microwave industry weather the economic storm.

This year, the MWJ/EuMA Defense/Security Executive Forum at European Microwave Week focused on where and how microwaves will spearhead systems targeting conventional and asymmetric threats. Will tension on the Korean peninsula or at airport security millimeter-wave backscatter machines escalate? In either case our technology is likely to play a role. Perhaps we are the pointy tip of the elephants' tusk, protecting the economy from harm.

Economic anxiety in the broad economy swayed the American electorate to the right. Was this past election about jobs or government size and spending? If it is the latter, the United States might pursue an austerity plan similar to England and Greece. It would be unfortunate if defense cuts impacted the industry that provides such economic benefit and jobs, improves security and will help save global energy costs (see this month's cover story).

A drastic cut to defense R&D funding is eerily reminiscent of when the banks stopped lending money. Over the past several years, the microwave industry has been poised to capitalize on the high demand for broadband wireless just as the financial markets seized up and companies without capital were laid to waste. For microwave applications, the need and technology was there; the funding was not. I'll leave it up to the reader to decide what part of the elephant best describes the financial markets.

This past year's editorial theme focused on the microwave supply chain with special reports on defense funding and procurement, surveys on competing suppliers and technologies and more. 2011 will be the year of the microwave engineer, with special editorial focused on your accomplishments.

The industry is full of many brilliant and inspiring individuals, some of whom passed away in 2010 including: Henry Riblet (co-founder of Microwave Development Laboratories), Roger Sudbury (MIT Lincoln Lab Director, IEEE Fellow), Harry Rutstein (President of Dorado International), George (Frak) Grund, (President of PamTech), Harold Harrison (co-founder of Aertech Industries) and Michael Cobb (Raytheon, friend and mentor to many); all great guys and tough acts to follow. But we stand on their shoulders and reach for the sky, tall and strong, just like the leg mistaken for a pillar in the old folk tale. So get busy, get writing and let's talk. Have a great year. ■

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11 RFIC 2011 Call for Papers Deadline	12	13	14	15
16	17 2011 IEEE Radio & Wireless Week	18 **Radio and Wireless Symposium** Phoenix, AZ (Jan 16–21) **MWJ/Besser Webinar: Radar Fundamentals** Sponsored By ROHDE&SCHWARZ	19	20	21	22
23	24	25 **MEMS 2011** **IEEE International Conference on Micro Electromechanical Systems** Cancun, Mexico (Jan 23–27) **MWJ/SA Webinar: AESA Radar Mkt.** Sponsored By Tektronix	26	27	28	29
30	31	1 **DesignCon 2011** Santa Clara, CA (Jan 31–Feb 3)	2	3	4	5

NEXT MONTH:

Mobile World Congress
February 14-17, 2011
Barcelona, Spain

National Association of Tower Erectors
February 21-24, 2011
Oklahoma City, OK

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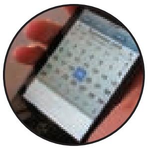

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RFIC 2011
Deadline: January 11, 2011
EuMW 2011
Deadline: February 12, 2011

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DECEMBER

APMC 2010
Asia Pacific Microwave Conference
December 7–10, 2010 • Yokohama, Japan
www.apmc2010.org

JANUARY

RWS 2011
Radio and Wireless Symposium
January 16–20, 2011 • Phoenix, AZ
http://rawcon.org

MEMS 2011
IEEE International Conference on Micro Electromechanical Systems
January 23–27, 2011 • Cancun, Mexico
www.ieee-mems2011.org

DesignCon 2011
January 31–February 3, 2011
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www.designcon.com

FEBRUARY

MWC 2011
Mobile World Congress
February 14–17, 2011 • Barcelona, Spain
www.mobileworldcongress.com

ISSCC 2011
International Solid-State Circuits Conference
February 20–24, 2011 • San Francisco, CA
http://isscc.org

Nate 2011
National Association of Tower Erectors
February 21–24, 2011 • Oklahoma City, OK
www.natehome.com

MARCH

SATELLITE 2011
March 14–17, 2011 • Washington, DC
www.satellite2011.com

CTIA with RF/Microwave and M2M Zones
March 22–24, 2011 • Orlando, FL
http://rfmwzone.com

ACES 2011
27th International Review of Progress in Applied Computational Electromagnetics
March 27–31, 2011 • Williamsburg, VA
http://aces.ee.olemiss.edu/conference/

APRIL

WAMICON 2011
IEEE Wireless and Microwave Technology Conference
April 18–19, 2011 • Clearwater, FL
www.wamicon.org

JUNE

RFIC 2011
IEEE Radio Frequency Integrated Circuits Symposium
June 5–7, 2011 • Baltimore, MD
www.rfic2011.org

IMS 2011
IEEE MTT-S International Microwave Symposium
June 5–10, 2011 • Baltimore, MD
www.ims2011.org

ARFTG 2011
ARFTG Microwave Measurement Conference
June 10, 2011 • Baltimore, MD
www.arftg.org

AUGUST

EMC 2011
IEEE International Symposium on Electromagnetic Compatibility
August 14–19, 2011 • Long Beach, CA
www.emc2011.org

OCTOBER

EuMW 2011
European Microwave Week
October 9–14, 2011 • Manchester, UK
www.eumweek.com

AMTA 2011
33rd Annual Symposium of the Antenna Measurement Techniques Association
October 16–21, 2011 • Englewood, CO
www.amta.org

NOVEMBER

IEEE COMCAS 2011
International IEEE Conference on Microwaves, Communications, Antennas and Electronic Systems
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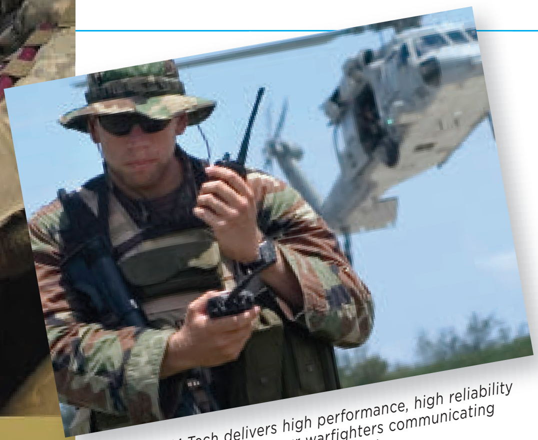

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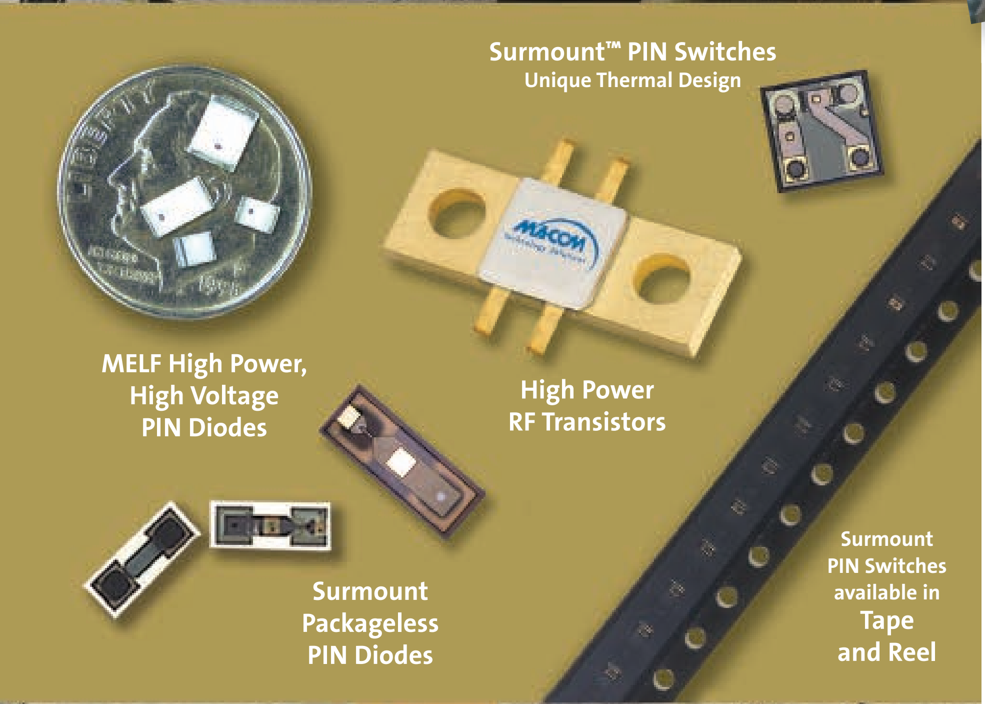

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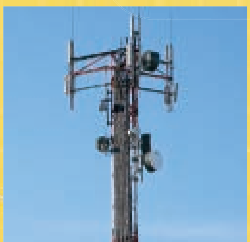

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COVER FEATURE
INVITED PAPER

The Smart Grid Communications Evolution: "Closing the Loop" for the Intelligent Electric Grid

A vast amount of activity is occurring on a global basis to upgrade electrical power grids to make the delivery of electricity more efficient, reliable, environmentally friendly and cost effective. This includes a wide variety of equipment and technology within the generation, transmission, distribution and metering portions of the grid. One key aspect of these upgrades is the inclusion of communications capability within a variety of monitoring and metering equipment. Various wireless and wired communication technologies are being evaluated and deployed across the world. RF communications is already the technology of choice in various regions and applications, but is not without its own challenges.

The addition of communications to the grid is driven by the general principle of providing two-way communication between generation, distribution and consumption points in the network. Such communication links are a vital tool in order to operate the grid more efficiently. However, this is not the basis on which the deployment of RF technology first began. Initially, the motivation was to automate the reading of electric, water and gas meters, and to eliminate the need for humans to manually record consumption data.

These automatic meter reading (AMR) systems were designed to support a one-way flow of electricity from the utility to the consumer. The AMR systems also provided a one-way flow of information back to the utility for billing purposes, transmitting the electric consumption over a given time period. Data rates were low, as were the total amount of data communicated, typically less than 1 kbit per month. There are approximately 150 million electric, water and gas meters in the field that already have communication capability; the majority of them have this low data rate, one-way communications capability.

A combination of forces has driven a new vision of a grid that is fundamentally different from the one developed over the past century. With worldwide electricity demand rising rapidly and a strong desire to limit dependence on

JAMES FRAME, PHD, JERITT KENT AND IAN LAWEE
Analog Devices Inc., Norwood, MA

fossil fuel, new generation sources will increasingly come from renewable sources such as wind and solar. The US energy administration predicts that worldwide electricity consumption will grow by over 80 percent over the next 25 years and that renewables will grow to become the second leading source of power generation (see ***Figure 1***).

Wind and solar generation are more unpredictable than traditional fossil fuel generation plants and, therefore, create a more complex system to manage. In addition, a significant increase in demand is expected to come from electric vehicles, which creates an uneven demand profile. Finally, to slow the demand growth for electricity, business and home consumers will need to manage their usage in new ways.

Therefore, a vision of a "smart grid" is needed, a name signifying a higher level of measurement, communication, control and protection capability that involves a two-way flow of information on a more frequent basis for purposes beyond just meter reading. This enables a wide array of capabilities, including:

- balancing of generation among centralized power plants;
- optimizing electrical power distribution;
- improving power quality monitoring and outage response;
- enabling control of end-user load profiles;
- implementing time-of-day tariffs;
- accommodating multiple sources of energy including renewable sources;
- enabling remote connect/disconnect;
- providing consumers with real-time feedback on their demand profiles.

Once such communications are in place, utilities and consumers can collectively reduce consumption, increase grid efficiency and reliability, and enable the broader use of electric vehicles and renewable sources of energy.

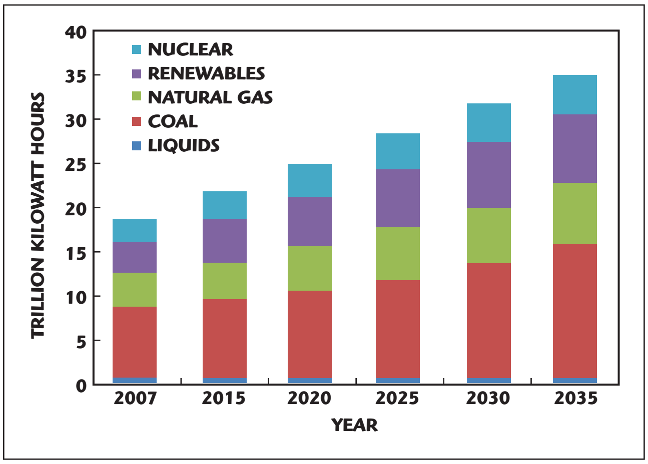


Fig. 1 World net electricity generation by fuel (US Energy Information Administration, 2010).

DRIVING REQUIREMENTS AND CHALLENGES FOR THE SMART GRID

Smart grid initiatives have been launched, targeting a range of ambitious goals. In many cases, these goals require building an infrastructure to solve existing and future challenges, in advance of full understanding of both the problems and the solutions. The US Energy Independence and Security Act of 2007 defines no fewer than 10 key policy goals for the smart grid, ranging from an overarching goal to "use digital technology to improve reliability, security and efficiency of the electric grid" to more specific targets of "deploying automated metering, grid operations and status and distribution grid management." These goals anticipate a grid that integrates distributed renewable resources, puts in place demand response resources, enables electricity storage, accommodates plug-in electric vehicles and integrates "smart" appliances and other devices that provide the consumer with timely information and control of their energy usage.

Along with these challenges, there are also anticipated risks driving the need for cyber security and interoperability standards. Standards will allow utilities to begin deployment of an initial network infrastructure in anticipation of millions of future interconnected devices developed by many companies. This same image of millions of easily interconnecting nodes, some with the ability to turn off or on power at homes and sub-stations or add unmanageable loads to the grid, raises the specter of malicious attacks paralyzing our electricity dependent countries. Added to these broad risks are concerns for personal privacy. Minute by minute tracking of energy usage is viewed by some as yet another unwanted digital window into people's homes and lives.

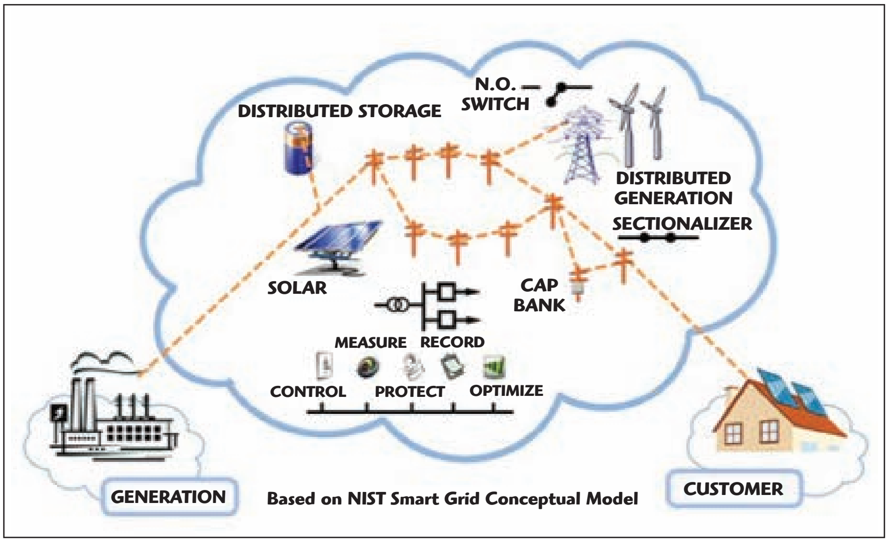
Added together, these goals and risks represent a complex closed loop systems problem. When comparing just the needed data rates of the smart grid to the Internet or cellular networks, existing communications technology seems more than capable. The real challenge is the balance between longevity, reliability, cost and future requirements. The smart grid will be a huge utility and government investment (Pike's Research estimates the cumulative global spending to hit $200 B by 2015) and the utilities traditionally require a 20 year or longer lifetime on their equipment investments. These communications systems require future proofing, designed in head room, for problems that will not appear for over a decade. Utilities and equipment providers are continually comparing and trading off immediate implementation costs versus more hazy future requirements.

SMART GRID COMMUNICATIONS: MULTIPLE INTERCONNECTED NETWORKS

As the smart grid extends two-way communications between different forms of generation to the electricity consumer, there are multiple systems with different degrees of control, measurement, data recording, protection and optimization. The main systems can be divided into separate groupings: 1) distribution and transmission field and wide area networks; 2) smart meter to data collector or network access point; and 3) smart meter to appliances or charging stations within the home (see ***Figure 2***).

SMART METER COMMUNICATIONS: DOMINATING THE INVESTMENT

The communications systems centered in the smart meters are attracting the most attention from competing technologies. With a potential replacement of over 140 million meters in the US and over one billion meters worldwide, smart meters represent the vast majority of nodes, and therefore cost, within the smart grid com-



▲ *Fig. 2 Smart grid communications: A connection of multiple networks.*

munications systems being deployed by the utilities.

The two main competing technologies, RF and power line carrier (PLC), are being adopted to different degrees across the world. RF solutions have dominated the North American market. The availability of spectrum in the license-free high power ISM band and the fact that there are relatively few meters for each transformer, has generally meant that RF can be deployed at lower cost in North America.

SMART METER RF COMMUNICATIONS TECHNOLOGY ADOPTION TO DATE

Focusing further on the RF systems currently being deployed to connect meters to utilities, another level of competing technology is seen between mesh and star-based systems. These two system approaches attempt to address the RF challenges of the smart grid differently.

Connecting millions of meters back to the utility represents a unique challenge. Connecting existing meters means creating an RF link to over 100 million predetermined locations in the US alone. Many of these locations are in difficult environments for RF communications, such as in basements and behind cement walls. Many are also in urban areas with dense and changing RF interferers.

Mesh systems create multiple short paths (through neighboring meters) for a single meter to reach a central collector, which acts as a gateway into the utility wide area network. Mesh systems, available from multiple vendors, are typically delivering data rates of 100 to 150 kbits/sec, operate using FSK or spread spectrum modulation schemes, are typically within the ISM band centered at 915 MHz and have channel bandwidths of 50 to 200 kHz.

Star-based systems primarily use narrow band signals on licensed channels to bridge a longer distance to fewer central collectors. Fewer central collectors are required, albeit with higher transmit powers, located in clear line-of-sight positions such as mountaintops or tall buildings. Star-based systems typically operate with FSK-based modulation and utilize lower data rates than wider band mesh systems. In addition to the need for fewer central collectors, proponents of star-based systems cite the benefits of in-band interference-free spectrum and simpler network protocols.

SMART METER RF NETWORKS: HOW TO SUCCESSFULLY DEPLOY WITHIN AN INTERFERENCE LIMITED ENVIRONMENT

In the US, both the ISM and licensed bands are becoming increasingly crowded. For both mesh and star systems, this means that interference becomes the central challenge to overcome. The deployment of large scale metering networks significantly increases this crowding since a system's biggest source of interference could be the system itself.

This crowding has a significant impact on the radio and network require-

ments. For example, good clear channel assessment (CCA) and frequency hopping routines can ease finding a clear channel. Increasing the data rate reduces the length of time each node is transmitting, but it comes at the cost of reduced link margin. For the radio, this crowding also means that the blocking and adjacent channel rejection are often more critical than the receiver sensitivity.

As described above, a primary challenge for the metering infrastructure is that the location of the meters is fixed. Interference problems cannot be solved by adjusting the orientation or height or location, as can be done with a wireless router in a home. Furthermore, because the meters are very often retrofits that fit within an existing meter housing, there is little or no flexibility to modify the package for the purposes of RF performance enhancement. The meters are often secured against a thick reinforced concrete wall only a meter or so above the ground. Very seldom can a simple line-of-sight model be legitimately used to describe the channel.

The interferers of interest vary by band and region of the world. In the US, significant interferers exist for both licensed band and ISM band systems. Common interferers include signals in the TV white bands, cellular carriers and other devices operating in the same bands, which may or may not be part of the same system. Devices operating in the same band may not have been designed for peaceful coexistence, both from the packet structure and modulation choices as well as emission spectra that marginally meet FCC guidelines.

Communication is relatively easy for 80 to 90 percent of the meters that are deployed. The last 10 to 20 percent present the most difficult RF challenges, due to geography and physical objects, significant local interference, or nearby noise sources. Since the problematic meters cannot be moved, the only system-level solutions are the addition of data collectors or repeaters, the addition of a second alternate communications device, like PLC or cellular, or enhanced radio performance. The widespread metering infrastructure ultimately needs to be extremely robust, with 100 percent coverage. To put this in context, a large scale deployment may be five million units. If the utility coverage is only 99 percent, 50 thousand meters cannot be read.

RADIO ARCHITECTURE AND DESIGN

A typical radio module contains an antenna, an external power amplifier for higher output applications, an RF band select filter, a radio IC, a communications processor and various discrete elements for matching and bypassing. Many modules also contain an external low noise amplifier (LNA), usually co-packaged with the external RF band select filter, switch and amplifier in a front-end module (FEM). Because of the physical constraints of both the meter housing and the location of the meter itself, the antenna is often located in a non-optimal location or built into the meter housing itself.

The external RF band select filter, such as a surface acoustic wave (SAW) filter, is often used to help attenuate interferers outside the band of interest. For example, in a 902 to 928 MHz system, the filter would help remove interference from the 850 MHz cell bands, 896 to 901/935 to 940 MHz land mobile licensed bands and the 901 to 902 MHz Part 24 Personal Communication Services (PCS) band. Typical RF band select filters can attenuate the signals between 30 and 60 dB, depending on the quality of the filter and the frequency of the interfering signal and how close the signal is to the pass band.

In any transceiver design, there are many architectural and design tradeoffs that have to be made with regards to various performance parameters, cost and power dissipation. Many of the performance challenges faced in metering communications environments can be eased with the application of additional money or power (voltage and/or current). However, utilities face difficult justifications regarding the deployment of large scale fixed network systems and additional cost may not be an option.

Additional power is a more complex argument. Many radios are designed to operate in both line-powered and battery-powered systems, and the power dissipation is driven by the battery-powered requirements. Most radio modules in electrical meters have a "last gasp" capability so they can operate for a limited time even if main power is lost, and the radio power

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IF/RF MICROWAVE COMPONENTS

459 rev F

requirements are a major contributor to sizing the charge storage necessary for this capability. Also, any increase in power consumption is multiplied by the scale of the deployment. Using the same five million node example above, a relatively benign current increase of 100 mA over 2.5 V leads to an increase of 1.25 MW, or 30 MW-hr per day.

A low-IF architecture can be advantageous for metering applications where the fixed receiver often faces very strong electromagnetic fields, which generate spurs at 50 or 60 Hz multiples that could affect a zero-IF architecture. The data rates in the control and measurement side of the meter will likely stay under 1 Mbps. As the associated filtering requirements can be described as narrowband, a zero-IF architecture would need to address challenging issues of both DC offset and CMOS flicker noise.

EXAMPLE: HOW PHASE NOISE IMPACTS BLOCKING PERFORMANCE

There are many parameters that influence the blocking performance of a transceiver. Usually, the narrowband blocking performance is set by the rejection profile of the receiver's channel filter and the wideband blocking performance is set by the phase noise performance of the receiver's local oscillator (LO).

Blocking is typically measured using a bit error rate (BER) test by finding the maximum blocker power that results in a BER degradation of 10^{-3} with the receiver's input power set at the sensitivity level of +3 dB. The receiver's wideband blocking performance can be estimated as:

MaxBlocker (dBm) = -174 dBm + 3 dB + Noise Figure - Phase Noise - 6 dB

where MaxBlocker is the maximum blocker level in dBm that results in a BER degradation of 10^{-3}. Phase Noise is the receiver's LO phase noise and Noise Figure is the receiver's noise figure. ***Table 1*** contrasts maximum blocking levels derived from the phase noise performances of transceivers from various suppliers.

In this simplified example it is easy to see the importance that the LO phase noise has on the maximum blocking level. At 10 MHz offset, an LO performance of -142 dBc/Hz will result in a maximum blocking level of -30 dBm. In comparison, a transceiver with a LO phase noise of -130 dBc/Hz (at the same 10 MHz offset) would have a maximum blocking level of -42 dBm. To achieve similar performance, an external RF band select or SAW filter is required at the antenna input to improve the blocking performance. However, this will increase the overall system cost and degrade the receiver's noise figure due to the insertion loss of the RF filter.

A receiver's IIP2 and IIP3 performance must also be considered in wireless metering applications, especially in urban areas where high levels of in-band and out-of-band interferers can give rise to unwanted spectral products at the mixer output and thus limit the receiver's usable dynamic range. As a benchmark of what may be required for device resiliency to two-tone interferers, the transceiver described in this example demonstrates a measured IIP2 of +18.5 dBm and an IIP3 of -11.5 dBm, while maintaining a low power dissipation of 12.8 mA. Moreover, an on-chip Reed Solomon forward error correction (FEC) capability, supported by the on-chip RISC processor, offers additional resilience to burst type errors that result from transient interference or in rapid signal fading environments.

The importance of the phase noise and its impact on the receiver's dynamic range performance also has implications for clear channel assessment (CCA). In "Listen before talk," a contention-based MAC protocol, the meter's receiver makes a power measurement on the channel that it wants to use to transmit. A clear channel is one that the receiver "sees" with a power measurement near the thermal noise floor. A radio with poor linearity and/or phase noise specifications may see a large interferer as elevated noise, and consistently fail the CCA test. Significant interference or inadequate linearity and phase noise may prevent some nodes from communicating with the network because of these failures.

TABLE I
MAXIMUM BLOCKING LEVEL FOR TRANSCEIVERS WITH DIFFERENT LEVELS OF PHASE NOISE

	LO Phase Noise (10 MHz offset)	Blocker (dBm)
ADF7023	-142 dBc/Hz	-30
Transceiver A	-130 dBc/Hz	-42
Transceiver B	-125 dBc/Hz	-47

In conclusion, most transceivers for the metering infrastructure are designed to deliver the maximum performance within cost and power constraints. This requires both careful design and challenging tradeoffs to be made for many parameters. It is important that system designers appreciate that in addition to sensitivity and channel selectivity that the receiver's nonlinear performance and its interference resilience are analyzed and considered as part of wireless network design for the smart grid.

FUTURE ISSUES THAT IMPACT TODAY'S DEPLOYMENT

Increase in interferers with AM components

The environment in which the deployed metering communication system exists is expected to be constantly changing. The increased desire for higher bandwidth for streaming applications or for solving bottlenecks resulting from high aggregate concentration means that it is likely there will be more interferers with more complex modulation schemes, often with significant amplitude modulated (AM) components. Anticipating these challenging interferers, IIP2 and IIP3 specifications will become increasingly critical to the radio and network performance.

Narrow band is getting narrower

Recently the FCC has tightened the spectral efficiency requirement for the Part 90 licensed bands, which are used in many metering systems in the US. The Part 90 Private Land Mobile Services band was previously allocated with 12.5 and 25 kHz channels. Later an additional option was added for 6.25 kHz channels. The 25 kHz channels are being phased out and an additional requirement to increase the spectral efficiency has been added, to support a data rate of 4.8 kbps per 6.25 kHz of bandwidth. It is expected that, over time, additional spectral efficiency regulations will be put in place worldwide, forcing the use of more complex modulations or lower modulation indices.

Increasing headroom for new protocol and security standards

The smart grid RF challenges can be described as anticipating current and future spectral challenges and making the proper tradeoffs between performance, power and cost of the RF components. The drive to adopt industry-wide protocols and network security standards forces additional future proofing strategies that extend to all resources, spanning RF, processing and memory. One example is the anticipated transition from ZigBee SEP 1.0 to ZigBee SEP 2.0. Many smart meters are being deployed with certified ZigBee networks using the smart energy profile 1.0 to communicate to future devices in the home. A new profile, ZigBee smart energy profile 2.0, is under development, supporting IP-based addressing, redefining the layers above the MAC and PHY. Utilities have a strong desire to deploy meters that can support the existing SEP 1.0 standard, yet ensure that the meters can download the new profile when it is finalized. This is one of a number of examples of upgradeability to new standards driving an increased need for both processing and memory headroom.

CONCLUSION

The smart grid presents many technical, market and societal challenges. RF designers must aim for new optimizations, satisfying a need for industrial strength products that will last for decades and perform in an increasingly crowded spectrum. The payoff will be a grid infrastructure with the flexibility to adapt as the demand and supply of electricity evolve. ■

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Jeritt Kent *received his BSEE and MEngEE degrees from the University of Idaho. He has been with Analog Devices for 11 years and is currently the RF and Energy Specialist for ADI's Industrial and Instrumentation segment. He was previously employed at Allegro Microsystems, and before that, spent six years in CMOS ASIC design at American Microsystems Inc.*

Ian Lawee *received his BS and MSEE degrees in computer science from the University of Pennsylvania in 1988 and his MSEE and MBA degrees from the Massachusetts Institute of Technology in 1995. He is currently a marketing manager at Analog Devices, responsible for energy communications, power and measurement ICs. Prior to this position, he spent 14 years in the semiconductor test and measurement industry holding various positions in engineering and marketing management.*

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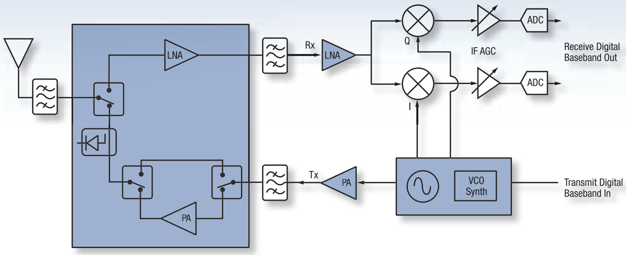
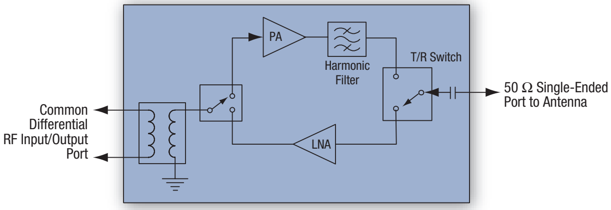


Skyworks Short-Range Radio Block Diagram

Front-End Modules for Smart Energy and Industrial Applications

Skyworks FEMs allow for significant size and cost reduction and are designed for "plug and play" functionality, reducing the design time for new products. Customized FEMs can be created depending on transceiver implementation requirements. Various modules are available at 450, 915, and 2400 MHz frequency bands.



SKY65352 Front-End Module (FEM) Block Diagram

Part Number	Function	P_{Out} (dBm)	Tx Gain (dB)	I_{CC} (mA)	Frequency Band (MHz) 450	915	2400
SKY65338	Tx / Rx Front-End Module	27	32	315	•		
SKY65342	Tx / Rx Front-End Module	29	34	650	•		
SKY65346	Tx / Rx Front-End Module with LNA	26	35	200		•	
SKY65313	Tx / Rx Front-End Module with LNA	30.5	28	695		•	
SKY65336	Tx / Rx Front-End Module with LNA	20	17	140			•
SKY65337	Tx / Rx Front-End Module	20	17	140			•
SKY65343	Tx / Rx Front-End Module	20	19.5	105			•
SKY65344	Tx / Rx Front-End Module with LNA	20	19.5	105			•
SKY65352	Tx / Rx Front-End Module with LNA	20	19.5	110			•
SKY65348	Tx / Rx Front-End Module with LNA	27	26	380			•
SKY65296	WLAN Front-End Module	21	24	210			•

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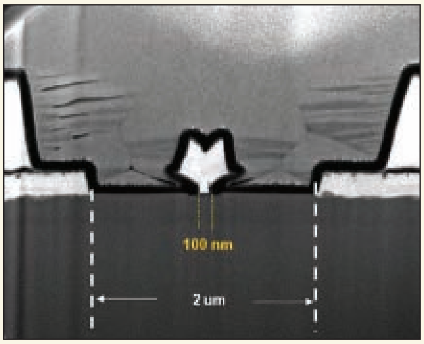


0.1 μm PHEMT Process for E-band Power Applications

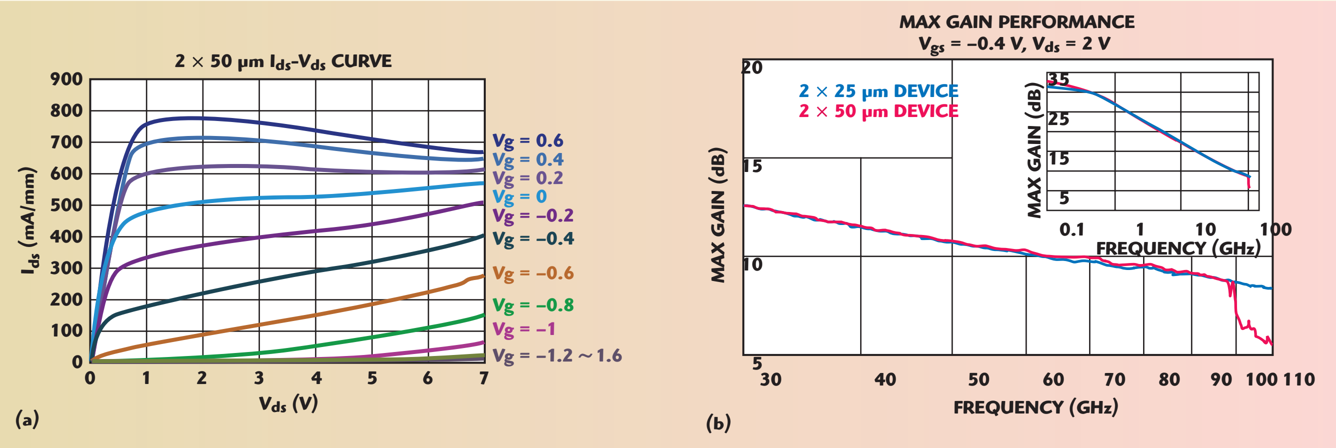
To meet the ever-increasing demands of next generation wireless infrastructure, fiber optics and advanced military systems markets, WIN Semiconductors Corp. has developed an ultra-high performance 0.1 μm GaAs PHEMT technology. This device platform, named PP10, is produced on 150 mm GaAs wafers in WIN Semiconductor's state-of-the-art wafer foundry located in Taiwan and is available with an option of 50 or 100 μm substrate thickness. With F_t greater than 135 GHz and F_{max} over 185 GHz, PP10 is targeted towards millimeter-wave power products at E- and V-band, and will enable the realization of high data rate 70 to 90 GHz point-to-point radios used in the backhaul of 3G/4G mobile base stations. Additionally, the superior performance of PP10, as well as the volume availability of products built on this technology will make possible a wide range of high frequency products in entirely new applications.

PROCESS DESCRIPTION

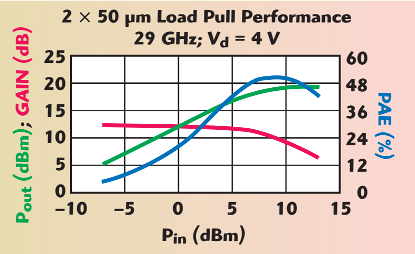
The PP10 process leverages an advanced materials design with electron-beam defined 0.1 μm gates and a qualified 150 mm manufacturing infrastructure to obtain a high volume, ultra-high performance technology platform. The critical 0.1 μm T-shaped gate is defined in a Leica direct-write E-beam lithography system. The e-beam lithographic process has been optimized to enable a wafer to be patterned in less than 30 minutes and provides more than adequate throughput to support volume production of 0.1 μm gate products. The electron beam lithography process forms the 0.1 μm T-Gate profile, which simultaneously provides the short gate length necessary for high frequency operation and a low gate resistance. The high pattern accuracy and resolution capabilities of E-beam patterning is illustrated in the cross-section shown above, which shows a typical PP10 gate with a 0.1 μm foot and 0.5 μm top dimension positioned within the 2 μm drain-to-source spacing. PP10 has been designed with a 2 μm source to drain spacing and uses a single recess channel geometry to achieve optimum current/transconductance characteristics while maintaining an adequate breakdown voltage for reliable 4 V operation.

As with all high performance technology platforms built by WIN Semiconductors, the transistor cells employ through the substrate source vias and airbridge connections to reduce parasitic capaci-

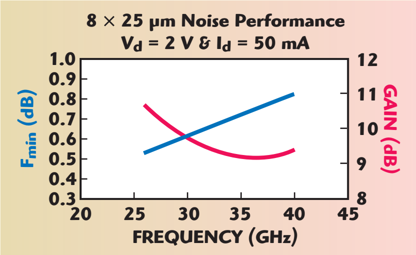
WIN SEMICONDUCTORS CORP.
Tao Yuan Shien, Taiwan



▲ *Fig. 1 The 7 V I-V curve (a) and MSG (b) of the PP10 process.*



▲ *Fig. 2 29 GHz power performance of PP10.*



▲ *Fig. 3 26 to 40 GHz noise performance of PP10.*

tances. Additionally, the MMICs are fully passivated using silicon nitride deposited via PECVD and is used as the dielectric for standard 400 pF/mm^2 Metal-Insulator-Metal (MIM) capacitors.

To provide the product designer additional flexibility, PP10 is available with a 100 µm wafer thickness as well as the production proven 50 µm substrate option. WIN Semiconductors has been producing high yield 50 µm thickness 150 mm diameter GaAs wafers for more than 10 years, providing customers with volume availability of this advantageous design option. The 50 µm substrate thickness provides better thermal management in the package and better confinement of electric fields on microstrip line designs and is especially important for the 60 to 90 GHz frequency range. At the same time, the smaller size of backside via available at the 50 µm wafer thickness provides a reduction in the gate-to-gate pitch for better signal coherence between each single transistor cell.

DC AND RF PERFORMANCE

DC I-V curves of a typical 2 x 50 µm PP10 device is shown in ***Figure 1***. The IV characteristics are well behaved and exhibit a nominal pinch off voltage of -0.9 V, peak transconductance of 750 mS/mm and a maximum current density of 720 mA/mm (measured at V_{gs}=0.5 V). The material and device design produces a knee voltage of less than 1 V and a typical gate-to-drain breakdown voltage greater than |9 V| providing large available current and voltage swing for the RF signal, and very high power density under 4 V operation.

S-parameter measurements taken at V_{ds}= 2 V and extraction of Maximum Stable Gain (MSG) to 110 GHz is shown in ***Figure 2*** for both 2 x 25 µm and 2 x 50 µm transistors. These data show the PP10 devices provide 9 to 10 dB gain from 70 to 90 GHz; the 2 x 25 µm transistor provides approximately 8 dB gain at 110 GHz. Load pull measurements for a 2 x 50 µm transistor taken at 29 GHz are shown in Figure 2 and illustrate the power capability of PP10. These measurements are taken at V_{ds}=4 V and show excellent RF performance with a saturated power density of 850 mW/mm with a gain of 12 dB and peak power added efficiency (PAE) of 50 percent.

The physical tradeoffs that accompany a power device designed for E-band (high gain, high available current) also provide for excellent noise performance. Shown in ***Figure 3*** are measured F_{min} and associated gain from an 8 x 25 µm PP10 transistor taken at a bias V_{ds}=2 V and 50 mA/mm. From the data of Figure 3, one observes that PP10 also demonstrates excellent noise performance with a minimum noise figure of 0.8 dB and associated gain over 9 dB at 40 GHz. The confluence of high power density, superior gain and excellent noise performance of the PP10 technology allows the product designer to realize a highly integrated multifunctional device with high power amplifier, medium power amplifier and low noise amplifier on one chip for the E-band to V-band Tx/Rx core circuit, and is simply not possible in a technology of lesser performance.

WIN Semiconductors has developed and released an ultra-high performance 0.1 µm PHEMT technology for E-band power products. This technology platform is produced exclusively on 150 mm diameter GaAs wafers and is available in 100 and 50 µm wafer thickness for added product flexibility. The PP10 process offers WIN's customers an optimum combination of excellent power and gain performance through 110 GHz as well as very low noise figure enabling highly integrated multifunctional products. By taking advantage of WIN Semiconductor's high volume manufacturing infrastructure and short cycle times, the company's customers can leverage PP10 to produce highly differentiated products for new high frequency applications and markets.

ACKNOWLEDGMENT

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ViaSat Demonstrates Mesh SATCOM COTM

ViaSat Inc. has successfully demonstrated full-mesh satellite communications at Ka-band between an Australian Army deployable 1.0 m Compact Transmit Receive Suite (CTRS) terminal located at the Defense Science and Technology Organization (DSTO) and a 48 cm communication-on-the-move (COTM) terminal located at BAE Systems Australia, using a ViaSat LinkWayS2™ MF-TDMA satellite modem. This demonstration further shows the ability of the LinkWayS2 modem to simultaneously support satellite communications with fixed site, at-the-halt and on-the-move terminals within a single tactical LinkWay® network.

The full-duplex mesh connection streamed high-definition video simultaneously in both directions between remote sites while the mobile SATCOM antenna was exercised on a multi-axis, full motion platform using the steerable Ka-band spot beam on the Optus C1 satellite. The LinkWayS2 master reference terminal for the demonstration originated from a fixed terminal with a DVB-S overlay sourced from another Ka transponder on Optus C1.

The LinkWay full-mesh communication system... will increase its ability to provide network-centric operations...

The LinkWay full-mesh communication system has been a satellite networking workhorse for US defense over many years and with the addition of this new COTM capability, will increase its ability to provide network-centric operations, particularly over the Wideband Global Satcom (WGS) constellation.

The COTM antenna was designed and developed as a concept technology demonstrator by EM Solutions Pty Ltd. based in Brisbane, Australia, under contract to DSTO and has been successfully tested on an Australian Bushmaster Personnel Mobility Vehicle (PMV).

Lockheed Martin Awarded High-power Microwave Energy Weapon Contract

Lockheed Martin received a $230,000 US Air Force contract to define requirements for a weapon that uses high-power microwave energy beams instead of explosives to take out enemy electronic systems. The Non-Kinetic Counter Electronics Capability (NKCE) contract will lead to a new type of weapon that will destroy electronic equipment without endangering personnel.

The contract, awarded by the US Air Force Air Armament Center at Eglin Air Force Base, FL, calls for the development of an operations concept for the NKCE system, along with a mission planning strategy. Lockheed Martin will deliver its findings to the US Air Force during the first quarter of 2011. The contract also involves the development of system requirements and a concept of packaging the high-power microwave source system into an aerial platform. In addition, Lockheed Martin will identify hardening strategies to ensure system survivability in heavily defended areas. The contract also involves the development of system requirements and a concept of packaging the high-power microwave source system into an aerial platform. In addition, Lockheed Martin will identify hardening strategies to ensure system survivability in heavily defended areas.

The Non-Kinetic Counter Electronics Capability (NKCE) contract will lead to a new type of weapon...

When fielded, the weapon would require an aerial delivery platform for operational flexibility and the ability to engage multiple targets per mission. The system would be aimed at buildings or other structures containing identified electronic equipment that high-power microwave bursts would quickly render useless.

Raytheon Completes Software Specification Review for GPS OCX

The Raytheon team has successfully completed a key design review of the Global Positioning System (GPS) Advanced Control Segment (OCX), signaling the team's readiness to proceed with the next development phase of the program. Nearly 70 representatives from the government, aerospace and System Engineering and Integration, a contractor for the GPS Wing, recently completed a three-day software specification review at Raytheon's Intelligence and Information Systems facility in Aurora, CO. During the review, the team detailed its architecture and software requirements for GPS OCX, which will deliver the advanced control segment designed to provide secure, accurate and reliable navigation and timing information to military, commercial and civil users. Raytheon is the prime contractor for the $886 M program.

"We are extremely pleased with the outcome of this important review," said Bob Canty, Raytheon Vice President and GPS OCX Program Manager. "The successful software specification review sets the foundation for the preliminary design review scheduled for spring 2011 and is an indicator of the maturity of the software and interface requirements and the operational concept for GPS OCX." The software specification review is the culmination of several analyses: the architecture; OPSCON (Operations Concept); segment, prime mis-

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sion and interface requirements; and allocation to the software requirements specifications, interface requirements specifications and operational concept document.

The Counter-IED Market 2010-2020: System and Technology for Force Protection

Improvised explosive devices (IED) have been brutally effective weapons for insurgents in Iraq and Afghanistan, and increasingly, in other parts of the world. IEDs have been blamed for thousands of deaths of military personnel and also civilians. The US and its allies have responded to the IED threat by spending billions of dollars on vehicles, equipment, personnel and training for counter-IED and explosive ordnance disposal (EOD) missions. This has provided very strong demand in recent years in the counter-IED systems market. Based on Visiongain's research, global spending on counter-IED systems amounted to $7.7 B in 2009.

However, demand is expected to decline from these high levels with the continuing US and allied withdrawal from Iraq and the imminent drawdown in Afghanistan. Visiongain finds a market in decline, albeit still retaining high value due to the central importance placed on countering IEDs.

The new report, *The Counter-IED Market 2010-2020: Systems and Technologies for Force Protection*, provides an analysis of the global market for mine-resistant vehicles, electronic countermeasures mainly in jammers, IED detection equipment and unmanned systems purposely designed for counter-IED. This report examines corporate announcements and news accounts, policy documents, reports of relevant contracts and original expert views from industry, to analyze how the counter-IED systems market will develop during the period 2010 to 2020.

> *...global spending on counter-IED systems amounted to $7.7 B in 2009.*

Although many systems have already been acquired, countries are expected to continue making spending on counter-IED systems a priority in the context of tighter defense spending in general.

The US has by far spent the most in counter-IED systems as it was an urgent and vital part of force protection mainly in Iraq but currently and in the near future, in Afghanistan where US operations have escalated with a surge of tens of thousands of new troops. Major Western-allied powers like the UK, Canada and Australia have followed suit in investing heavily in counter-IED systems. Countries like India, which faces its own insurgent groups who have reportedly taken to using more IEDs, is also likely to become a key market in the future.


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Richard Mumford, International Editor

ITU Selects Next-generation 4G Mobile Technologies

ITU's Radiocommunication Sector (ITU-R) has completed the assessment of six candidate submissions for the global 4G mobile wireless broadband technology, otherwise known as IMT-Advanced. Harmonization among these proposals has resulted in two technologies, LTE-Advanced and WirelessMAN-Advanced, being accorded the official designation of IMT-Advanced, qualifying them as true 4G technologies.

IMT-Advanced (4G) provides a global platform on which to build the next-generations of interactive mobile services…

IMT-Advanced (4G) provides a global platform on which to build the next-generations of interactive mobile services that will provide faster data access, enhanced roaming capabilities, unified messaging and broadband multimedia.

In its recent meeting in Chongqing, China, ITU-R Working Party 5D, which is charged with defining the IMT-Advanced global 4G technologies, decided on these technologies for the first release of IMT-Advanced. In the ITU-R Report the LTE-Advanced and WirelessMAN-Advanced technologies were each determined to have successfully met all of the criteria established by ITU-R for the first release of IMT-Advanced.

ETSI Takes Lead Role in M2M Standardisation

Machine-to-Machine (M2M) communications need standards—and the European Telecommunications Standards Institute (ETSI) is taking the lead to make sure that the standards are in place—was the main conclusion from the recent ETSI M2M workshop. Reflecting the enormous potential that is foreseen for M2M applications and technologies, it was the most popular ETSI workshop to date with over 220 attendees from across the world.

…many network operators are encouraging a first release of M2M standards by early 2011.

Among the speakers and delegates were representatives from the world's major telecommunication manufacturers and network operators, security companies, utilities, regulators, universities and research institutes. The workshop presented the current status of Machine-to-Machine standards work, both in ETSI and in other standards bodies, and examined how M2M capabilities will be a stepping stone toward the 'Internet of Things'.

Participants heard how existing and evolving communication technologies networks, mostly wireless (cellular and low-power), but also fixed networks, including power line communications, provide a firm basis for connecting M2M sensors and applications. Specification of appropriate interfaces that allow network technology neutrality is a priority, and one that ETSI is already addressing.

The workshop included two live demonstrations organised by InterDigital Inc. These demonstrated an M2M gateway and core network, and an M2M Wireless Personal Area Network (sensors connecting via low-power wireless devices to a database, simulating e-Health, home automation and security application scenarios). The implementations were based on current specifications from ETSI's M2M Technical Committee and confirmed both the effectiveness of the implications and of the ETSI specifications.

The standards work of ETSI's M2M Technical Committee is reaching an advanced stage, and many network operators are encouraging a first release of M2M standards by early 2011. The committee is currently finalising the architecture for the service platform that will enable the integration of multiple vertical M2M applications. The workshop confirmed that ETSI is well placed to address a vital aspect of standardisation in support of M2M, the specification of interfaces that will facilitate the interconnection and interoperability of the diverse applications and of the networks that will underlie them.

SEPIA Project Will Colour Mobile Device Security Standards

Five partners from industry and academia have joined forces in the Secure Embedded Platform with advanced Process Isolation and Anonymity capabilities (SEPIA) European research project, to define security standards for next generation mobile devices, including high-end cell phones and tablet devices. SEPIA brings together ARM, Brightsight, Giesecke & Devrient (G&D) and Infineon Technologies, and is coordinated by Graz University of Technology (Austria).

SEPIA… supports Europe's foothold as a leading innovator in the sphere of mobile technology...

As financial services, such as banking and payment, become increasingly accessed from mobile devices, it becomes critical to provide secure, certified cell-phone platforms to ensure such sensitive applications are efficiently protected from security threats.

From a technical viewpoint, the SEPIA project will be based on a mobile platform combining ARM® TrustZone® technology, which creates a protected area in advanced

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systems-on-chip, and the high-security MobiCore© operating system developed by G&D. The interplay between TrustZone and MobiCore ensures that if online services incorporate security sensitive functions it is not possible for malware on the phone to manipulate username and password entries via the keypad or data output on the display.

Infineon is contributing next-generation technology to allow secure storage of user credentials and passwords, while Brightsight will develop novel and cost-effective certification methods that allow mobile platforms to be certified incrementally. The Institute for Applied Information Processing and Communications (IAIK) of Graz University of Technology is responsible for the scientific aspects of the project, including techniques to preserve anonymity and the development of security mechanisms for future cell phone processors.

The SEPIA project receives funding from the European Union's FP7 scheme. It supports Europe's foothold as a leading innovator in the sphere of mobile technology and will make it easier to establish cross-platform, common security concepts and reduce time-to-market.

UK Engineering and Technology Centre Opens

The Engineering Technology Centre (ETC), specialising in pioneering technology to address global challenges such as health and security, has opened. The ETC, part of the STFC, helps businesses, industry and academia find cost-effective solutions to complex and often unique technical challenges, from accelerator technology for medical applications to custom made technology for airport security systems, each bringing valuable investment to the UK economy.

The ETC…helps businesses, industry and academia find cost-effective solutions…

The ETC is based at two UK locations, the Daresbury Science and Innovation Campus in Cheshire and the Harwell Science and Innovation Campus in Oxfordshire, where highly skilled ETC staff use some of the world's leading science and engineering facilities for large and small scale projects.

The Centre offers a 'one stop shop' approach providing a range of expertise and engineering systems, from project management and feasibility studies through conceptual design and simulation to prototyping, manufacturing, installation and commissioning. These involve capabilities in mechanical design and analysis, vacuum technology, cryogenics, computer controlled machining, advanced metrology, electrical systems integration and intelligent control systems.

Dan Massé, Associate Technical Editor

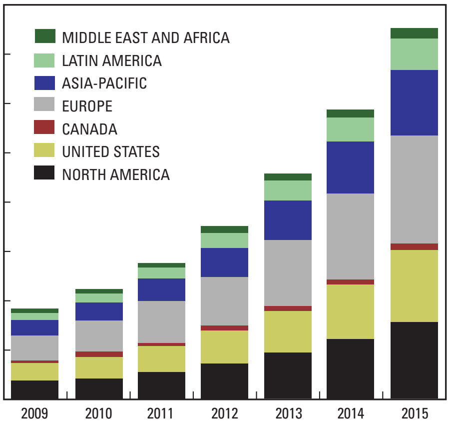
Market Watch

In the growing field of medical microwave ablation procedures, the development of better applicators can overshadow the microwave power generation development and result in the system development work being subcontracted, which can result in large development costs. To provide customers with a complete, fully functional and 60601 approved solution, Emblation Microwave has developed the MSYS245 microwave generator, one of the smallest and most efficient microwave systems. The compact solution, weighing less than 10 lbs. and about the size of a ream of paper, has a broad range of surgical applications, including microwave hyperthermia therapy, diathermy, microwave coagulation therapy, and soft tissue ablation. To compliment the advancements in percutaneous technologies for soft tissue and tumor ablation in the field of oncology, e.g. lung ablation and liver ablation, the microwave generator is a small and ultra-portable replacement technology for RF ablation treatments and magnetron-based microwave systems. This generator produces an efficient 2.45 GHz microwave system capable of generating variable power in excess of 100 W with excellent reflection measurement capability and temperature stability. The system has the ability to measure reflected power accuracy to a new level independent of the effects caused by applicator match and phase. Please visit www.emblationmicrowave.com for more information.

Cellular M2M Connections Will Show Steady Growth to 2015

Cellular M2M (machine-to-machine) connections continue to show steady growth, and are expected to exceed 297 million in 2015. In the latest update to ABI Research's forecasts, the 2009 forecast of about 225 million connections by 2014 has also been raised to 232.5 million.

**TOTAL CELLULAR M2M CONNECTIONS BY REGION
WORLD MARKET FORECAST 2009–2015**



Source: ABI Research

Within this worldwide picture, however, are many regional differences. Europe continues to account for the largest regional share with 110 million connections in 2015; North America will rank second with 79 million and the Asia-Pacific region third with almost 66 million.

The European market is the most diversified and has the most mature deployments. The EU benefits from regulatory mandates surrounding eCall and smart energy. In North America, the focus has traditionally been more on telematics, although M2M is now growing strongly in other areas including smart energy. Both telematics and energy are providing impetus in Asia-Pac, but the markets are less mature, outside of key countries such as Japan.

To learn more about the cellular M2M connectivity services market and how it may affect business models now and in the future, ABI has developed "Cellular M2M Connectivity Services," which discusses these market trends, analyzes cellular M2M connectivity service provider strategic responses, and forecasts cellular M2M connections and revenue growth for the period from 2007 through 2015.

Sioux Valley Energy Deploys Full Spectrum Private Mobile Broadband Data Solution

Sioux Valley Energy is deploying Full Spectrum's FullMAX Mobile Broadband System for its private wide-area mission critical mobile data needs. The FullMAX system, based on the worldwide Mobile WiMAX standard, is used for a variety of energy related mobile workforce management applications, including real-time work order and outage management, automatic vehicle location (AVL), remote GIS database and e-mail access.

FullMAX is the only 4^{th} generation mobile broadband system designed for operation in all VHF/UHF frequencies. A single FullMAX base station can provide coverage up to 20 miles from a tower site making it one of the only cost-effective private broadband mobile data solutions.

FullMAX is the only 4^{th} generation mobile broadband system designed for operation in all VHF/UHF frequencies.

Sioux Valley Energy's deployment of the FullMAX system will use licensed IVDS frequencies it has already acquired in the lower VHF band. Sioux Valley intends to expand the service to areas beyond its own service territory, including offering private smart grid mobile and fixed wireless connectivity to utilities in Sioux Falls and Rapid City, South Dakota.

"The smart grid goes beyond adding intelligence to the meter at the home and along transmission and distribution lines. It also means providing our remote workers with the most advanced troubleshooting tools for rapid outage restoration," said Joel Brick, Telecommunications Director for Sioux Valley Energy. "Our employees need to cover

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both our residential and business customers as well as the remote grid assets. Commercial wireless services focus almost entirely on population centers and lack the redundancy for mission critical operations."

AHAM Issues Assessment of Communications Protocols for Smart Grid Enabled Appliances

The Association of Home Appliance Manufacturers (AHAM) recently announced the findings of the home appliance industry's technical evaluation of communications protocols for smart grid enabled home appliances. The results of the evaluation can be found in a newly released Assessment of Communication Standards for Smart Appliances.

The results of the latest report are based on a technical evaluation of numerous existing technologies designed for the Application (APP), Network (NET) and Media (MAC, PHY) layers of communications protocols. Each technology was evaluated against a set of consumer requirements, as identified by participating AHAM members, and ranked using a requirement driven scoring system by an independent consultant on the ability of the technology to meet the unique needs of appliance consumers.

According to the Assessment's results, the most relevant communications technologies were clearly separated from their peers for use in smart grid appliance applications. For the Application layer, SEP 2.0 and OpenADR scored the highest. Across the physical, media and network layers evaluated, Wi-Fi, ZigBee and HomePlug Green PHY scored the highest. Further, in addition to the evaluation of the existing technologies, the Assessment presents a clear position by the home appliance industry that the preferable communications architecture at this time features a hub that can communicate using common protocols and serve as the bridge to other devices on the Home Area Network (HAN).

Across the physical, media and network layers evaluated, Wi-Fi, ZigBee and HomePlug Green PHY scored the highest.

This Assessment was developed to address the four communication parameters, namely an open, flexible, secure and limited in number set of communication standards, outlined in AHAM's previous White Paper titled, "The Home Appliance Industry's Principles & Requirements for Achieving a Widely Accepted Smart Grid," released in December 2009. The Assessment of Communication Standards for Smart Appliances can be downloaded for free at www.aham.org/smartgrid.

Around the Circuit

Jennifer DiMarco, Staff Editor

INDUSTRY NEWS

Richardson Electronics Ltd. announced the signing of a definitive agreement to sell its RF, Wireless and Power Division (RFPD) and certain other assets to **Arrow Electronics Inc.** for $210 M in cash. RFPD is a provider of engineered solutions and a distributor of electronic components to the RF and wireless communications market and the industrial power conversion market. RFPD designs, manufactures and distributes discrete devices, components, and assemblies used in RF and wireless infrastructure communications networks, digital broadcasting, defense applications and power conversion. RFPD generated revenue of $356 M during fiscal year 2010. Arrow intends to operate RFPD, which will be called "Richardson RFPD," as a separate business unit of Arrow Electronics. Richardson RFPD headquarters will remain in LaFox, IL.

Silicon Laboratories Inc. announced the acquisition of Ireland-based **ChipSensors Ltd.**, an early stage technology company creating innovative single-chip CMOS sensors designed to detect temperature, humidity and gases. ChipSensors' technology complements Silicon Labs' touch, proximity sensing and recently acquired MEMS technology, expanding the company's capabilities in CMOS-based sensors.

DragonWave Inc. announced its acquisition of **Axerra Networks Inc.** Axerra is well known in the mobile network industry as a leader in pseudowire technology and has a product portfolio that allows carriers to address the increasing need to carry legacy TDM traffic over a packet-based network. Axerra's industry leading portfolio of pseudowire products will strengthen and complement DragonWave's packet microwave products.

Maxtek Components Corp., a Tektronix company, announced that it will now be known as **Tektronix Component Solutions**. Leveraging one of the technology world's most trusted brands in test instrumentation, this name change reflects the customer's increased access to core capabilities and high performance technologies developed by Tektronix Component Solutions in support of its parent company, Tektronix.

Harris Corp. and **ITT Corp.** are collaborating to accelerate the fielding of the Soldier Radio Waveform, a central piece of the US Department of Defense vision for a networked digital battlefield. Harris and ITT have successfully exchanged voice and data between the Harris Falcon III® AN/PRC-117G manpack and ITT's Soldier Radio development model using the specified SRW Version 1.01.1C. This is the first time that independently developed tactical radios have interoperated using open-standard wideband JTRS technology. Both the AN/PRC-117G and ITT's Soldier Radio were developed under the JTRS Enterprise Business Model, which is designed to spur innovation in tactical communications. Harris's rapid implementation demonstrates the portability of SRW.

CapRock Government Solutions announced that it has partnered with **Tampa Microwave**, a provider of innovative remote terminal solutions, to deliver complete end-to-end man-packable military-grade satellite communications solutions. The agreement enables CapRock to provide government and military users deployed in remote areas of operation with a lightweight, portable man-pack satcom solution that easily connects to CapRock's CommandAccess™ network.

Planar Monolithics Industries and **Amplitech** announced the collaboration of their combined product offering, engineering skills and marketing efforts. The companies will retain independent and independently run the administrative and production facilities, but will share a combined manufacturer's representative sales force, marketing effort and will direct future engineering requirements to the facility best suited to achieve a particular customer's requirement. This collaborative effort takes advantage of the unique skills and offerings of each company independently, culminating in demonstrable best-of-breed microwave system integration and designs for the benefit of end users and customers.

Symmetricom® Inc., a leader in precise time and frequency technologies, announced that it has partnered with **Wintegra** to deliver a cost-effective, high performance, versatile and power-efficient reference design for customers requiring IEEE 1588 (Precision Time Protocol) compliant products. The reference design combines Symmetricom's SCi 2000 Embedded Software Clock with Wintegra's WinPath3 platform. This combination enables customers to implement IEEE 1588 in wireless base stations and other network elements in an affordable, portable manner without the need for dedicated silicon.

Skyworks Solutions Inc. announced that it has opened an office in Singapore (Skyworks Global Pte Ltd.) to support increasing demand for solutions within its linear products portfolio and to further enhance its manufacturing activities in the region.

Apollo Microwaves, a supplier of passive microwave components and subsystems, announced that it has moved into a new 60,000 square foot, fully integrated facility near Montreal, Quebec. The new premises are 240 percent larger than Apollo's previous location. All of the nearly 150 employees will be housed under one roof. The move into a new facility was spurred by the need to increase production capacity to satisfy customer requirements for quick deliveries. The new facility provides much needed space for Apollo's new equipment acquisitions—additional high precision, flexible machining centers—which increase manufacturing capacity by 200 percent, and are scheduled to be fully operational in late 2010.

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SYNERGY® MICROWAVE CORPORATION

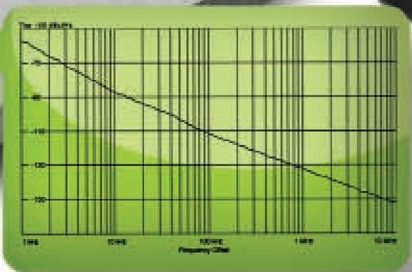
MINIATURE FOOTPRINT VCO'S

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 0.1
DCO6080-3	600 - 800	0 - 3	+3 @ 15 mA	-105	0.3 x 0.3 x 0.1
DCO7075-3	700 - 750	0.5 - 3	+3 @ 12 mA	-108	0.3 x 0.3 x 0.1
DCO80100-5	800 - 1000	0.5 - 8	+5 @ 26 mA	-111	0.3 x 0.3 x 0.1
DCO8190-5	810 - 900	0.5 - 16	+5 @ 34 mA	-118	0.3 x 0.3 x 0.1
DCO100200-5	1000 - 2000	0.5 - 24	+5 @ 36 mA	-95	0.3 x 0.3 x 0.1
DCO1198-8	1195 - 1205	0.5 - 8	+8 @ 30 mA	-115	0.3 x 0.3 x 0.1
DCO170340-5	1700 - 3400	0.5 - 24	+5 @ 29 mA	-90	0.3 x 0.3 x 0.1
DCO200400-5 DCO200400-3	2000 - 4000	0.5 - 18	+5 @ 46 mA +3 @ 46 mA	-90 -89	0.3 x 0.3 x 0.1
DCO300600-5 DCO300600-3	3000 - 6000	0.5 - 18	+5 @ 35 mA +3 @ 35 mA	-80 -78	0.3 x 0.3 x 0.1
DCO400800-5 DCO400800-3	4000 - 8000	0.5 - 18	+5 @ 20 mA +3 @ 20 mA	-78 -76	0.3 x 0.3 x 0.1
DCO432493-5 DCO432493-3	4325 - 4950	0.5 - 11	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 0.1
DCO473542-5 DCO473542-3	4730 - 5420	0.5 - 22	+5 @ 20 mA +3 @ 20 mA	-88 -86	0.3 x 0.3 x 0.1
DCO490517-5 DCO490517-3	4900 - 5175	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 0.1
DCO495550-5 DCO495550-3	4950 - 5500	0.5 - 12	+5 @ 22 mA +3 @ 22 mA	-83 -85	0.3 x 0.3 x 0.1
DCO579582-5	5780 - 5880	0.5 - 10	+5 @ 20 mA	-90	0.3 x 0.3 x 0.1
DCO608634-5 DCO608634-3	6080 - 6340	0.5 - 5	+5 @ 20 mA +3 @ 26 mA	-85 -86	0.3 x 0.3 x 0.1
DCO615712-5 DCO615712-3	6150 - 7120	0.5 - 18	+5 @ 22 mA +3 @ 22 mA	-85 -83	0.3 x 0.3 x 0.1

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 0.1
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 0.1
DXO10701095-5	10.70 - 10.95	0.5 - 15	+5 @ 25 mA	-82	0.3 x 0.3 x 0.1
DXO11441200-5	11.44 - 12.0	0.5 - 15	+5 @ 30 mA	-82	0.3 x 0.3 x 0.1
DXO11751220-5	11.75 - 12.2	0.5 - 15	+5 @ 30 mA	-80	0.3 x 0.3 x 0.1

Features

- Exceptional Phase Noise
- Dimensions: 0.3" x 0.3" x 0.1"
- Excellent Tuning Linearity
- Models Available from 4 to 12 GHz
- High Immunity To Phase Hits
- Lead Free RoHS Compliant
- Patented Technology



For additional information, contact Synergy's sales and application team.

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RoHS COMPLIANT

NDK (Nihon Dempa Kogyo Co. Ltd.) announced the opening of a new sales engineering and customer support office in northern California. **NDK America-Silicon Valley** is located at 1551 McCarthy Boulevard, Suite 202, Milpitas, CA 95035. The company can be reached by phone at (408) 428-0800, fax (408) 428-0801 or e-mail sales@ndkxtal.com.

Cobham Sensor Systems, a GaAs MMIC supplier, has completed the requalification of its new, state-of-the-art manufacturing facility in Blacksburg, VA. The relocation of its manufacturing and design facilities from Roanoke to Blacksburg began in February and culminated in October with the successful completion of key reliability and qualification tests on the MMIC processes and products. The qualification results verify that the company has successfully replicated its proprietary MMIC technology at the Blacksburg site and is prepared to restart volume production of GaAs MMICs for key aerospace and defense programs.

Paciwave Inc., a supplier of microwave components and custom integrated microwave assemblies for the military market, announced that it has relocated from its existing facility into a newer and larger facility in order to facilitate company growth. The new 15,000 square foot facility, located at 1286 Hammerwood Avenue in Sunnyvale, CA, includes a 2500 square foot Class 1000 clean-room. Products to be manufactured in the new facility include solid-state switches, attenuators, limiters, DLVAs, switch matrices and filter banks, and custom integrated microwave assemblies such as tuners, receivers, T/R modules, frequency converters and RF sources, operating between 100 MHz and 40 GHz.

Restor Metrology provides test equipment calibration and repair services to companies in Florida and across the US. Their capabilities include RF and microwave to 50 GHz, EMI/EMC (CISPR 16 compliant calibration for EMI receivers, CDNs, LISN), general purpose electrical, mechanical, physical/dimensional and fiber optics. Restor Metrology has announced that they have achieved A2LA accreditation for the new Z540.3 standard.

PCTEST Engineering Laboratory, an accredited laboratory in Columbia, MD, is fully operational and testing LTE UEs utilizing the **Rohde & Schwarz** TS8980FTA. Scope of testing includes LTE RF, RRM and Protocol Conformance as well as operator test plans covering all aspects of LTE and LTE-CDMA InterRAT operation.

Astrolab President, Stephen Toma, was presented the SHARP award from NJ Commissioner of Labor and Workforce, Harold J. Wirths. Commissioner Wirths commended the management and workers of Astrolab Inc. for their successful and cooperative commitment to workplace safety and presented the company's safety team with the prestigious Occupational Safety and Health Administration (OSHA) SHARP award. Astrolab is one of only 16 companies in New Jersey that received this nationally recognized award for safety and health in the workplace. The award ceremony was held in Warren, NJ, and included a celebration commemorating Astrolab's 49 years in business.

Rice University research that capitalizes on the wide-ranging capabilities of graphene could lead to circuit applications that are far more compact and versatile than what is now feasible with silicon-based technologies. Triple-mode, single-transistor amplifiers based on graphene—the one-atom-thick form of carbon that recently won its discoverers a Nobel Prize—could become key components in future electronic circuits. The discovery by Rice researchers was recently reported in the online journal ACS Nano.

OBITUARY

Bob Burke, a sales, marketing and business development professional with over 20 years of experience in RF and microwave products, passed away on October 27th. Burke was a graduate of Merrimack College ('82) and Rivier College ('88). At various points in his career, he represented M/A-COM, TRU Corp. and Richardson Electronics, providing expertise in microwave interconnects, components and cable assemblies for defense, aerospace and semiconductor applications. Burke was "an excellent customer oriented engineer with a ready grasp of business opportunities in solving customer problems/needs," according to a former co-worker.

CONTRACTS

TASC Inc. has been awarded a 10-year contract worth up to $827.8 M for National Airspace System (NAS) support services that will enable the FAA to accomplish a smooth and successful transition to NextGen, a satellite-based network that will replace the US radar-based air traffic control system.

Agilent Technologies Inc. announced that it has been awarded a $35 M contract by the US Army. Under the terms of the contract, Agilent will deliver up to 1,600 MXG microwave analog signal generators over seven years, to the Army as part of its Test Equipment Modernization (TEMOD) program.

Wavestream Corp. announced it has received a $19 M purchase order from **General Dynamics SATCOM Technologies** for the company's high power 50 W Ka-band solid-state amplifiers to support US Army and Marine Corps satellite communications systems. Product deliveries are scheduled starting in October 2010.

Crane Aerospace & Electronics, Power Solutions, was awarded by the US Department of Defense, a $7.9 M contract for repair, upgrade and new manufacture of high-voltage power supplies and high-voltage distribution units for the AN/SLQ-32(V) electronic warfare system. Under the contract, Power Solutions will work closely with the Naval Surface Warfare Center, Crane, IN. These products are designed to drive multiple traveling wave tubes for jamming oncoming missile threats. The production is scheduled to begin January 2011 in Fort Walton Beach, FL.

TECOM Industries Inc. announced a Firm Fixed Price Indefinite Delivery Indefinite Quantity (IDIQ) contract award from the Defense Logistics Agency. The contract calls for TECOM to supply the Compass Sail antenna in support of electronic warfare missions on various military aircraft. The contract is for a base year with a two-year option and is valued at up to $3.5 M.

Comtech Telecommunications Corp. announced that its Tempe, Arizona-based subsidiary, **Comtech EF Data Corp.**, won a $3.2 M order for satellite communications equipment from the United States government. The equipment will be utilized to upgrade fielded satellite terminals that support tactical military communications.

TriQuint Semiconductor Inc. has received a $2 M contract from the US Naval Research Laboratory (NRL) to develop S-band amplifiers with new benchmarks for noise floor, linearity and efficiency performance.

RF Micro Devices (RFMD) announced that it has been awarded a $1.5 M R&D contract by the Office of Naval Research (ONR) related to gallium nitride (GaN) microelectronics, including the development of materials, device fabrication and high power circuits. The $1.5 M R&D contract award expands RFMD's contract backlog over the next six quarters to approximately $5 M. Since calendar 2004, RFMD has been awarded over $14.5 M in R&D contracts by the US Government for development of its GaN high power RF technology.

ITS Electronics Inc. has been selected by **General Dynamics** SATCOM Technologies to supply Ka-band solid-state power amplifiers (SSPA) with integrated Block Up Converters (BUC) for the company's SATCOM-on-the-Move™ (SOTM™) terminals.

REP APPOINTMENTS

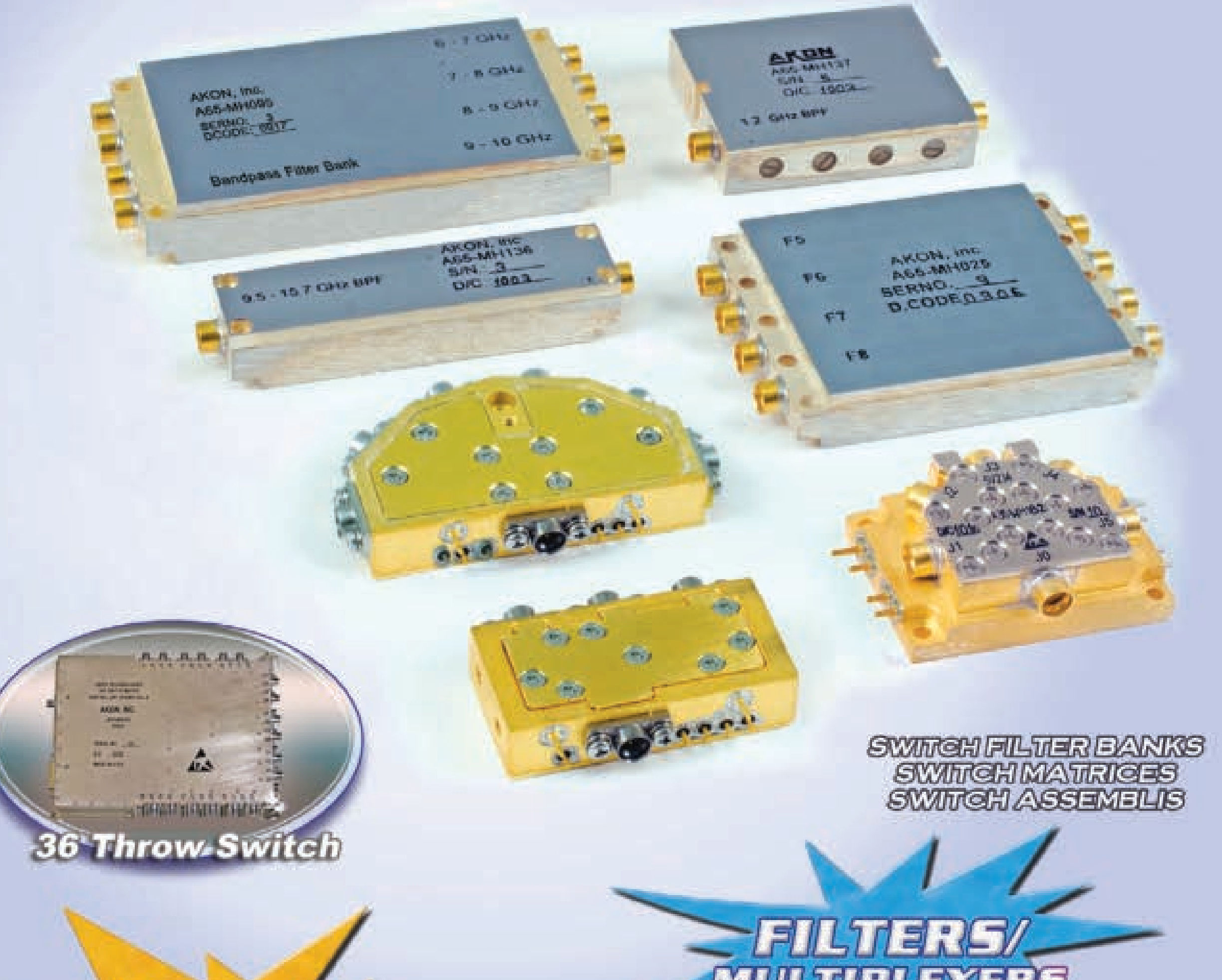
Tektronix Inc. announced new agreements with **Allied Electronics**, **Entest** and **TestEquity**, giving US customers the choice of working with these leading electronic component and test instrumentation distributors who now will offer the full line of Tektronix test instrumentation. These three distribution partners provide an additional 500+ sales engineers who will now be authorized to offer Tektronix higher performance oscilloscopes, signal generators, spectrum analyzers, logic analyzers and bit error rate testers.

Anaren Inc. announced that **Avnet Electronics Marketing Americas** (EMA), a business region of Avnet Inc., will now carry Anaren's new family of Anaren Integrated Radio (AIR) modules in the Americas.

Wireless Telecom Group (WTG) has signed a service agreement with **Electroservices (Midlands) Ltd.**, Telford, UK, to become a fully authorized Wireless Telecom Service center for the EMEA region. With a staff of more than 60, 35 of which are highly experienced engineers, Electroservices is well equipped to guarantee the highest service standards for WTG customers.

Reactel Inc., a manufacturer of RF and microwave filters, multiplexers and multifunction assemblies to the commercial, military, industrial, and medical industries, announced the appointment of **Matrix Sales Inc.** as the company's exclusive representative in New England. For more information about Matrix Sales, please telephone Bill Brann at (508) 612-0007.

FILTERS AND SWITCHES
FOR SYSTEM CRITICAL APPLICATIONS



SWITCH FILTER BANKS
SWITCH MATRICES
SWITCH ASSEMBLIS

MINIATURE SWITCHES

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- SMA and GPO Connectors Options
- SPST to SP8T, to Custom Multi-throw
- 50 Nanoseconds Switching Time (typical)
- Reflective or Absorptive
- Isolation Greater than 60 dB
- Custom Switch Configurations & Assemblies

FILTERS/ MULTIPLEXERS

-Lumped Element Filters
10 MHz to 25 GHz
Bandwidth 1% to 200%
High Selectivity
Group Delay Equalized
Small Size
High Reliability

- Combline & Interdigital Filters
100 MHz to 40 GHz
Bandwidth of 1% to 66%
Low Loss
Small Size and Weight
High Power Handling

-Waveguide Filters
2 GHz – 40 GHz Frequency Range
Bandpass, Lowpass & Notch Configuration
Lowest Loss
High Power Applications

-Switched Filterbanks
10 MHz to 26 GHz
Standard switch filters or custom designs
2 to 16 Channels
Typical switching speed 50 nSec
Use GaAs MMIC or discrete diodes
Integrated with suspended substrate lumped element, combline, printed microstrip filter technology.

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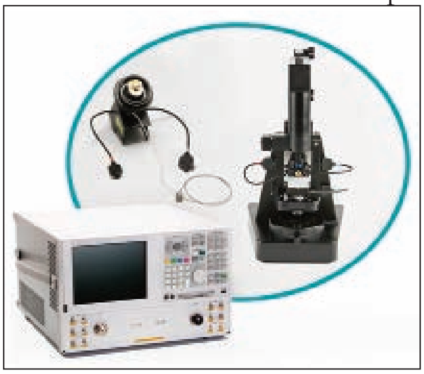
AFM-VNA TECHNIQUE ENABLES COMPOUND, CALIBRATED ELECTRICAL AND SPATIAL MEASUREMENTS AT NANOSCALE

Measuring electromagnetic properties of materials can provide insight into applications in many areas of science and technology. Increasingly, these properties need to be evaluated at the nanometer scale. Since electromagnetic properties, such as the dielectric constant, are ultimately related to a material's molecular structure, correlating the detailed physical structure of a material with its electromagnetic properties is frequently more valuable than the knowledge of either alone.

Developed by Agilent Technologies, scanning microwave microscopy (SMM) is a technique that combines the compound, calibrated electrical measurement capabilities of a microwave vector network analyzer (VNA) with the nanoscale spatial resolution and angstrom-scale positioning of an atomic force microscope (AFM) (see ***Figure 1***). This unique method allows the measurement of highly localized capacitance, dopant density, charge distribution and dielectric properties on a broad variety of samples, thus offering the semiconductor industry a host of new application possibilities.



▲ *Fig. 1 Scanning microwave microscopy system.*

SMM outperforms traditional AFM-based scanning capacitance microscopy techniques by providing higher sensitivity and dynamic range, the ability to acquire quantitative results, and greater application versatility. SMM works on all classes of semiconductors: Si, Ge, III-V (such as GaAs, InAs, GaN) and II-VI (such as CdTe, ZnSe). Unlike traditional scanning capacitance microscopy, it does not require an oxide layer.

SMM can also be used on dielectric materials, ferroelectric materials, insulators and biological materials to measure properties associated with small variations in the electromagnetic interactions of a sample's different components with the incident microwave signal, either statically or dynamically. Data from representative samples demonstrate that SMM is capable of mapping material properties at a resolution ultimately limited by the sharpness of the AFM probe.

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THE ROLE OF THE VNA

The vector network analyzer utilized to perform SMM is a state-of-the-art characterization instrument that makes extremely accurate, calibrated measurements of complex-valued ratios on electromagnetic signals. The ratios are R = reflected signal/incident signal and T = transmitted signal/incident signal.

The incident signal is generated and controlled inside the VNA; as a result, the ratios R and T are not merely relative, but referenced to the well-known, accurately quantified incident signal. This measurement capability, delivered to the apex of an AFM tip, enables calibrated, traceable measurements of electrical properties such as impedance and capacitance.

The VNA is a stimulus-response instrument, optimized for accurate and repeatable measurement of the response of a network or a device under test (DUT) to a known stimulus signal. This is in contradistinction to instruments, such as the spectrum analyzer, which are usually configured simply as a receiver of an unknown signal and which do not include a source for a stimulus to be applied to the DUT.

The VNA has two operational modes: transmission and reflection. In the reflection (alternatively, transmission) mode, the VNA measures the magnitude and phase characteristics of the DUT by comparing the signal that reflects off (alternatively, transmits through) the device with the stimulus signal. Each of the two modes enables measurement of several useful parameters. For instance, in the reflection mode, the VNA can measure the impedance of the DUT (such as the total resistance that a DUT presents to the flow of an AC signal at a given frequency).

SCANNING IMPEDANCE MICROSCOPY

One of the most common applications of network analysis is measuring the impedance of a component, so as to evaluate if it matches the impedance of the other components with which it must interface in a network. In SMM, the reflection mode of the VNA is used for measuring the impedance of a "network" that includes the tip-sample interface. Here, the DUT for the VNA consists of the AFM probe and the region of the sample immediately beneath the metal AFM tip. The incident microwave signal travels through a series of components before it reaches the tip-sample interface by means of a transmission line. The impedance mismatch between the transmission line and the DUT causes the incident microwave signal to partially reflect from the tip-sample interface back towards the stimulus signal source inside the VNA; this reflected signal is proportional to the impedance mismatch. The incident microwave signal and the reflected microwave signal together contain information about the impedance of the DUT.

Impedance can actually be measured in three different ways with a VNA, according to the frequency and the magnitudes involved. The reflection method of measuring impedance is the one that works best at microwave frequencies and for impedance values at or near the characteristic impedance of transmission lines (50 or 75 Ω). The accuracy of a VNA impedance measurement diminishes, however, as the impedance values move away from these characteristic values.

SMM's VNA-based impedance measurement technique is a simple yet effective scheme that brings the instrument's reflection-mode measurement capabilities to bear upon solving the problem of measuring with a very high resolution the small changes of a very small impedance (capacitance), that is that of the MOS capacitor (AFM tip/semiconductor) to the RF ground.

The magnitude of the complex-valued reflection coefficient S_{11} changes with both the load impedance Z_L and the source impedance Z_S (internal to the VNA) as follows:

$$S_{11} = (Z_L - Z_S) / (Z_L + Z_S) \qquad (1)$$

The complex-valued reflection coefficient S_{11} is one of four scattering parameters (S-parameters) that are used to characterize the response of a DUT at high frequencies in a way consistent with transmission line theory. All four S-parameters are ratios of voltage traveling waves entering and exiting the DUT. When the value of Z_L is close to that of Z_S, the plot has the steepest slope, which corresponds to the highest sensitivity and the highest resolution. Z_S is 50 Ω, but Z_L is generally not near this value.

In order to bring the value of Z_L closer to that of Z_S and therefore exploit the VNA's impedance measurement capability in its most accurate and sensitive range, SMM uses a half-wavelength impedance transformer to place the measurand, the DUT, directly across an external 50 Ω impedance (that is parallel to it). In this way, SMM operates the VNA with the sensitivity and resolution required to measure capacitance changes on the order of 0.1 aF across a 0.1 fF base capacitance. Furthermore, this impedance transformation is done at a location that is physically remote from the tip-sample interface, thereby facilitating mechanical design implementation.

The results for this setup show that the VNA now operates with a resonant structure as its load, thus enabling it to measure minute changes in the value of the capacitance-to-ground in the highest sensitivity range of the VNA.

SCANNING CAPACITANCE MICROSCOPY

One application of impedance measurement with SMM is scanning capacitance microscopy (SCM) of semiconductors. Measuring the capacitance-to-ground (C) of the tip-sample interface and its variation (dC/dV) with an applied AC bias ($V = V_0 \sin \omega t$) is an important extension of atomic force microscopy for the electrical characterization of semiconductors. It enables two-dimensional mapping of the carrier density across different regions of a semiconductor, with applications in the failure analysis, characterization, modeling and simulation of device performance, as well as in the development of the semiconductor fabrication process.

Traditionally, a resonant capacitive sensor-based SCM technique has been used to implement this type of AFM technique with some success. One of the main shortcomings of traditional SCM is the difficulty of making absolute measurements of the strength of the tip-sample electrical interaction; therefore, SCM images remain maps of the relative difference in carrier densities across the scanned

area. For this reason, accomplishing the much coveted task of using SCM to reliably and repeatably extract numerical estimates for carrier densities in semiconductor devices remains elusive.

The VNA hardware utilized in SMM includes precision components for the calibration and performance verification of the instrument, thereby extending its applications to those that require calibrated, traceable and absolute measurements of capacitance, for example.

CAPACITANCE CALIBRATION PROCESS

In order to achieve quantitative capacitance measurements, calibration samples were fabricated on a single-side polished Si wafer using customary deposition, etching and photolithographic procedures. These samples consist of a series of micro-capacitors that vary in lateral dimension and dielectric thickness. The calibration capacitance sample was developed as a parallel plate capacitor, with the SiO_2 dielectric sandwiched in between the plates. The two plates correspond to the gold caps (in electrical contact with the conductive AFM-tip), and the circular regions of silicon below the dielectric material.

For routine capacitance calibration, gold pads of 3 µm diameter were used. However, a second capacitance proportional only to the cap area, but not dependent on the thickness of the dielectric layer, had to be considered (abbreviated as C_{back} on the equation below). The two capacitors, C_{diel} and C_{back} are in series. The two capacitors in series result in the following model for the total measured capacitance C_{tot}:

$$\frac{1}{C_{tot}} = \frac{1}{C_{diel}} + \frac{1}{C_{back}}; C_{diel} = \frac{A\varepsilon}{d} \quad (2)$$

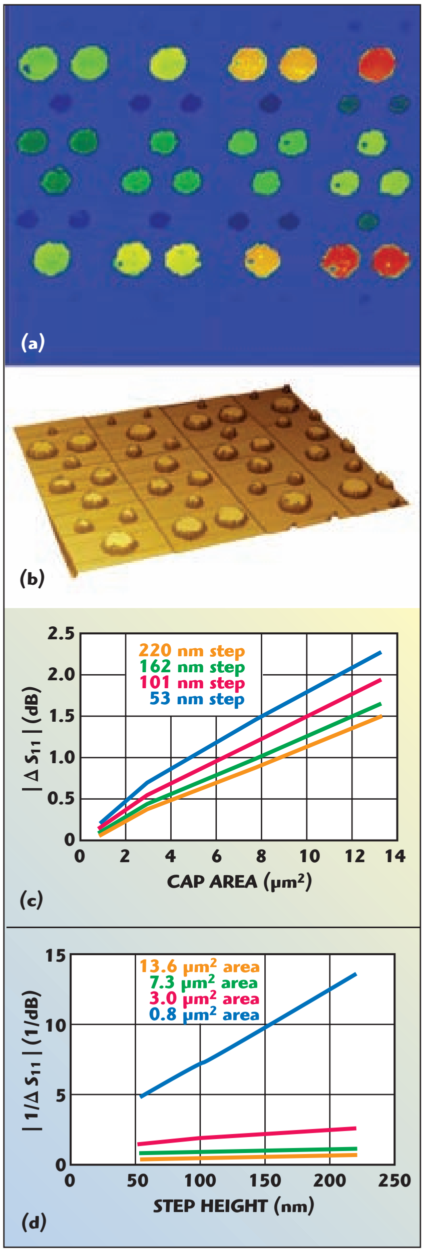
with C_{diel} being the capacitance of the SiO_2 capacitor, C_{back} the background capacitance, A the pad area, d the dielectric step height and ε the dielectric constant.

Scanning microwave microscopy's calibrated measurements and high-resolution imaging of capacitance-to-ground between an AFM tip and a semiconductor sample enables reliable, repeatable, extraction of numerical values of the carrier densities in a semiconductor. SMM typically operates at microwave frequencies of 2 to 16 GHz, which is substantially higher than the frequencies used in traditional SCM (approximately 900 MHz). The higher frequencies in SMM lead to better sensitivity and electrical resolution for measuring the tip-sample capacitance. SMM uses a lock-in amplifier for measuring the in-quadrature and in-phase components of dC/dV, allowing the determination of the polarity of the majority carriers in the semiconductor (see ***Figure 2***). Figure 2a shows the VNA amplitude image with a scan size of 60 × 60 µm. Figure 2b shows that a topographical image at the same scan size was simultaneously attained. For each gold pad, the $|\Delta S_{11}|$ amplitude value was determined and plotted versus the gold pad area, as shown in Figure 2c. The data is shown for the

four different steps of the dielectric staircase structure. A plot of the inverse amplitude $|1/\Delta S_{11}|$ with respect to the dielectric step height ranging from ≈ 50 nm to ≈ 200 nm is shown in Figure 2d.

THE ROLE OF THE AFM

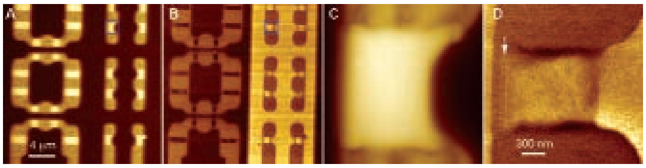
To take full advantage of the VNA-based measurement scheme, SMM incorporates several innovations into the AFM hardware. These include a sophisticated microwave shielding to improve the instrument's electromagnetic compatibility with its surroundings and minimize the effect of stray capacitances, which are inevitable with the probe's movement during raster scanning. The innovation of this design is implemented in such a way as to minimize the impact on the performance of the AFM scanner, where the cantilever holder attaches to the rest of the AFM.



▲ *Fig. 2 Reflection amplitude data on the 50 nm stepped sample acquired by VNA at 2 GHz.*

In SMM, the VNA sends an incident microwave signal through a diplexer microcircuit to a sub-7 nm conductive tip of a platinum-iridium cantilever. The AFM scans the tip over the sample and can move the tip to specific locations to perform point probing. SMM utilizes a multipurpose AFM scanner, either open- or closed-loop, capable of scanning areas up to 90 × 90 μm. When equipped with a 200 × 200 mm stage, samples up to 8" in diameter and 30 mm tall are easily accepted.

▲ *Fig. 3 SMM images of a doped SiGe device.*



▲ *Fig. 4 AFM topography and dC/dV images of SRAM.*

Custom software controls the data acquisition of all channels for SMM, including topography from the AFM controller, amplitude and phase of the reflection coefficient from the VNA, and the dC/dV components from the AC mode controller. The software saves all SMM data in 32 bit format to preserve the dynamic range of the data. ***Figure 3*** shows images of a doped SiGe device, acquired with scanning microwave microscopy. On the left is the topography, in the middle the capacitance, and on the right dC/dV.

SEMICONDUCTORS AND BEYOND

Scanning microwave microscopy is particularly useful for semiconductor test and characterization. Applications include highly localized measurements of impedance, capacitance and dielectric properties. The technique paves the way for extracting reliable numerical estimates of the carrier densities in semiconductors from the impedance (capacitance) data.

Exceptionally high electrical and spatial resolution also make SMM well suited to a wide range of biological and materials science applications, including the characterization of interfacial properties. As well as its ability to work on semiconductors, glasses, polymers, ceramics and metals, the technique lets researchers perform high-sensitivity investigations of ferroelectric, dielectric and PZT materials. Studies of organic films, membranes and biological samples can also benefit from the use of SMM. Its very high sensitivity (1.2 aF) is suited for looking at ion channels in cell membranes. It is anticipated that SMM-enabled nanoscale measurement capabilities will be expanded to include sweep frequency and spectroscopy volume in the near future. ***Figure 4*** shows the AFM topography (A and C) and dC/dV (B and D) images of SRAM.

C and D are zoom scans of one of the transistors in the n well marked in the blue square in A/B. A very fine line feature of 10 to 20 nm in width can be seen in the dC/dV image, as pointed in D, indicating high resolution capability of the scanning microwave microscope. ■

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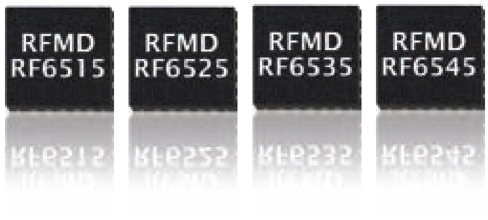

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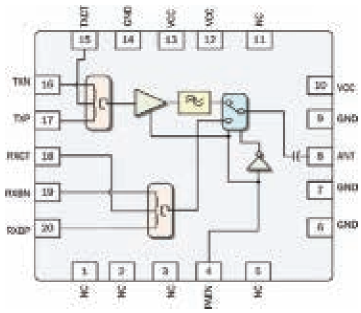
SPECIFICATIONS

Freq Range (Min) (MHz)	*Freq Range (Max) (MHz)*	*PA Gain (dB)*	*P_{OUT} (dBm)*	*OP1dB (dBm)*	*V_{CC} (V)*	*PA I_{CC} (mA)*	*LNA Gain (dB)*	*NF (dB)*	*LNA I_{CC} (mA)*	*Antenna Switch*	*Package (mm)*	*Part Number*
2400	2500	28.0	20.0	20.0	3.3	180	–	–	–	SP2T	QFN 3.5 x 3.5	RF6515
2400	2500	28.0	22.0	22.0	3.6	200	11.5	2.5	8	DPDT	QFN 3.5 x 3.5	RF6525
2400	2500	28.0	23.0	23.0	3.3	240	11.5	3.0	8	DPDT	QFN 3.5 x 3.5	RF6535
2400	2500	28.0	22.0	22.0	3.3	200	–	–	–	DPDT	QFN 3.5 x 3.5	RF6545

RF6515 block diagram



FEATURES

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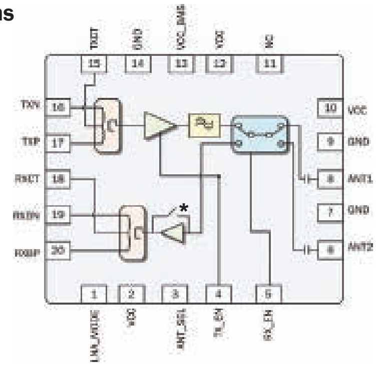
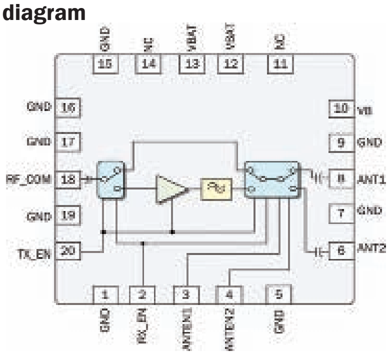
- Transmit gain: 28 dBm
- Integrated harmonic filter
- Highly integrated, small form factor
- High gain, low noise
- Designed for ZigBee® 802.15.4 based systems for remote monitoring and control, and other SmartEnergy/ISM band applications

RF6525 and RF6535 block diagrams



***RF6535 without LNA bypass**

RF6545 block diagram



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RF DRIVEN PLASMA LIGHTING: THE NEXT REVOLUTION IN LIGHT SOURCES

This article presents an overview of the relative merits of an innovation in the field of light sources, namely RF Lighting, with respect to incumbent technologies. The challenges this new light source poses for high-power RF Si LDMOS, the key enabling technology for delivering energy to this new light source, will also be discussed.

Lighting is about illuminating our world for a purpose. Whether it be for identification, recognition, beautification, accentuation, decoration, orientation, safety, security or ambience, the associated quest runs for ever more efficient, longer-lasting and sun-like light sources. Efficiency is reducing the amount of energy required to create certain amounts of light flux (lumen [lm]). Longevity strives to achieve maintenance-free, everlasting lighting systems. Finally, "sun-like" denotes the property of being a "white" light source, one that emits an almost continuous spectrum between 400 and 800 nm wavelengths—just like the sun. This kind of light also guarantees sun-like color rendition: all objects illuminated with a white source appear in their "natural" colors. This is in contrast to a source like the yellow/orange sodium vapor lamp, for example, which on the one hand has a very poor color rendition, but also provides the best currently achievable efficiency (155 lm/W).

The innovative RF lighting source combines several of the above-mentioned properties. It is bright (a small quartz bulb emits easily 10 to 20 klm), sun-like and effective in turning RF energy into light; typically 140 lm/W is achieved. The key technology to deliver the power to drive the RF Light (or Plasma Light) is based on laterally diffused metal oxide semiconductor (Si LDMOS) RF power transistors. These devices are typically used in cellular base stations or broadcast transmitters as final amplifier stages in the frequency range between a few MHz up to 3.8 GHz.[1] Recent developments in RF power technology; such as improved ruggedness and strongly enhanced power density up to 1000 W per single transistor device, have enabled their use for RF (plasma) lighting. However, using these transistors as power sources for this new lighting technology poses a few fundamental issues, which are discussed here.

THE NEW RF PLASMA LIGHT SOURCE

Developments in RF power technology, such as improved cost structure, ruggedness and power levels, have enabled a breakthrough light source technology, which is often referred to as 'RF plasma lighting'. All RF plasma lighting sources make use of a small, electrode-less quartz light bulb, which contains argon gas and metal halide mixtures. The bulb is powered by direct RF radiation, which ignites the gas mixtures to create and power a bright plasma, the color of which can be tuned by the composition of its constituents.

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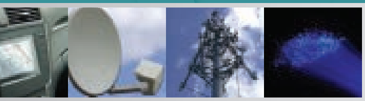

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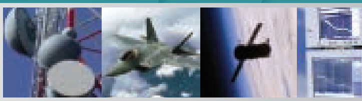

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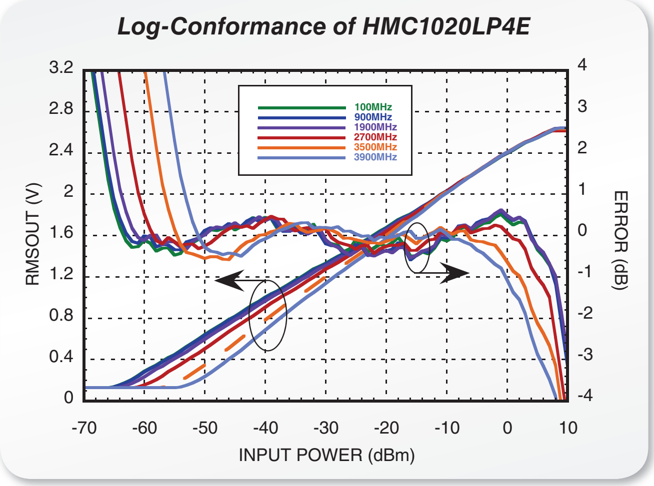

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	Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV/dB)	RF Threshold Level (dBm)	Bias Supply	Package	Part Number
	DC - 3.9	RMS	60 ±1	37	-69	+5V @ 50mA	LP4	**HMC1010LP4E**
NEW!	DC - 3.9	RMS, Single-Ended	75 ±1	35	-68	+5V @ 50 mA	LP4	**HMC1020LP4E**
NEW!	DC - 3.9	RMS, Single-Ended	71 ±1	35	-68	+5V @ 70 mA	LP4	**HMC1021LP4E**
	DC - 5.8	RMS, Single-Ended	40 ±1	37	-69	+5V @ 42mA	LP4	**HMC909LP4E**
	50 Hz - 3.0	Log Detector / Controller	74 ±3	19	-66	+3.3V @ 29mA	LP4	**HMC612LP4E**
	0.001 - 8.0	Log Detector / Controller	70 ±3	-25	-61	+5V @ 113mA	LP4	**HMC602LP4E**
	0.001 - 10.0	Log Detector / Controller	73 ±3	-25	-65	+5V @ 103mA	Chip	**HMC611**
	0.001 - 10.0	Log Detector / Controller	70 ±3	-25	-65	+5V @ 106mA	LP4	**HMC611LP4E**
	0.01 - 4.0	Log Detector / Controller	70 ±3	19	-68	+3.3V @ 30mA	LP4	**HMC601LP4E**
	0.05 - 4.0	Log Detector / Controller	70 ±3	19	-69	+3.3V @ 29mA	LP4	**HMC600LP4E**
	0.05 - 8.0	Log Detector / Controller	54 ±1	17.5	-55	+5V @ 17mA	LP3	**HMC713LP3E**
	0.1 - 2.7	Log Detector / Controller	54 ±1	17.5	-52	+5V @ 17mA	MS8	**HMC713MS8E**
NEW!	1 - 23	mmW Log Detector	54 ±3	14.2	-52	+3.3V @ 91mA	LP3	**HMC948LP3E**
	8 - 30	Log Detector	54 ±3	13.3	-55	+3.3V @ 88mA	LP3	**HMC662LP3E**
	0.1 - 20	SDLVA	59	14	-54	+3.3V @ 83mA	LC4B	**HMC613LC4B**
	0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80mA	Chip	**HMC913**
	0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80mA	LC4B	**HMC913LC4B**
	1 - 20	SDLVA	59	14	-67	+12V @ 86mA	C-10 / SMA	**HMC-C052**
NEW!	1 - 26	SDLVA	59	11	-52	+3.3V @ 135mA	Chip	**HMC813**
	2 - 20	SDLVA	50	45	-45	+12V @ 370mA -5V @ 20mA	C-21 / SMA	**HMC-C078**

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TABLE I

LIGHT GENERATING TECHNOLOGIES COMPARISON

Lighting Type / Parameter	Lifetime (hrs)	Luminous Flux (klm)	Efficacy (lm/W)	Color Rendering	Color Temperature (K)	Start-up Time (s)	Re-strike Time (s)
Incandescent	2,000	1,700	10-17	100	3,200	0.1	0.1
Fluorescent	10,500	3,000	115	51-76	2,940-6,430	0.3	0.1
LED	25,000	130	60-100	30	6,000	0.1	0.1
HID (High Intensity Discharge)	20,000	25,000	65-115	40-94	4,000-5,400	60	480
RF Plasma	50,000	25,000	100-140	70-94	4,000-5,500	30	25

This technology works without any additional electrodes in the bulb, unlike standard high intensity discharge lamps. No electrodes means very long operating lifetimes, since contamination and wire erosion that lead to decreased efficiency and eventual lamp failure are precluded. The RF light source lives up to 50,000 hrs when it reaches 65 to 70 percent of its original light output. Typical high intensity discharge lamps, in comparison, achieve 20,000 hrs operating life. Another strong point of the plasma light is its efficiency: 1 W of RF power is converted to 130 to 140 lm of light.

OTHER TECHNOLOGIES IN COMPARISON

Table 1 summarizes currently available technologies that generate bright light either more or less efficiently. It lists a few key parameters, including lifetime, luminous flux, efficacy, color rendition index, color temperature, start-up time and re-strike time (time to start after switch off from normal operation). Please note that the numbers are only valid for a qualitative comparison.

The plasma light source is among the brightest and most efficient light sources available to date and boasts a very long life time. Important to note is the high brightness per bulb (much brighter than LEDs, for example). Consequently, one needs multiple LEDs to generate the light output of a single plasma light source. Hence, LED luminaries for street lighting will be considerably larger than those for plasma light sources.

Given the high brightness per bulb, the plasma light currently enters the market on the high "output power" end for street lighting and stage lighting, which is true in general for applications requiring more than 5000 lm per luminaire. Competitors in that realm are the incumbent, other metal halide or vapor-based, high intensity discharge lamps and LEDs. On the other hand, light sources like (compact) fluorescents or LEDs serve the < 5000 lm per appliance markets with high efficiency and decreasing color rendition.

RF IMPLICATIONS

In the following, the RF power to drive light sources will be assumed to be generated by Si LDMOS-based transistor devices. The RF-driven Plasma Light is a perfect example for novel applications that can be powered by RF energy in the industrial, scientific, medical (ISM) realm. Established technologies use RF to pump a gas discharge in a laser cavity (such as CO_2 and excimer lasers). These "gas discharge" applications and in general most of the ISM applications form highly mismatched RF loads, certainly during some part of the usage cycle. In the case of gas discharges, for instance, the gas cavity acts as "open circuit" during switch-on. This, in turn, means that without protection or other measures, all of the "injected" RF power reflected back into the final stage of the amplifier needs to be dissipated in the transistor(s) right there and most likely will destroy the device(s) if this situation lasts too long. Hence, the final transistors should be extremely rugged to withstand these mismatched situations. After the discharge strikes, the load impedance eventually reverts to "matched" and the transistor sees a good load. Obviously, these mismatched conditions occur every time the plasma is "switched on," exerting strain on the output devices. The used devices should remain stable and not degrade over time.

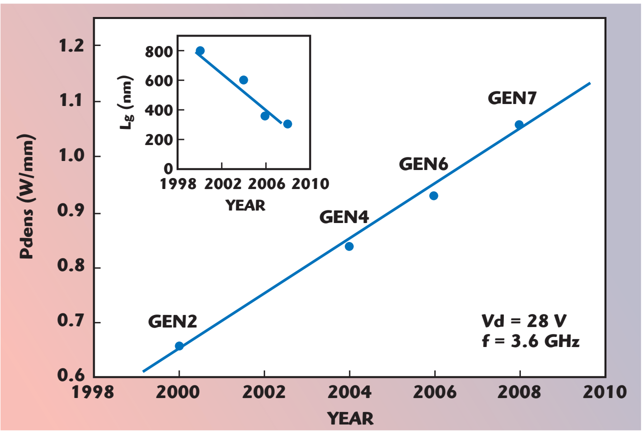
As for ruggedness, the efficiency and power handling capability of the devices is important—the more power per surface area, the better. These aspects—ruggedness, efficiency, power (density) and reliability—will now be further discussed for the 28 and 50 V LDMOS processes.

LDMOS TECHNOLOGY

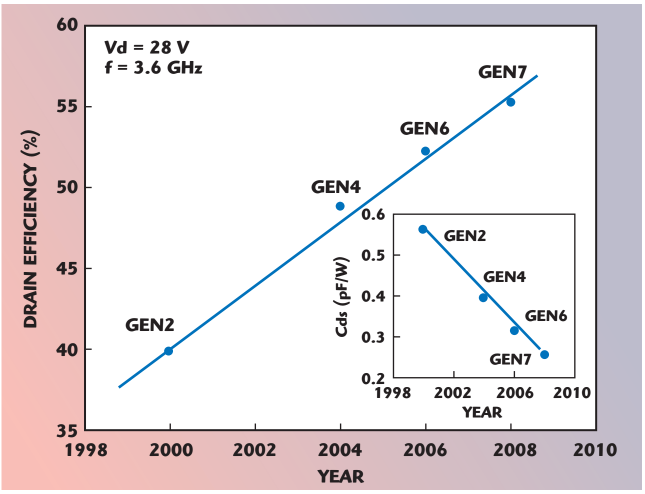
During the last decade, LDMOS technology has evolved[2] to become the preferred technology for RF power transistors for many applications. LDMOS transistors are voltage-controlled devices leading to a simple and low cost bias circuitry. Intrinsic properties of LDMOS enable overdrive to +5 dB without risk of failure, high flexibility for different pulse formats and to prevent thermal runaways, making the overall system design much simpler than for incumbent bipolar technologies. Furthermore, the source connection to the bulk-backside of LDMOS allows for the use of environment-friendly ceramic or plastic packages. Nowadays, LDMOS technology operating at 28 V is the leading RF power technology for base station applications, in particular for GSM-EDGE applications at 1 and 2 GHz, W-CDMA applications at 2.2 GHz, and for WiMAX applications at 2.7 and 3.8 GHz. Recently, another LDMOS family member, the 50 V LDMOS,[3] has emerged and is used for broadcast, ISM, defense and avionics applications. It combines high power density to achieve power levels up to 600 W per single device[4] and outstanding ruggedness with high gain and efficiency at frequencies up to 1.5 GHz.

LDMOS PERFORMANCE EVOLUTION

The improvement in RF performance of LDMOS technology is summarized in ***Figures 1*** and ***2*** for the 28 V technology at 3.6 GHz, showing the power density and the drain efficiency evolution over the last decade. The



▲ *Fig. 1 LDMDS evolution of power density at 3.6 GHz.*



▲ *Fig. 2 LDMOS evolution of drain efficiency at 3.6 GHz.*

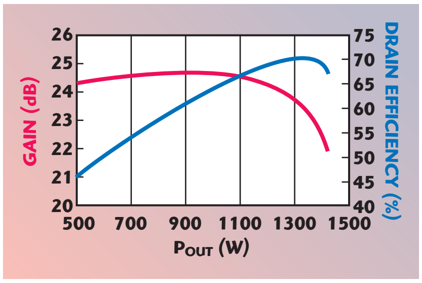
power density has doubled, reaching values over 1 W/mm at 3.6 GHz for the latest technologies. The drain efficiency values exceed 50 percent at 3.6 GHz, while efficiency values close to the theoretical Class B efficiency of 78.5 percent are reached for LDMOS at frequencies below 1 GHz.

This LDMOS performance evolution has been realized by a continuous reduction of the gate length and of the drain output capacitance[5] (see insets of Figures 1 and 2), making use of the capabilities of the high-volume silicon manufacturing processes, with well-known and proven reliability behavior. These properties of high-power density and efficiency make LDMOS the preferred technology for RF lighting applications and opens the path for RF lighting to become a performance and price competitive lighting solution.

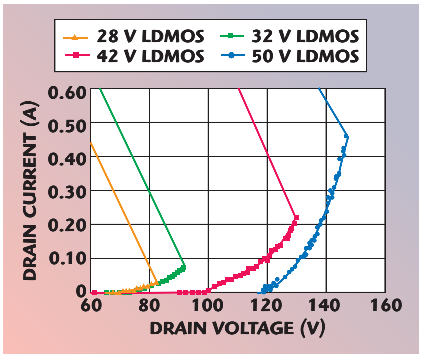
The RF plasma lighting sources can operate over a wide range of RF frequencies, but initial applications typically focus at frequencies of approximately a few hundred megahertz. At these frequencies, both the 28 and 50 V LDMOS technologies can be used, yielding high-efficiency values of 70 to 80 percent and low-heat dissipation, making compact plasma lamp designs possible. The 50 V LDMOS technology has the advantage that the elevated supply voltages lead to higher power densities and higher output impedances for easier matching and more compact designing. Power densities of 2 W/mm can be achieved in combination with high efficiency, as can be seen in ***Figure 3***.[6] The drain efficiency at 225 MHz is more than 70 percent for a transistor of 1300 W of (P1dB) pulsed power in combination with a gain of 24 dB. The efficiency can be boosted further towards the 80 to 90 percent by higher harmonic matching. Since the cut-off frequency of LDMOS transistors is above 10 GHz, there is enough power at the higher harmonics to optimize the waveform shapes for high efficiency and change the operation class from AB towards more advanced transistor classes like Class E, F, J,....

RUGGEDNESS RELIABILITY

These RF lighting applications and most of the ISM applications form highly mismatched RF loads, certainly during some part of the "gas discharge" part of the usage cycle. During this part of the cycle, all of the "injected" RF power is reflected back into the final stage of the amplifier. LDMOS transistors are extremely rugged to withstand these mismatch situations in general and do not degrade over time. Ruggedness, or the ability to withstand "harsh" RF conditions in general, be it mismatch or extremely short pulse rise- and fall-times, is of prime importance to reliable device performance. RF power companies have gone to great lengths to achieve best in class device ruggedness. The technologies have been hardened under the most stringent ruggedness tests during development, which is particularly true for the 50 V technology. Amongst other factors, the base resistance of the parasitic bipolar and the drain extension of the LDMOS device play key roles. These key parameters have been engineered to achieve drain breakdown voltages far exceeding the Class AB supply voltage swing. Drain voltages as high as 150 V for the 50 V technology node can be tolerated, as shown in ***Figure 4***.



▲ *Fig. 3 RF class AB performance of a 50 V LDMOS technology device at 225 MHz.*



▲ *Fig. 4 Pulsed current voltage measurements of LDMOS for different technologies.*

As a ruggedness characterization tool, short pulse (50 to 200 ns) measurements of the current-voltage characteristics are used. The current and voltage are measured with a memory scope during the discharge. The snapback in the I-V curve gives insight in the device properties of the technology. The characterization is done on wafer with small (test) devices in a 50 Ω commercially available setup. Power RF devices cannot be used since the setup is not able to generate enough current. This is a fast and adequate evaluation of device and process changes on ruggedness without influence of test circuits and matching conditions.

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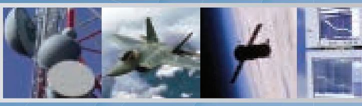

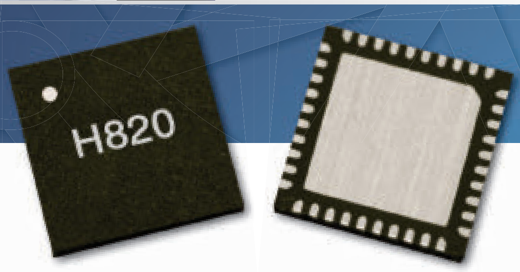

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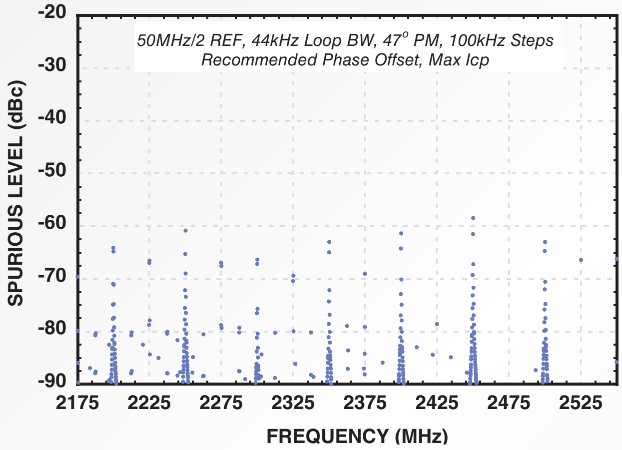

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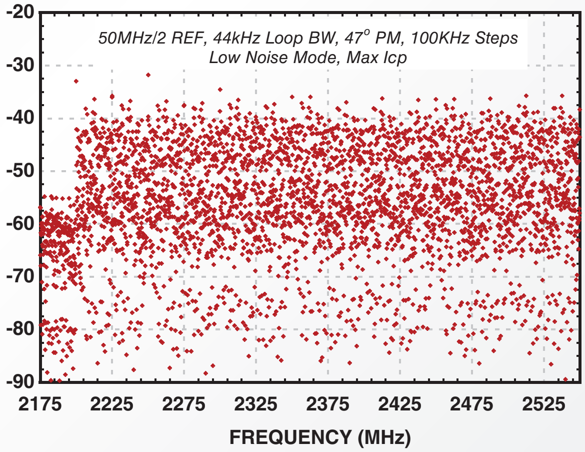

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	0.78 - 0.87	-120 dBc/Hz	-147 dBc/Hz	+12	190	0.05	**HMC824LP6CE**
NEW!	0.795 - 3.78	-108 dBc/Hz	-143 dBc/Hz	+7.5	120	0.07	**HMC838LP6CE**
	0.99 - 1.105	-118 dBc/Hz	-145 dBc/Hz	+10	190	0.07	**HMC826LP6CE**
NEW!	1.05 - 4.82	-110 dBc/Hz	-140 dBc/Hz	+7	120	0.09	**HMC839LP6CE**
	1.285 - 1.415	-116 dBc/Hz	-142 dBc/Hz	+10	190	0.10	**HMC828LP6CE**
	1.33 - 1.56	-115 dBc/Hz	-142 dBc/Hz	+10	190	0.10	**HMC822LP6CE**
	1.72 - 2.08	-113 dBc/Hz	-140 dBc/Hz	+10	190	0.12	**HMC821LP6CE**
	1.815 - 2.01	-112 dBc/Hz	-141 dBc/Hz	+9	190	0.13	**HMC831LP6CE**
	2.19 - 2.55	-110 dBc/Hz	-139 dBc/Hz	+10	190	0.17	**HMC820LP6CE**
	3.365 - 3.705	-107 dBc/Hz	-135 dBc/Hz	0	190	0.25	**HMC836LP6CE**
	7.3 - 8.2	-102 dBc/Hz	-140 dBc/Hz	+15	196	0.55	**HMC764LP6CE**
	7.8 - 8.5	-102 dBc/Hz	-139 dBc/Hz	+13	193	0.58	**HMC765LP6CE**
	11.5 -12.5	-100 dBc/Hz	-134 dBc/Hz	+11	181	0.78	**HMC783LP6CE**
	12.4 - 13.4	-98 dBc/Hz	-134 dBc/Hz	+8	175	0.81	**HMC807LP6CE**

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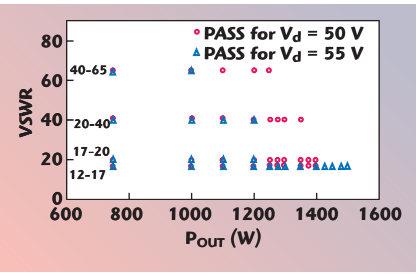
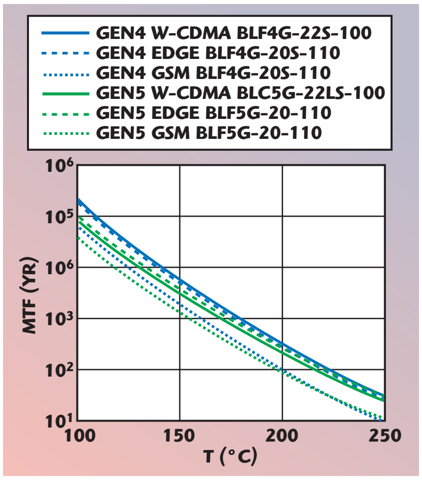


▲ *Fig. 5 VSWR ruggedness measurements at various output power for a pulsed sign (20% duty cycle) at 225 MHz.*

These ruggedness tests ultimately result in devices that can withstand VSWRs of at least 10:1 at nominal load, all phase angles and perform flawlessly in the field. The 50 V LDMOS devices can withstand a larger mismatch condition,[7] as shown in ***Figure 5***. The device can tolerate 55 V drain voltage in combination with a VSWR of 65:1 at a power of 1 kW, values far above the nominal operation settings for most applications. This extreme ruggedness is of importance for the new "gas discharge" applications, where highly mismatched RF loads—certainly during some part of the usage cycle—can occur.



▲ *Fig. 6 MTF comparison for a W-CDMA, EDGE and GSM device made with GEN4 and GEN5 technologies.*

LDMOS RELIABILITY: ALUMINUM METALLIZATION

LDMOS technology is based on high-volume silicon manufacturing processes, with well-known and proven reliability behavior. Early LDMOS technologies worked with Au metallization and bonding wires and hence had the built-in advantage of high electromigration resistance. The development of more recent technology nodes in modern submicron processes triggered the use of Al-based metallization and bond wires. Of course, at that time, the perception was that Al could not withstand the pulsed applications as reliably as Au. However, extensive research and experience in the field have shown that Al is at least as good as Au in this respect, if not better in certain aspects. Comparing technology generation 4 (GEN4) with Au and GEN5 with Al metallization at the device level show identical mean time to failure results, although the GEN5 device has an even higher power density. ***Figure 6*** depicts the results, in this case for GSM base station devices, which experience a similar operating stress (CW operation) as RF lighting applications. It should be kept in mind that the power density and thus the current density for the GEN5 devices is 20 percent higher than for the GEN4 devices. The thermal resistance for the GEN5 device is lower than that of GEN4.

CONCLUSION

This article has given an overview of an innovation in the field of light sources, namely RF lighting. The RF plasma lighting sources make use of a small, electrode-less quartz light bulb, which contains argon gas and metal halide mixtures. The bulb is powered by directed RF radiation, which ignites the gas mixtures and creates and powers a very bright plasma, the color of which can be tuned by the composition of the plasma constituents. This new RF application poses efficiency and ruggedness challenges on the RF devices needed to power the bulb. These challenges have been discussed for high-power RF Si LDMOS, the key enabling technology for delivering energy to this new light source. ■

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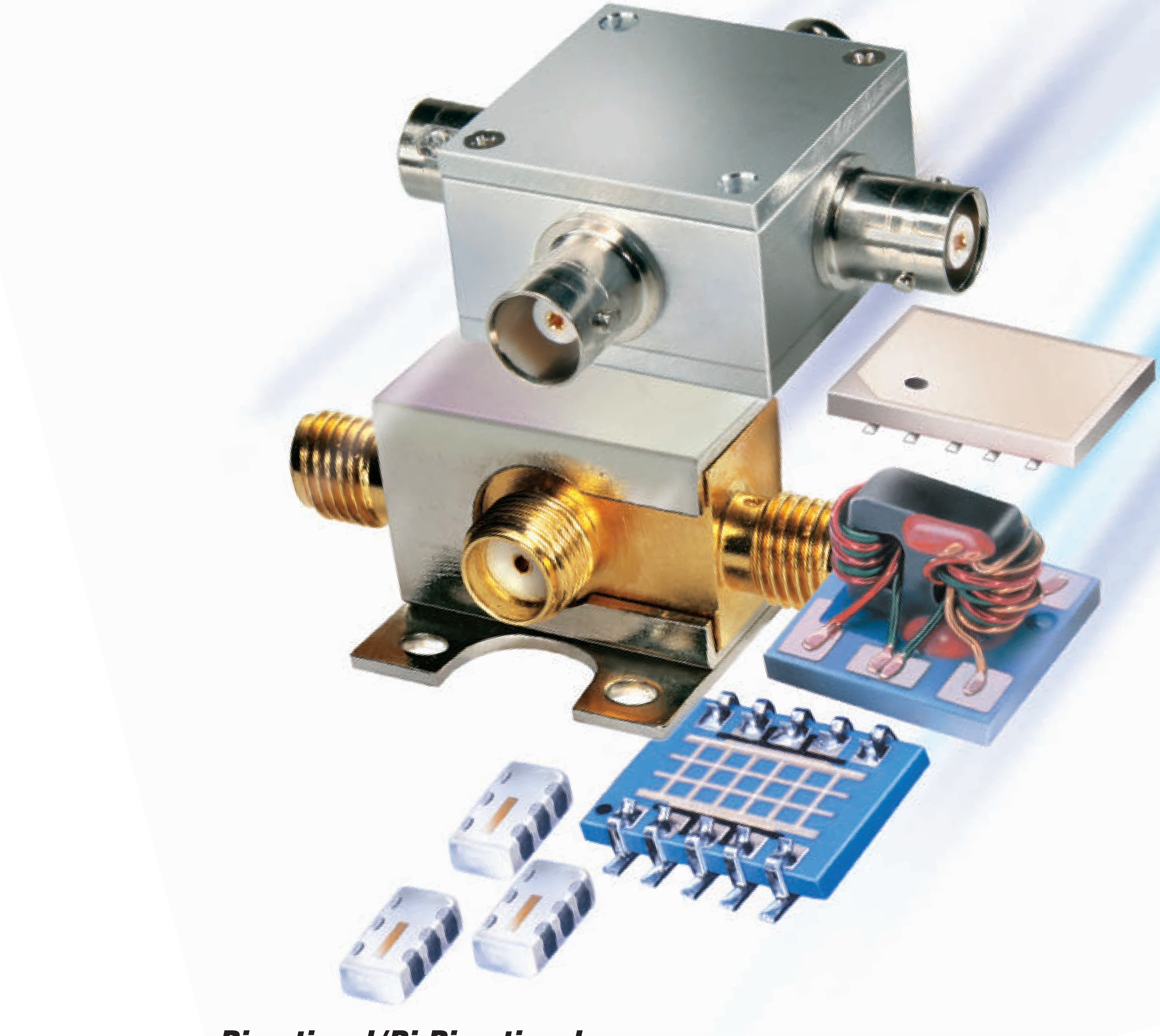

A Miniaturized Multi-section Transformer on Si RFIC for Low Impedance Transformation in UWB

A highly miniaturized and broadband impedance transformer was developed for application to broadband low impedance matching, using a coplanar waveguide employing a periodically arrayed grounded-strip structure (PAGS) on silicon substrate. The multi-section transformer was designed using the Chebyshev polynomials design technique for ultra broadband operation. Its size is 0.026 m² on silicon substrate, which is 8.7 percent of the one fabricated by a conventional coplanar waveguide on silicon substrate. The transformer showed good RF performance over an ultra broadband from 8 to 49.5 GHz. This miniaturization technique can be used in compound semiconducting and silicon substrates.

In broadband communication systems, such as ultra-wideband (UWB), low impedance transformation is required for impedance matching between active devices because the input and output impedances of the FETs are much lower than 50 Ω in the RF band.[1] Therefore, for efficient impedance matching in a radio frequency integrated circuit (RFIC) in a broadband communication system, a broadband and low impedance transformer performing low impedance transformation between active and passive devices is indispensable and should be highly miniaturized for integration in RFICs.

λ/4 impedance transformers have been widely used for comparatively broad bandwidth.[2] However, conventional impedance transformers have been fabricated outside of RFICs, due to their large size, and used for applications to high impedance transformation (in the range of 40 to 70 Ω) because the line width of the coplanar waveguide with a low impedance is very large and cannot be realized on a RFIC. For example, the line width W should be 1000 μm to obtain a characteristic impedance Z_0 of 20 Ω from the conventional coplanar waveguide on silicon substrate with a height of 600 μm.

In this work, in order to realize a highly miniaturized and low impedance on-chip transformer, a multi-section transformer was fabricated using a periodically arrayed grounded-strip structure (PAGS) on silicon substrate. For ultra broadband operation, it was designed using the Chebyshev polynomials design technique.

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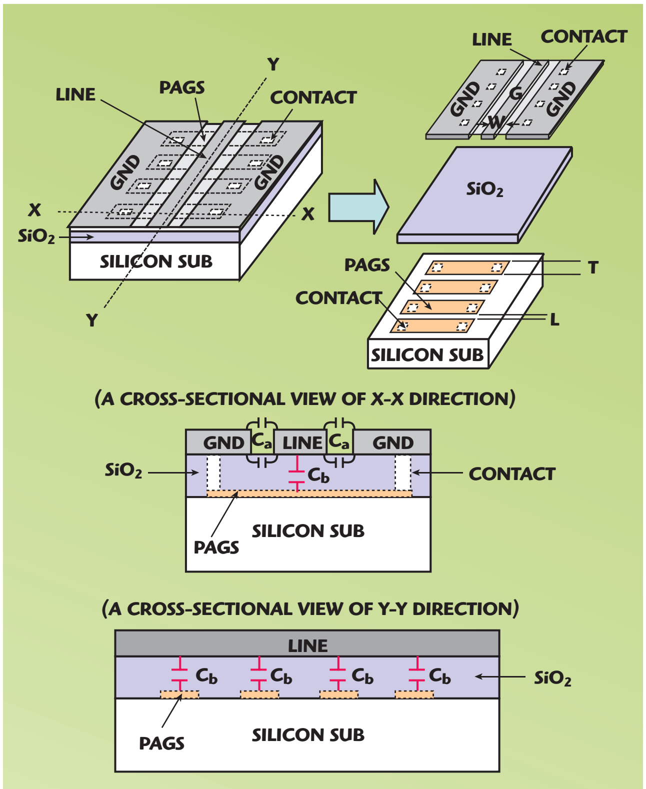
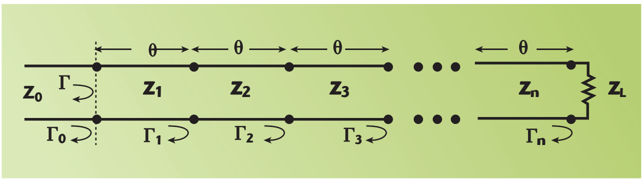


▲ *Fig. 1 The structure of a coplanar waveguide using a PAGS.*



▲ *Fig. 2 Schematic circuit of a multi-section λ/4 impedance transformer using a PAGS.*

A COPLANAR WAVEGUIDE USING A PAGS ON SILICON SUBSTRATE

A coplanar waveguide, employing a slow wave structure, was fabricated on a GaAs substrate for the first time.[6] A miniaturized passive component was recently proposed, employing a slow-wave structure on silicon substrate.[3] ***Figure 1*** shows the structure of the coplanar waveguide employing a PAGS. As shown, the PAGS is placed at the interface between the SiO_2 film and the silicon substrate, and is electrically connected to the top-side ground planes (GND planes) through the contacts. Therefore, the PAGS is grounded through the GND planes.

As is well known, a conventional coplanar waveguide without a PAGS has only a periodical capacitance C_a per unit length, while the coplanar waveguide employing a PAGS has an additional capacitance C_b, as well as C_a, due to the PAGS. C_b is the capacitance between the line and PAGS. In other words, the total capacitance (per unit length) of the coplanar waveguide employing a PAGS corresponds to $C_a + C_b$, but it only corresponds to C_a for a conventional coplanar waveguide without a PAGS. Therefore, the coplanar waveguide employing a PAGS exhibits a much shorter guided-wavelength (λg) and a lower characteristic impedance (Z_0) than a conventional one, because λg and Z_0 are inversely proportional to the periodical capacitance; in other words, $\lambda g = 1/[f(LC)^{0.5}]$ and $Z_0 = (L/C)^{0.5}$. As shown in ***Table 1***, at 40 GHz the wavelength of a conventional coplanar waveguide on silicon substrate is 2.95 mm, while it is 1.86 mm for a coplanar waveguide employing a PAGS.

TABLE I

MEASURED WAVELENGTH AT 40 GHz FOR A CONVENTIONAL COPLANAR WAVEGUIDE AND ONE USING A PAGS

	Wavelength
Conventional CPW	2.95 mm
CPW employing PAGS	1.86 mm

TABLE II

CHARACTERISTIC IMPEDANCE OF A COPLANAR WAVEGUIDE USING A PAGS AS A FUNCTION OF T

T (μm)	0	10	20	30
Z_0 (Ω)	67	40	36	34

In this structure, the value for Z_0 can be easily controlled by only changing the spacing T, because an increase in T results in a reduction of Z_0, due to an increase in C_b. Actually, as shown in ***Table 2***, low impedance values of Z_0 were obtained from 30 to 70 Ω by only changing T. In this work, the distance L between the unit strip and the height of silicon substrate are 20 and 600 μm, respectively. In the Table, T = 0 corresponds to a conventional coplanar waveguide without a PAGS.

A HIGHLY MINIATURIZED MULTI-SECTION TRANSFORMER EMPLOYING PAGS ON SUBSTRATE

Using the coplanar waveguide employing a PAGS, a highly miniaturized and low impedance on-chip transformer employing multi-section lines was developed for broadband applications. For broadband operation, a multi-section transformer was designed using the Chebyshev function. ***Figure 2*** shows a multi-section transformer. For broad bandwidth, the reflection coefficient should follow a Chebyshev function response, and the following equations should be satisfied:[2]

$$\Gamma(\theta) = \qquad (1a)$$
$$2e^{-jN\theta}[\Gamma_0 \cos N\theta + \Gamma_1 \cos(N-2)\theta + \ldots + \Gamma_n \cos(N-2n)\theta$$
$$+ \ldots + \frac{1}{2}\Gamma_{N/2}] = \Gamma_m e^{-jN\theta} T_N(\sec\theta_m \cos\theta),\ \text{for N even}$$

$$\Gamma(\theta) = \qquad (1b)$$
$$2e^{-jN\theta}[\Gamma_0 \cos N\theta + \Gamma_1 \cos(N-2)\theta + \ldots + \Gamma_n \cos(N-2n)\theta$$
$$+ \ldots + \Gamma_{(N-1)/2} \cos\theta] = \Gamma_m e^{-jN\theta} T_N(\sec\theta_m \cos\theta),\ \text{for N odd}$$

$$\sec\theta_m = \cosh\left[\frac{1}{N}\cosh^{-1}\left(\frac{1}{\Gamma_m}\left|\frac{Z_L - Z_0}{Z_L + Z_0}\right|\right)\right] \qquad (2)$$

where Γ_m and T_N are a maximum value of the reflection coefficient and the nth order Chebyshev polynomial, respectively. N and Γ_n are the number of sections and the reflection coefficients of the multi-stage transformer. If N, Γ_m, Z_L and Z_0 are determined, $\sec\theta_m$ can be obtained from Equation 2. In this work, a three-section transformer was designed to match a 50 Ω load to a 19 Ω line, with $\Gamma_m = 0.05$. From Equations 3 and 1b, with N = 3, Equation 4 can be obtained.

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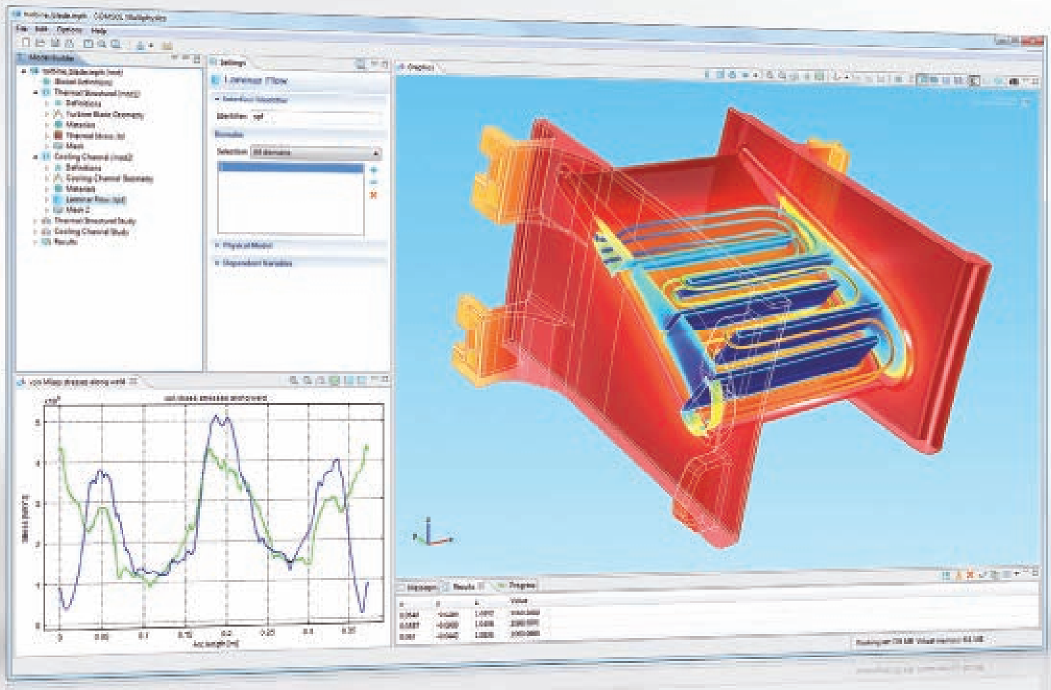

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$$T_3(\sec\theta_m \cos\theta) = \sec^3\theta_m(\cos 3\theta + 3\cos\theta) - 3\sec\theta_m \cos\theta \quad (3)$$

$$\Gamma(\theta) = 2e^{-j3\theta}\left[\Gamma_0 \cos 3\theta + \Gamma_1 \cos\theta\right] = \Gamma_m e^{-j3\theta} T_3(\sec\theta_m \cos\theta)$$
$$= \Gamma_m e^{-j3\theta}\left[\sec^3\theta_m(\cos 3\theta + 3\cos\theta) - 3\sec\theta_m \cos\theta\right] \quad (4)$$

From the above equation, the following results can be obtained:

$$\cos 3\theta : 2\Gamma_0 = \Gamma_m \sec^3\theta_m \quad (5a)$$
$$\cos\theta : 2\Gamma_1 = 3\Gamma_m(\sec^3\theta_m - \sec\theta_m) \quad (5b)$$
$$\Gamma_2 = \Gamma_1 \quad (5c)$$
$$\Gamma_3 = \Gamma_0 \quad (5d)$$

Then the characteristic impedances of the three-section transformer are

$$Z_1 = Z_0 \frac{1+\Gamma_0}{1-\Gamma_0} \quad (6a)$$
$$Z_2 = Z_1 \frac{1+\Gamma_1}{1-\Gamma_1} \quad (6b)$$
$$Z_3 = Z_L \frac{1-\Gamma_3}{1+\Gamma_3} \quad (6c)$$

The characteristic impedances $Z_1 = 26\ \Omega$, $Z_2 = 35\ \Omega$ and $Z_3 = 43\ \Omega$ from N = 3, $Z_L = 50\ \Omega$ and $Z_0 = 19\ \Omega$ are obtained. A photograph of the three-section transformer is shown in ***Figure 3***. The length of each section of the λ/4 transformer, L_1, L_2 and L_3 are 0.38, 0.44 and 0.485 mm, respectively. Therefore, the size of the transformer including via holes is 0.261 mm², which is 8.7 percent of the size of the transformer fabricated from a conventional coplanar waveguide. This result is summarized in ***Table 3***.

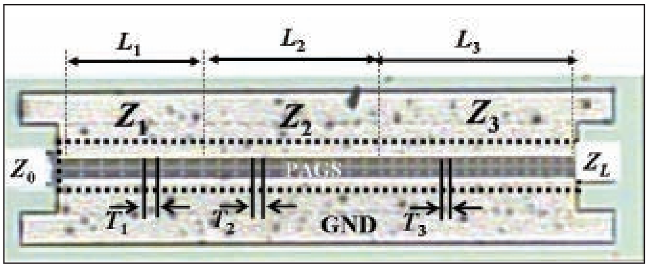

Fig. 3 Photograph of the on-chip multi-section impedance transformer using PAGS on silicon substrate.

The measured return loss S_{11} and the insertion loss S_{21} of the three-section transformer are shown in ***Figure 4***, respectively. The measured S_{11} of the single section transformer was also plotted for comparison. Compared with the single section transformer, the three-section transformer shows a much broader bandwidth with ripples. The three-section transformer exhibits return loss values better than 10 dB from 8 to 49.5 GHz, and the insertion loss values are 1.5 ± 1 dB in the same frequency range, which is 1.15 ± 0.76 dB/mm for a length of 1 mm (the length of the multi-section transformer is 1.305 mm). Considering that a silicon substrate is lossy due to its high conductivity,[5-9] the above insertion loss is comparatively small, and is sufficiently low for application to silicon RFICs. These results indicate that the highly miniaturized multi-section impedance transformer is a promising candidate for application to low

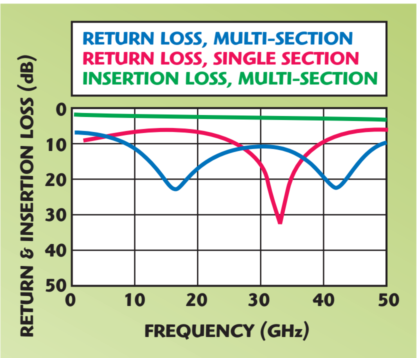

Fig. 4 Measured return loss and insertion loss of the three-section transformer.

TABLE III

DIMENSIONS OF THE THREE SECTION TRANSFORMERS USING A CONVENTIONAL COPLANAR WAVEGUIDE AND ONE USING A PAGS

	Z_1		Z_2		Z_3		Size (mm^2)
	W (μm)	λg/4 (mm)	W (μm)	λg/4 (mm)	W (μm)	λg/4 (mm)	
Conventional CPW	210	1	60	1	30	1	0.3
CPW employing PAGS	20	0.38	20	0.44	20	0.485	0.0261

impedance transformation in ultra broadband applications.

CONCLUSION

Using a coplanar waveguide employing a PAGS on silicon substrate, a highly miniaturized on-chip transformer was developed for application in ultra broadband, low impedance transformation. For ultra broadband operation, the multi-section transformer was designed using the Chebyshev polynomials design technique. The impedances of a three-section transformer were determined so that the reflection coefficient of the transformer would be a Chebyshev function response. The three-section transformer exhibited return loss values better than 10 dB from 8 to 49.5 GHz; the insertion loss values are 1.15 ± 0.76 dB/mm in the above frequency range. Its size is 0.026 m^2 on a silicon substrate, which is 8.7 percent of the one fabricated with a conventional coplanar waveguide on silicon substrate. These results reveal that the highly miniaturized multi-section impedance transformer is a promising candidate for application to low impedance transformation in ultra broadband. ■

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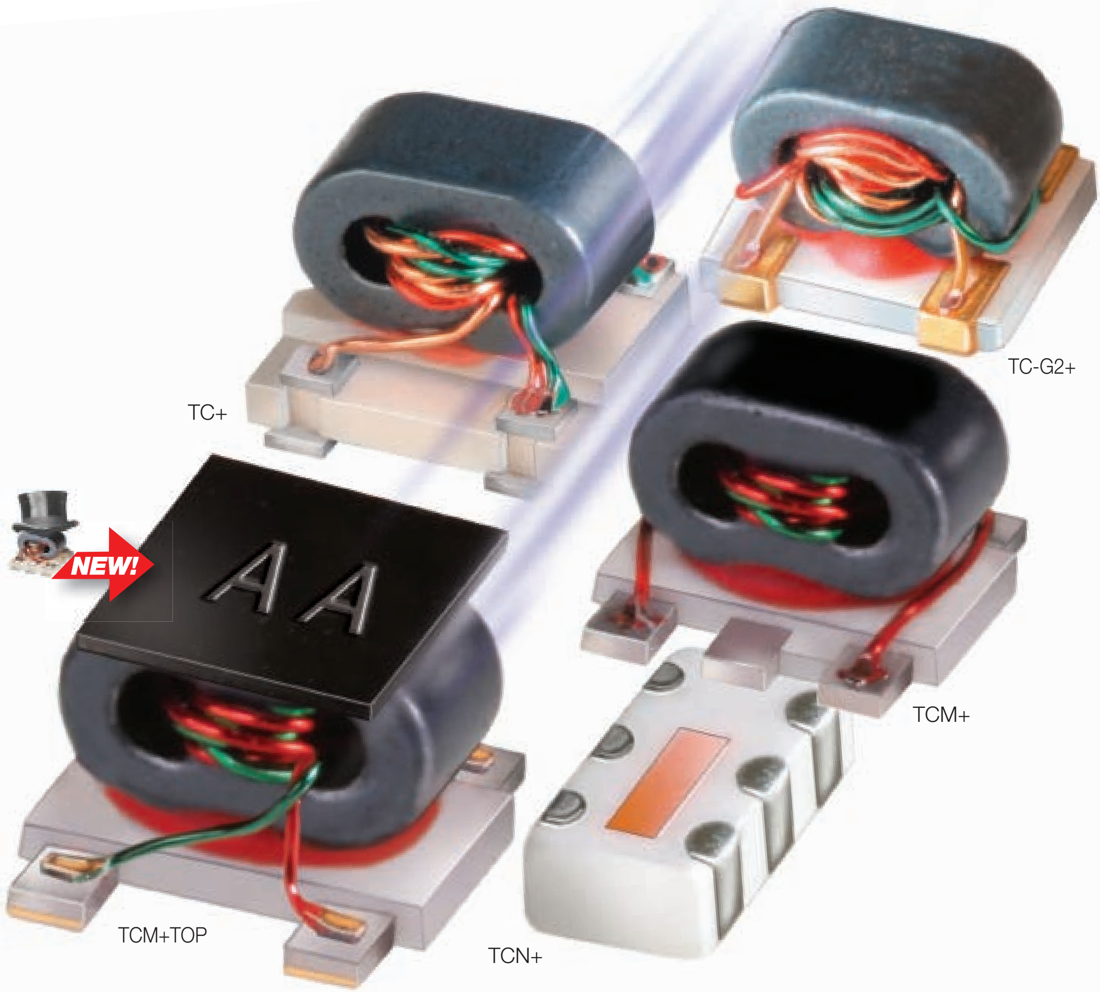

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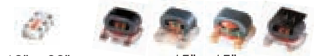

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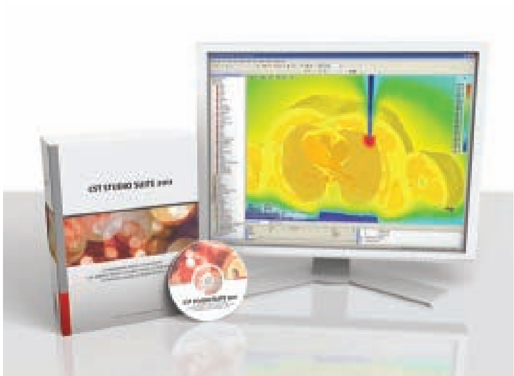
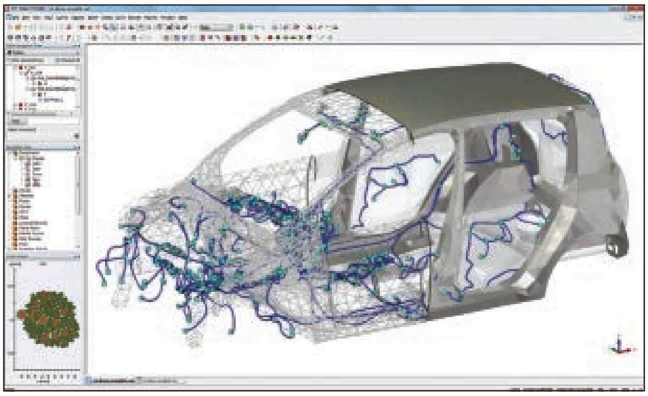


CST STUDIO SUITE 2011: INTEGRATING SIMULATION TECHNOLOGY

There is an increasing demand for evaluating a component's performance in the system environment. The performance of an antenna depends on the platform it is installed on, for example, and the antenna itself might be a system built from various RF components. The importance of the EM system simulation approach becomes obvious when considering the electromagnetic compatibility of a device. The overall performance depends on the interaction of all the components, such as PCBs, cables and housings (as illustrated by the automotive scenario shown in ***Figure 1***).



▲ *Fig. 1 3D model of a cable harness in a compact car. Small window shows cable cross section.*

However, for each of the device's components, there might be specialized solutions that will dramatically decrease simulation time. The new CST STUDIO SUITE 2011 integrates methods to synthesize and optimally handle both the constituent components and their interaction within a complex system. In addition, the high performance computing (HPC) options enable simulation with increasing complexity, such as the example shown in ***Figure 2***.

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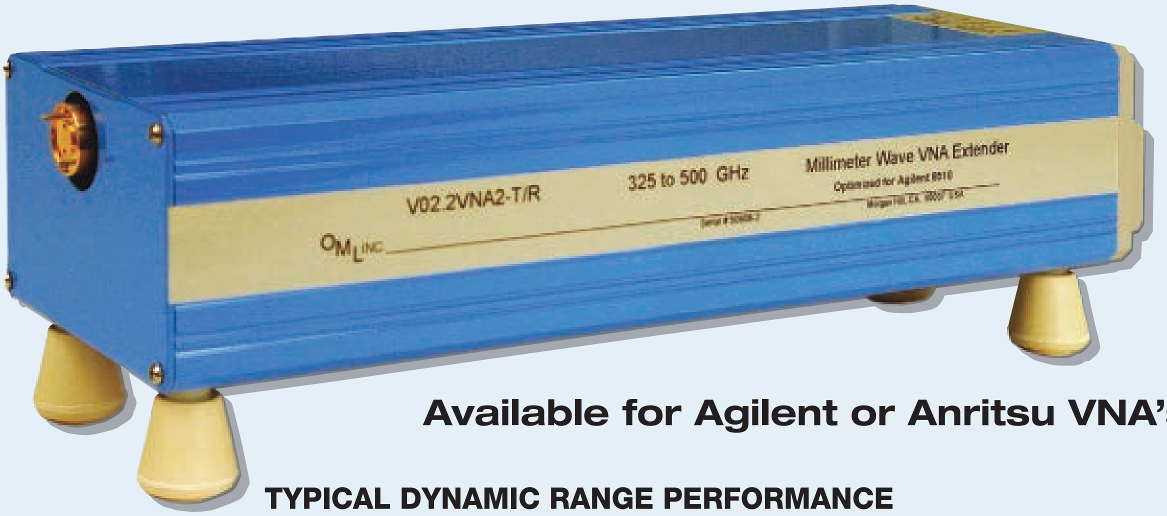

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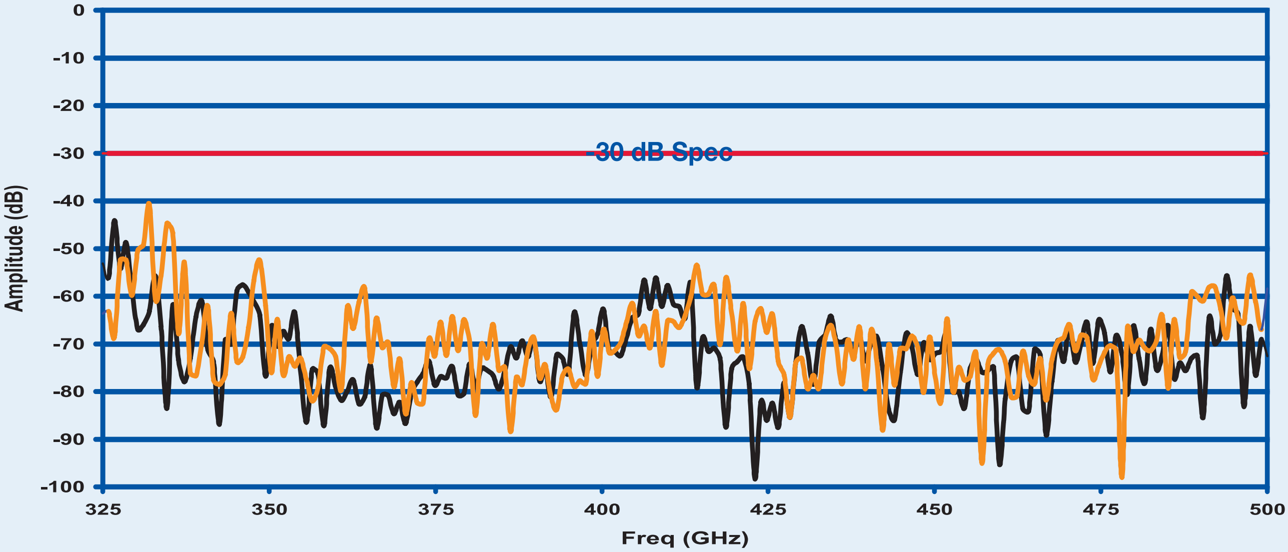

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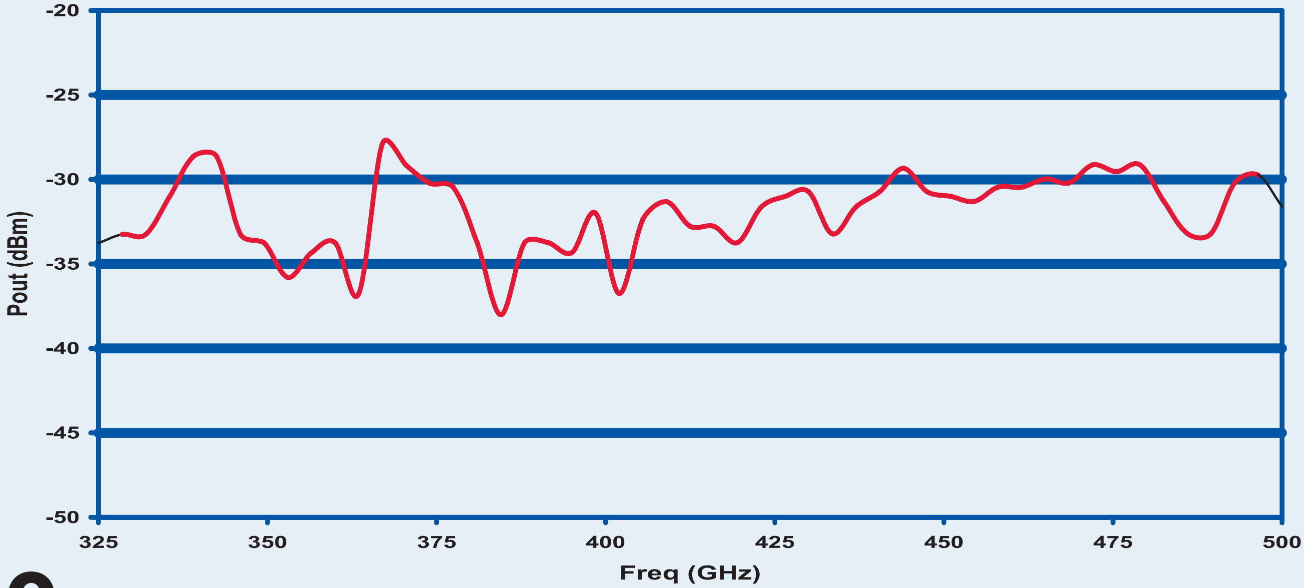

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FREQUENCY DOMAIN SOLVER WITH CURVED ELEMENTS

With version 2011, the CST MICROWAVE STUDIO (CST MWS) frequency domain solver will feature curved tetrahedral mesh elements of high geometrical orders. In comparison to using simpler curvilinear elements (first order curved elements), which often suffer from the creation of inaccuracies in the mesh representation, higher order curved elements deliver a much smoother representation of arbitrary surfaces.

As with all mesh adaptation schemes, simulations will only converge to the correct results if mechanisms such as True Geometry Adaptation are used. These actually improve the representation of the input model continuously, rather than simply refining the first discretization of the model. The higher order curved elements will also be available for the CST MWS eigenmode solver and the fast resonant solver.

ELECTRICALLY LARGE STRUCTURES

HPC can greatly benefit the simulation of very complex structures, like the one shown in Figure 2, but switching from standard volume methods such as FIT or FEM to surface-based integral equation or ray tracing methods is often the more efficient approach for electrically very large structures. CST MWS features an integral equation solver using the multilevel fast multipole method (MLFMM) for structure sizes of up to about 1,000 wavelengths and an asymptotic solver based on the shooting bouncing ray method for even larger structures.

Both solvers can now use farfields as excitation sources. These farfields can be computed by other CST MWS solvers including the transient or frequency domain solvers. This makes the calculation of an installed antenna's farfield possible, even for an electrically very large structure, such as the ship shown in ***Figure 3***. CST MWS 2011 also allows the importing of more than one farfield source, thus enabling the computation of the coupling between several antennas, or of the combined farfield of multiple antennas.

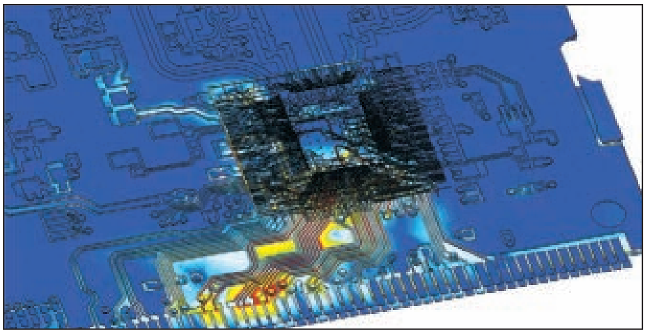
For radar scattering simulations, the structure can be simultaneously illuminated by multiple sources, the properties of which can be set by means of an excitation list. This enables the simulation of arbitrarily polarized incident waves from different directions. The asymptotic solver benefits from the inclusion of surface impedance models for the simulation of coatings or seawater.

SENSITIVITY AND YIELD ANALYSIS

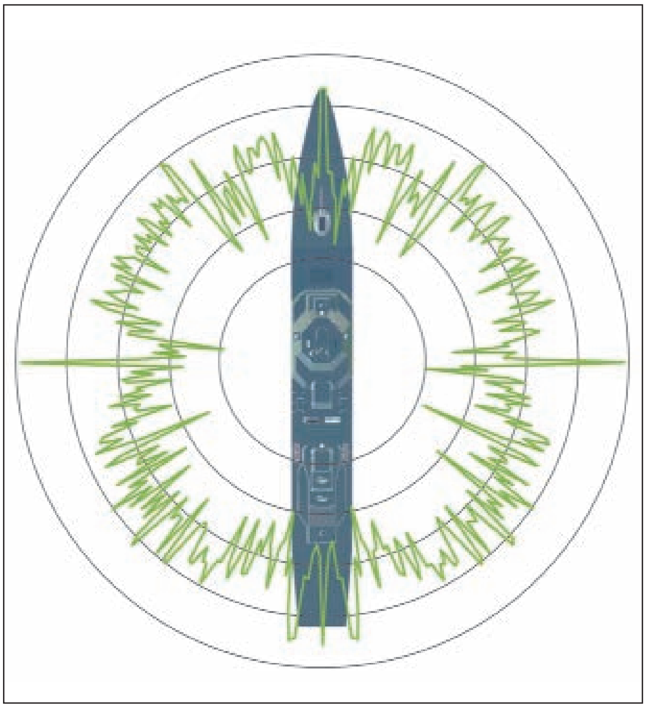
CST MWS transient solver provides efficient computation of broadband S-parameters and field results in one single simulation run. In version 2011, sensitivity analysis can evaluate the S-parameter dependencies on various model parameters on the basis of this single broadband simulation. Further evaluations for different model parameter sets can be derived without restarting the full-wave simulation. Hence, yield analysis for complex three dimensional (3D) models is available at virtually no additional computational cost.

OPTIMIZATION

The newly implemented trust region framework uses parametric models to find optimal solutions for the given goals, without rerunning expensive 3D simulations. By employing the sensitivity information provided by both of the general purpose electromagnetic solvers of CST MWS—time and frequency domain—the number of 3D simulations and, therefore, the optimization time can be cut down dramatically.



▲ *Fig. 2 Computation on a GPU cluster dramatically reduces simulation time for this crosstalk analysis.*



▲ *Fig. 3 Bistatic RCS of a destroyer at 16.8 GHz.*

MULTIPHYSICS

CST MPHYSICS STUDIO computes thermal and mechanical effects. While not fully integrated in the design environment, in version 2011 the temperature calculated from the electromagnetic losses can be used to change the material parameters for a consecutive electromagnetic field simulation. CST MPHYSICS STUDIO now also features a thermal solver on a tetrahedral grid.

EMC/EMI

CST STUDIO SUITE 2011 improves the integration of CST CABLE STUDIO and the CST MWS TLM solver (formerly CST MICROSTRIPES) into the CST design

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environment. Users interested in the analysis of radiated emissions and susceptibility will benefit from a single unified environment for all EMC related modeling tasks, including greatly simplified model set up and simulation.

In pre-processing, the definition of compact equivalent aperture models and cable harnesses can be performed in CST's familiar design environment. Coupling between the full 3D electromagnetic field and cable solvers enables direct transient simulation of susceptibility problems in systems containing complex cable bundles, including shielded twisted pairs (see Figure 2).

SIGNAL AND POWER INTEGRITY

For high accuracy and to address layouts with non-planar elements such as wirebonds, a full 3D simulation is often necessary. CST offers import filters to layout tools of leading EDA vendors, such as Cadence®, Mentor Graphics® or Zuken. All these links open the layout in the EM design environment before setting up and running simulations.

In a major collaborative project, a link has been created that allows Cadence layout engineers to stay within their familiar environment while performing a full wave 3D extraction and EM analysis in the background. Results are back annotated to the Cadence environment, thus simplifying the engineering workflow.

CST STUDIO SUITE version 2011 is addressing the challenges of modern electromagnetic system design by tightly integrating the latest in simulation technology within an intuitive user interface. Streamlined workflows are enabling real world problems to be tackled and solved in a virtual environment, ultimately leading to an accelerated and more cost-effective design cycle.

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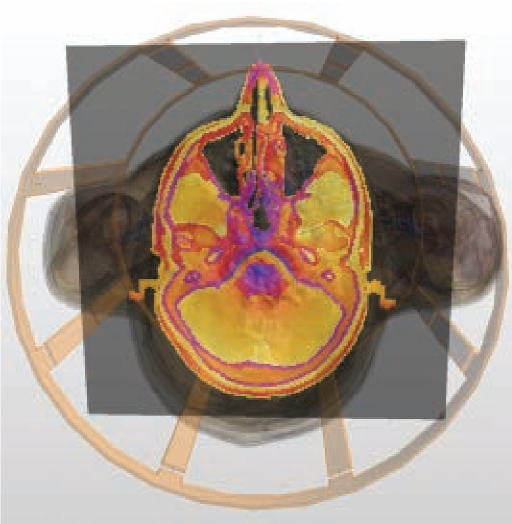
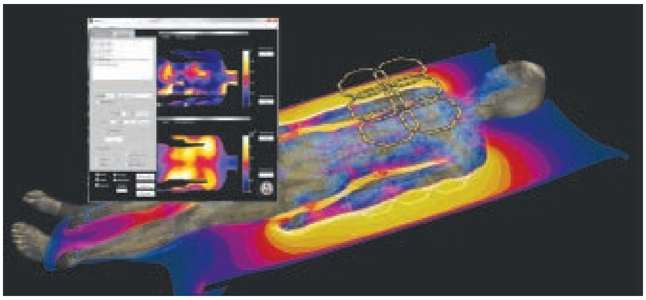


SOFTWARE PLATFORM FOR MRI PHASED ARRAY SYSTEM DESIGN & OPTIMIZATION

Nik Chavannes,
Director of Software Development,
Schmid & Partner Engineering AG (SPEAG).
Visit www.mwjournal.com to read this in-depth interview.

ExecutiveInterviews

With the widespread adoption of multichannel MRI systems using parallel imaging, the design and optimization of receive coil arrays has become imperative, while also being complex. Nevertheless, coil optimization techniques and performance verification are essential steps when designing coil arrays. To address this issue, a novel software platform combines SEMCAD X, the latest generation of 3-D Finite Difference Time-Domain (FDTD) & Finite Integration Technique (FIT) full-wave simulation software, and Musaik™ RF Array Designer software.



▲ *Fig. 1 Simulation of the MRI RF fields in anatomical models in SEMCAD X and analysis of the receive coil performance in Musaik.*

The result is the first software of its kind combining all the tools needed to design RF phased arrays in a single user-friendly program. The joint effort from Schmid & Partner Engineering AG (SPEAG), Switzerland, and the National Research Council of Canada (NRC) provides coil designers and radiologists with an essential set of advanced tools needed to simulate, predict and verify array performance, enabling radiologists to perform parallel MRI protocol optimization and quality assurance.

With the urgent need for faster, better, less expensive healthcare technologies, it is anticipated that experts in the global MRI community will recognize the value in the new software platform. Consequently, the combination of Musaik and SEMCAD X lays the groundwork for future breakthroughs in MRI system design.

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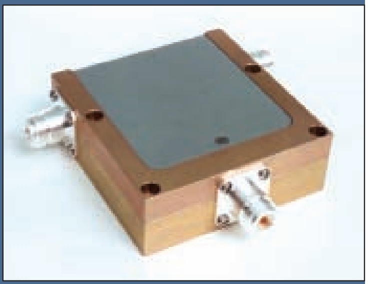

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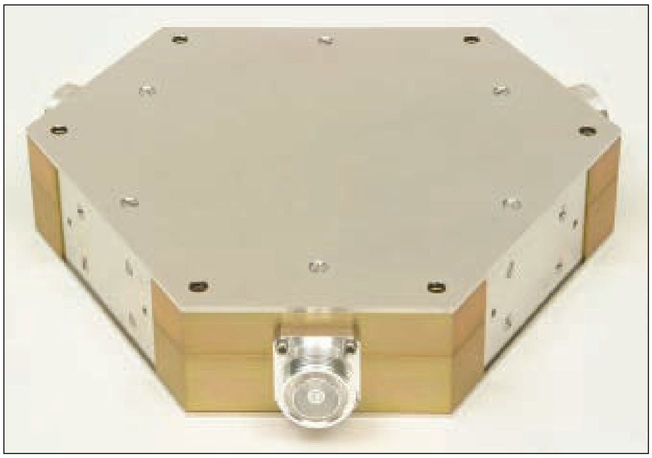
100 MHz HIGH POWER Circulator for Medical, Scientific and Industrial applications



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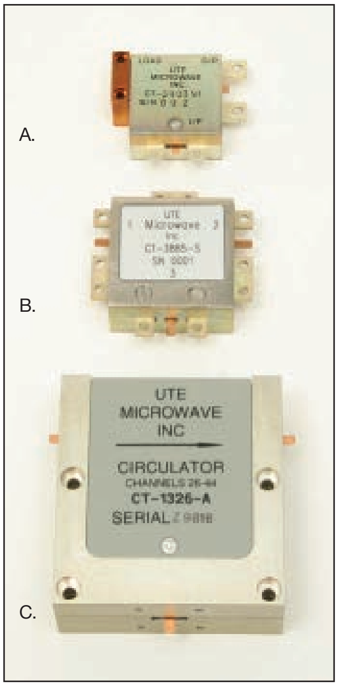
C) UHF TV Band 5 kW pk, 500 W av



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CT-3838-N	5 Kw Pk 500 W Av	N Conn.	2.7–3.1 GHz
CT-1645-N	250 W Satcom	N Conn.	240–320 MHz
CT-1739-D	20 Kw Pk 1 Kw Av	DIN 7/16	128 MHz Medical

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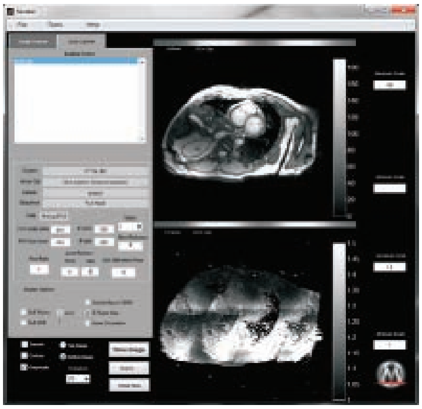
ARRAY COIL DESIGN AND PERFORMANCE

Musaik enables the user to import 3-D field simulation results from SEMCAD X (as illustrated in ***Figure 1***), build various virtual array coil configurations, investigate channel compression, and then assess signal-to-noise (SNR) and parallel MRI performance. Furthermore, it allows the user to import experimental data obtained on any MRI scanner, and perform the same SNR and parallel MRI evaluation for accurate performance verification.

Many different view options are provided, including phase analysis, transmit/receive coil functionality and thresholding, which is a desired region of interest (ROI) for region specific performance analysis or small field-of-view (FOV) computations. Two dimensional g-factor maps can be computed, exploring parallel MRI performance while varying the field-of-view and acceleration factor (see ***Figure 2***). Also, complex noise covariance matrices are computed, minimizing the technical knowledge required by users and enabling the assessment of coil isolation during construction troubleshooting.

PARALLEL MRI

Hospitals and diagnostic clinics need to be able to analyze and maximize the performance of their MRI systems as easy and painlessly as possible. Parallel MRI has become standard practice for better temporal or spatial resolution and shorter overall exam times. The challenge for hospitals is to get the most out of their MRI scanners; however, this is very difficult because there are many application specific parameters to optimize, such as acceleration factor, field-of-view, etc.



▲ *Fig. 2 Musaik screenshot with (top) an unaccelerated reference image SNR reconstruction and (bottom) g-factor map for a 12-fold (R = 4 × 3) 2D acceleration.*

It is the goal of Musaik to assist in understanding the intricacies of parallel MRI. To a radiologist, the concept of MRI protocol optimization would require countless hours of MRI time, altering scan parameters and observing their effects on the resultant image, in a trial and error fashion. This process is tedious and therefore not common practice.

With Musaik, 'fine tuning' of MRI protocols can be done offline and in a mathematical way without using valuable scan time, to show how imaging parameters such as field-of-view and acceleration factor can be interplayed to decrease imaging time or increase spatial resolution without significant SNR loss or increased artifacts in a specified region of interest.

With regards to coil design, analysis and optimization, Musaik facilitates the investigation of array coupling through noise correlation matrix calculation and offers 1D and 2D g-factor analysis for evaluating both 2D and 3D MRI acceleration capabilities. It utilizes a SNR/g-factor display to help gauge image quality limitations and is easy to add, combine or remove array channels to assess their contributions.

To sum up Musaik's image processing and optimization capabilities, the tool utilizes image ratios to assess regional SNR/g-factor gains and incorporates region-of-interest zooming with statistical analysis. The software features a color, grayscale and contour display, and can export in image format for presentations as well as having the capacity to export complex composite datasets for further post-processing.

In conclusion, the new platform offers a unique solution for the design of multi-channel phased array coils, parallel MRI protocol optimization and quality assurance. It is envisaged that the combination of Musaik and SEMCAD X will be key in assessing the limits of new or existing array coils.

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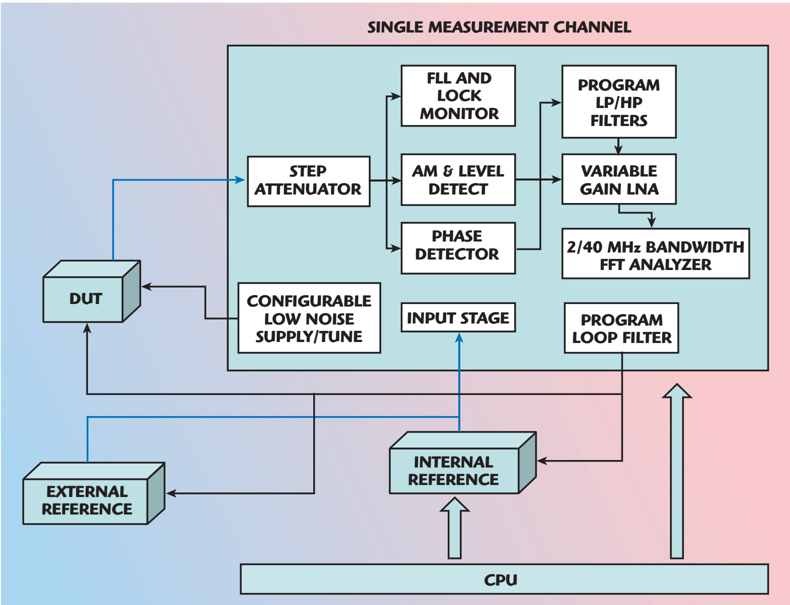
FULLY AUTOMATED SIGNAL ANALYZER

The versatile APPH6000 signal analyzer from AnaPico enables the fast and accurate measurement of single-sideband phase noise and amplitude noise, which play an important role in many RF and microwave designs, especially when developing crystal and voltage-controlled oscillators (VCO), prescalers, frequency converters and synthesizer phase locked loops (PLL). It is capable of performing sensitive measurements of baseband and supply noise and has the capacity to conduct parameter extraction of VCOs and useful time-domain transient measurements such as the locking behavior of PLLs.



▲ *Fig. 1 Block diagram of the APPH6000 signal analyzer.*

SYSTEM ARCHITECTURE

Figure 1 shows a block diagram of the APPH6000, which consists of one or two measurement channels (two when using phase noise cross-correlation). Each channel consists of a programmable step attenuator, a frequency counter, programmable phase and amplitude detectors, bandwidth-adjustable PLL and frequency acquisition loop, a gain and bandwidth programmable low noise amplifier and a high-resolution FFT analyzer. Each channel also includes programmable supply and control voltage for device under test (DUT) biasing.

MEASUREMENT CAPABILITY

The APPH6000 is a fully automated signal analyzer that provides reliable and fast noise measurements, is easily installed and config-

ANAPICO AG
Zurich, Switzerland

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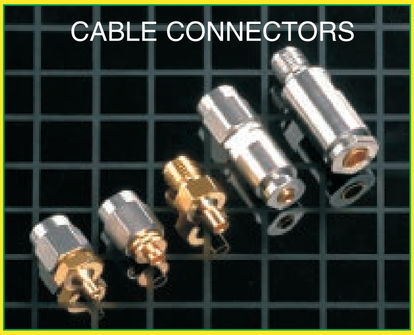

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ISO 9001:2008

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SGMC MICROWAVE

Manufacturer of Precision Coaxial Connectors
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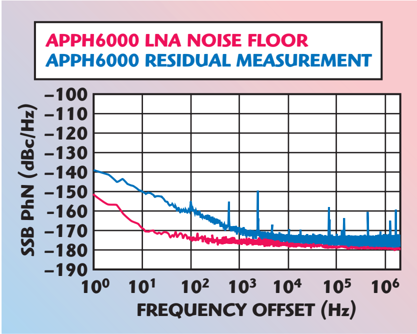
Phone: 321-409-0509 Fax: 321-409-0510
sales@sgmcmicrowave.com
www.sgmcmicrowave.com

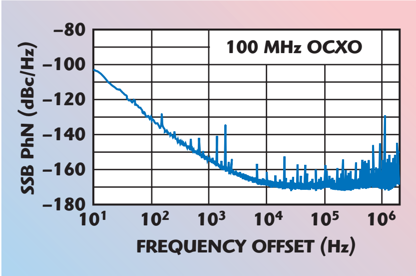
ured, and is highly reconfigurable for a variety of applications. It also covers a wide frequency range from 10 MHz to 6.2 GHz (up to 7 GHz with an external source).

The signal analyzer features SSB phase noise measurement using the PLL method with internal or external reference and either the DUT or reference can be tuned. The offset range is 0.1 Hz to 2 MHz (optionally extendable to 40 MHz) and the noise floor is -174 dBc/Hz at 1 kHz, but can be as low as -180 dBc/Hz with the high power option. A two-channel cross-correlation is available to further lower the instrument noise floor. ***Figure 2*** shows the instrument noise floor for the standard single channel operation; ***Figure 3*** shows a single-channel measurement of a low noise 100 MHz OCXO (16 averages).

Other features include: low RMS jitter or residual FM at a user-specified band of offset frequency, amplitude noise measurements with internal detectors, external detectors that can be used to cover higher frequency ranges, and two-port residual (additive) phase noise and AM noise measurements.



▲ *Fig. 2 The measurement noise floor of the APPH6000.*



▲ *Fig. 3 Single channel measurement of 100 MHz OCXO.*

The APPH6000 offers VCO characterization: tuning characteristics such as frequency versus tuning voltage; tuning sensitivity, signal power level versus frequency or tuning voltage, and supply pushing figure. It also provides low noise internal DC sources that support automatic measurement of tuning and pushing figures. There is direct access to FFT analyzer input for the low noise measurement of trace noise and transients on supply and control signals, together with transient measurements of frequency and phase and PLL locking measurements.

SINGLE-CHANNEL PHASE NOISE MEASUREMENT

For phase noise analysis, the instrument uses an enhanced version of the PLL method, whereby the DUT signal and a (tunable) low noise RF source are locked in phase quadrature. The resulting baseband voltage is directly related to phase noise of the DUT and reference, and is subsequently post-processed and visualized.

When the DUT and reference source are connected, the measurement starts detecting the signal power of the DUT and adjusting the input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8851 SW Old Kansas Ave, Stuart, FL 34997 USA
Phone: 772-286-9300 or 800-544-5594 | www.emc-rflabs.com
Visit http://mwj.hotims.com/28498-24 or use RS# 24 at www.mwjournal.com/info

step attenuator for optimum power level. Either the internal reference is auto-tuned near the DUT frequency or an externally applied reference is manually tuned by the user.

The remaining small frequency difference results in a beat signal at the phase detector output that is used to derive the demodulation calibration factor of the phase detector, taking into account possible nonlinear operation of the detector. After calibration, the optimum loop bandwidth with corresponding loop filter parameters are determined, depending on the desired frequency offset range, frequency tuning gain and DUT frequency agility.

The loop is closed and phase lock is achieved and maintained during measurement using proprietary frequency acquisition and lock monitoring circuitry. The loop bandwidth is adjusted depending on the stability and the expected noise performance of the DUT. To maintain locking during a long measurement, the frequency drift of the DUT is checked periodically and, if necessary, the internal reference frequency is adjusted.

Once the PLL is in phase quadrature, the voltage fluctuations at the output are band-pass filtered and amplified with a gain-adjustable low noise amplifier. The adaptive gain and switchable high pass filters ensure that optimum dynamic range is presented to the consecutive FFT analyzer, depending on the DUT noise and offset to be measured. The FFT analyzer performs Fourier transformation and visualizes the results accordingly. For close-in phase noise, the noise suppression of the loop is fully compensated to derive accurate measurement results. There is also a two-channel cross-correlation option available, which further lowers the instrument noise floor.

INTERNAL LOW NOISE REFERENCE

Optionally, the APPH6000 can also be equipped with a low noise, DCFM capable signal source. Depending on the DUT stability and noise performance, the DCFM is automatically set to the appropriate sensitivity levels. Tracking ranges up to three percent of the carrier frequency allow measurements of heavily time-varying sources.

The complete system operates with speed and precision without requiring any additional test equipment and the instrument is remotely controlled via either a USB or LAN interface and supports SCPI syntax for control. Software drivers are also provided to simplify integration in other application software. A user friendly, powerful GUI runs on any Windows™ or Linux system and facilitates easy measurement set-up and data post-processing, with all kinds of memory and mathematical functions.

CONCLUSION

The APPH6000 signal analyzer is a versatile instrument capable of meeting most needs of the RF and microwave engineer. It is available in a compact and robust enclosure and will soon be offered as a 1U 19 inch rack system.

AnaPico AG,
Zurich, Switzerland,
Tel: +41 444 40 00 51,
e-mail: info@anapico.com,
www.anapico.com.

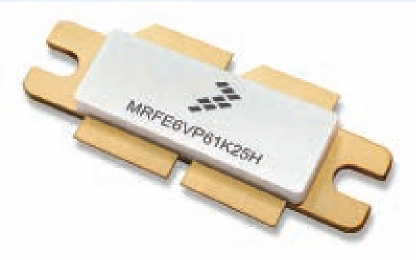
RS No. 301

TECH BRIEF

A 50 V LDMOS Power Transistor for High Impedance Mismatch Applications

Freescale Semiconductor has developed a RF LDMOS power transistor designed for operation from 1.8 to 600 MHz and optimized for use under the potentially-destructive impedance mismatch conditions encountered in applications such as CO_2 lasers, plasma generators and magnetic resonance imaging (MRI) scanners. The new MRFE6VP61K25H FET is the first 50 V LDMOS transistor to deliver its full-rated output power of 1250 W CW into a load after withstanding a Voltage Standing Wave Ratio (VSWR) of 65:1.

All solid-state RF power amplifiers operate most effectively when the greatest amount of power generated by their RF power transistors reaches the antenna. Under ideal conditions, this would result in a VSWR of 1:1, with all of the generated power reaching the load via the transmission line with none reflected back to the amplifier. VSWR levels in most applications rarely exceed 2.5:1 and most RF power transistors regardless of their technology can handle a VSWR of 5:1 to 10:1.

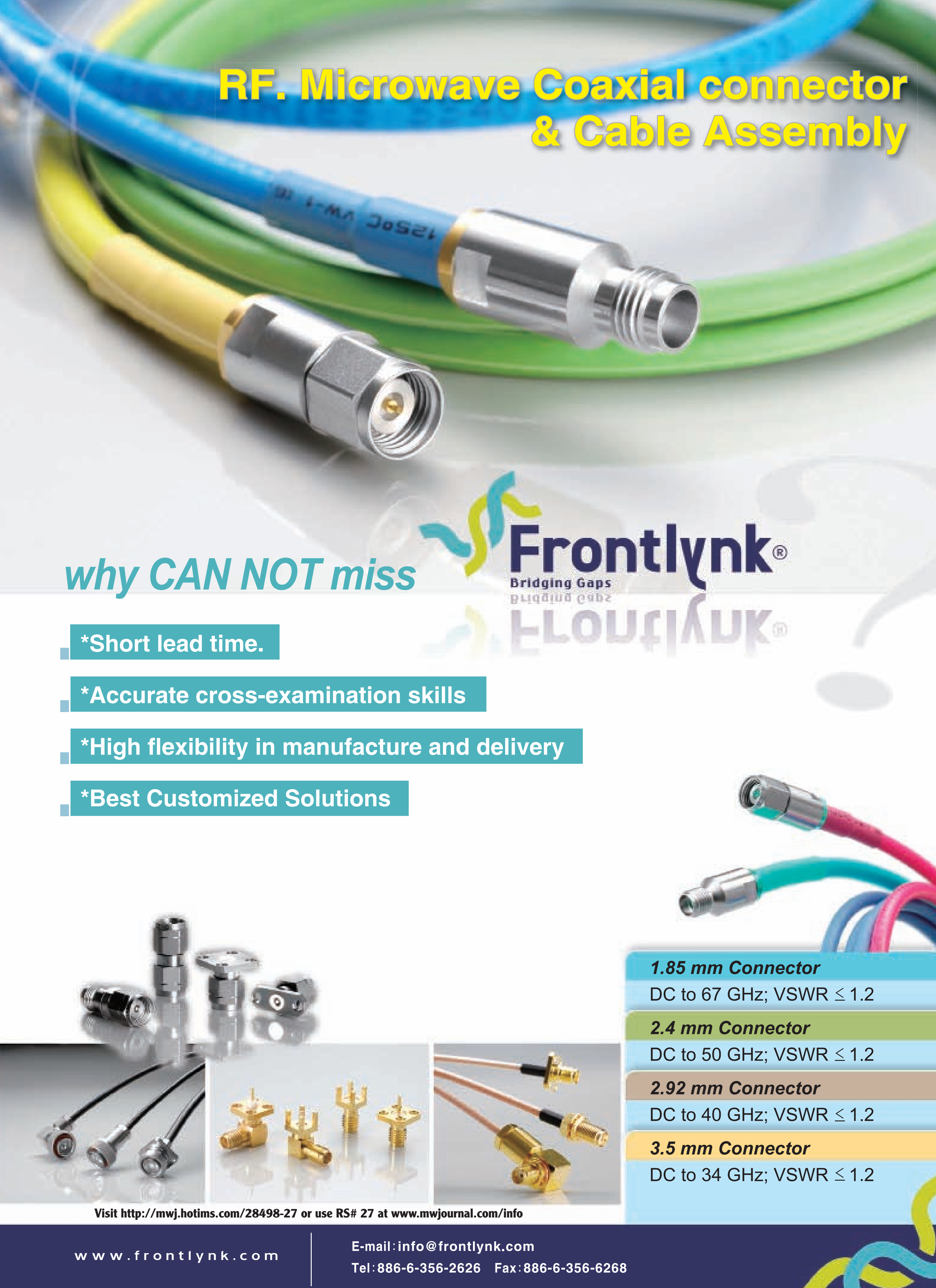


However, RF power amplifiers used to ignite CO_2 lasers and plasma generators, or to create an electromagnetic field in MRI systems, briefly encounter conditions in which nearly all of their generated power is reflected back to the amplifier. These extreme conditions present challenges for most RF power transistors.

The MRFE6VP61K25H LDMOS FET is designed primarily to serve these demanding applications and offers the ability to produce its full 1250 W of CW output power after withstanding a VSWR as high as 65:1 at all phase angles. It is the only 50 V LDMOS transistor commercially offered with this level of performance to date.

Freescale Semiconductor,
Austin, TX
(800) 521-6274,
www.freescale.com/rfpower.

RS No. 303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1.85 mm Connector
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DC to 50 GHz; VSWR ≤ 1.2
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DC to 40 GHz; VSWR ≤ 1.2
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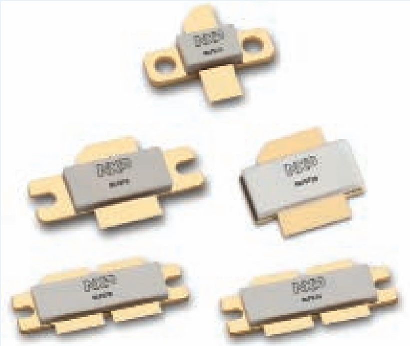
ISM RF Power LDMOS Transistor Family

To achieve higher power levels for Laterally Diffused MOS (LDMOS) transistors, NXP has developed a 50 V process that features the highest power density for LDMOS to date and is featured in the company's BLF57x family. The excellent power capabilities, gain, efficiency, linearity and reliability of LDMOS transistors make them the perfect choice for RF power amplifiers. The BLF57x devices deliver peak power levels between 20 and 1200 W. In Industrial, Scientific and Medical (ISM) applications, the outstanding bandwidth, ruggedness and thermal resistance of this HV LDMOS process are particularly critical features. Using advanced packages, the BLF57x family achieves thermal resistances as low as 0.14 K/W and can operate between 10 to >500 MHz. The BLF57x LDMOS transistors are designed to withstand, besides a VSWR of 10:1, an abrupt mismatch in the transmitter at full power.



KEY APPLICATIONS

- Broadcast transmitters
- Medical imaging
- RF plasma lighting
- RF heating
- Particle accelerators and storage rings
- Laser power supplies
- Solid-state cooking

KEY FEATURES

- Easy power control
- Integrated ESD protection
- Outstanding, field proven ruggedness
- High efficiency of 70 percent
- Excellent thermal stability
- Designed for broadband operation (10 to 500 MHz)

NXP Semiconductors,
Eindhoven, The Netherlands,
www.nxp.com.

RS No. 304

AR's Knowledge Center

VENDORVIEW

The AR Knowledge Center is a convenient virtual library featuring the company's complete educational and informative offerings including software and software updates, application notes, newsworthy articles and exciting product demonstrations. All materials are available for download including the Orange Book of Knowledge.

AR RF/Microwave Instrumentation,
160 School House Road,
Souderton, PA 18964

www.ar-worldwide.com

Hebrew Microsite

VENDORVIEW

AWR® Corp. has launched a Hebrew microsite on its corporate website to help RF/microwave engineers in Israel find company- and product-related information pertinent to AWR. The microsite also contains technical papers, white papers and industry news, as well as contact details for AWR's local sales support provider RDT Equipment and Systems Ltd. AWR is a Gold Sponsor of the upcoming 2011 IEEE (COMCAS) conference to be held November 7-9, 2011, in Tel Aviv, Israel.

AWR Corp.,
1960 E. Grand Avenue,
El Segundo, CA 90245

http://web.awrcorp.com/Hebrew

Components and Design Services

Electro-Photonics is a global supplier of high frequency components and design services. The company's products include wire bondable passive components, coaxial products, cable assemblies, printed antennas, high frequency test fixtures and custom high frequency packages. Electro-Photonics can support small R&D design requirements and offer chip and wire assembly services in a 10K clean room and high frequency measurements to 110 GHz.

Electro-Photonics LLC,
2293 SW Martin Hwy. #272,
Palm City, FL 34990

www.electro-photonics.com

ICs, Modules, Subsystems & Instrumentation

VENDORVIEW

Hittite's redesigned website includes a dynamic homepage featuring full specifications for over 875 products across 28 product lines, press releases and featured articles. Comprehensive Individual Product "Splash Pages" containing in-depth product information and technical content are located on one easy to navigate page. Engineers will find improved Product Support and streamlined Quality & Reliability pages containing invaluable reference materials.

Hittite Microwave Corp.,
20 Alpha Road,
Chelmsford, MA 01824

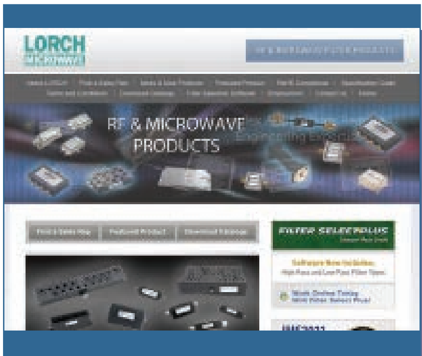
www.hittite.com

Video Tutorials

In order to get acquainted with the software, a new and convenient learning tool has been introduced in the download section of the EMPIRE XCcel website. Video tutorials demonstrate, step-by-step, how to use the software for typical applications. Mouse movements and clicks are indicated and the video can be stopped or rewound at any time. Videos offer guidance via audio comments, which explain all steps in detail. The videos can be displayed online by using the latest Acrobat reader or downloaded as an executable.

IMST GmbH,
E-mail: contact@imst.com.

www.empire.de



Microwave Components and Subsystems

The Lorch Microwave website has been redesigned with ease of navigation in mind and includes more product information on the company's complete line of filters, RF products and integrated assemblies. Lorch Filter Select Plus software has also been updated to include high pass and low pass options. Lorch provides microwave components and subsystems for the most demanding applications to military, industrial and commercial markets worldwide.

Lorch Microwave,
1725 N. Salisbury Boulevard,
Salisbury, MD 21802

www.lorch.com

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Phase1-63E5

Filters, Diplexers and Sub-assemblies

VENDORVIEW

Reactel Inc. has revamped its website, www.reactel.com, offering a new look and much more information. Accessing information of issuing an RFQ for the company's products has never been easier, and is now just a click away. Reactel's full line catalog of RF and microwave filters, multiplexers and multifunction assemblies catalog is available for download in support of its worldwide customer base.

Reactel Inc.,
8031 Cessna Avenue,
Gaithersburg, MD 20879

www.reactel.com

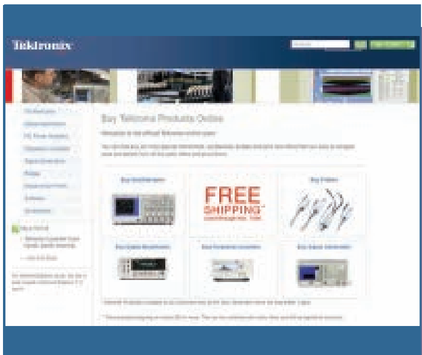
GaAs and GaN Products

VENDORVIEW

RFHIC's redesigned website provides a comprehensive, user-friendly selection of GaAs and GaN products. RFHIC, a global leader in the design and manufacture of RF and microwave components with a comprehensive product portfolio from discrete to integrated high power amplifiers, with high efficiency, thermally robust design and surprisingly low price, designs systems with high performance GaN and GaAs solutions growing in Green.

RFHIC USA,
1020 Southhill Drive, Suite 140,
Cary, NC 27513

www.rfhic.com

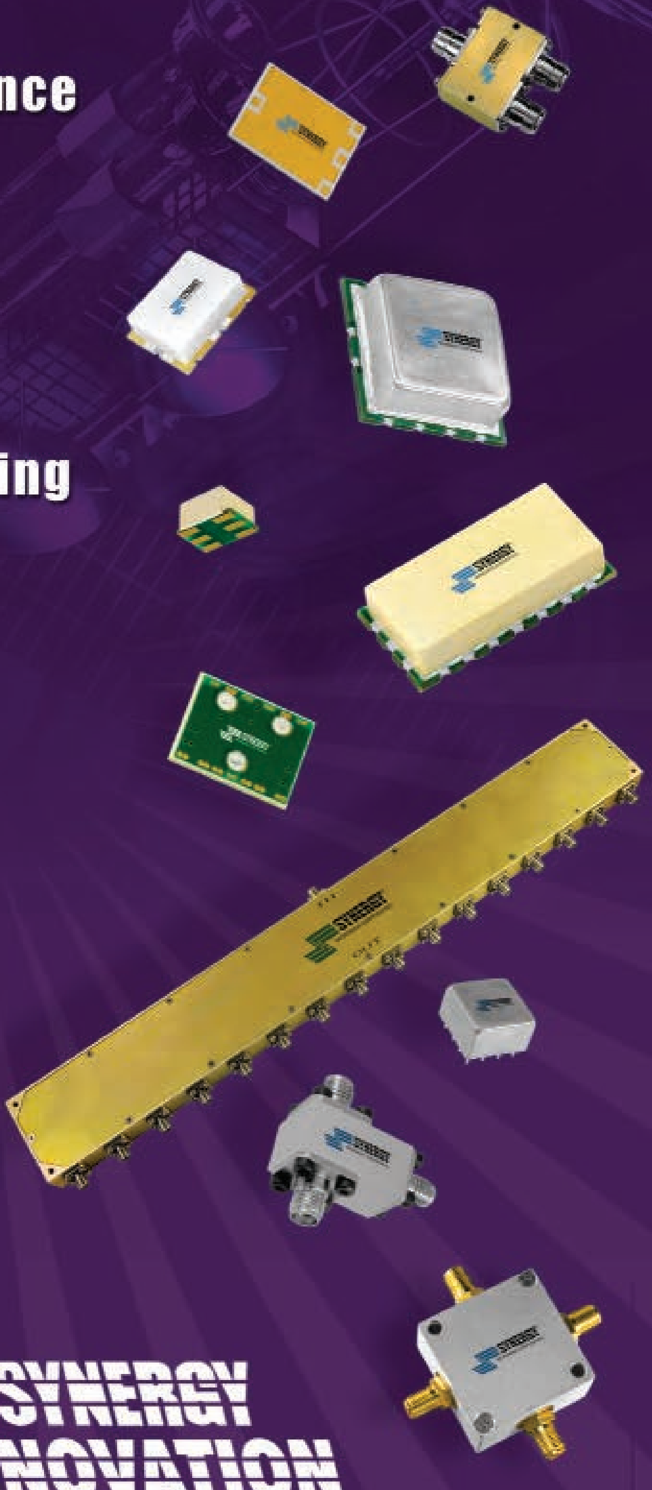


Online Store

The new online store gives customers the added convenience of purchasing many of the most popular instruments, accessories, probes and parts directly from Tektronix, and enables customers to take advantage of the latest offers and promotions. The store offers a convenient, easy-to-use purchase experience with a pay by credit card option – no purchase order is required – and is available 24/7 for customers in the United States.

Tektronix Inc.,
14150 SW Karl Braun Drive,
PO Box 500,
Beaverton, OR 97077

http://store.tektronix.com/



Components

SMPM Attenuator

Aeroflex/Inmet has introduced a new line of fixed attenuators incorporating the popular SMPM connector. This self-aligning push-on connector is a miniature version of the company's SMP attenuator and provides reliable high performance, excellent RF characteristics and mates with GPPO™ connectors. First to market is the model 6MP, the 6 GHz version, offering a variety of attenuation values designed for use in tight quarters whether the requirement is in manufacturing or semiconductor chip test applications. Higher frequency ranges for expanded use are in the works and will be available soon.

Aeroflex/Inmet,
Ann Arbor, MI (734) 426-5553,
www.aeroflex.com.

RS No. 216

Integrated Microwave Assemblies

This X-band assembly is another example of AML's expertise in designing compact multifunctional integrated microwave assemblies (IMA) while delivering industry leading low phase noise performance. Characteristics include high gain (60 dB), a high Q bandpass filter, a variable phase shifter (360° range) and multiple coupled ports. This IMA is part of a low phase noise oscillator with high spectral purity developed for military radar and communication systems.

AML Communications Inc.,
Camarillo, CA (805) 388-1345,
www.amlj.com.

RS No. 217

SP3T-SP6T Multi-position Switch

The QK series coaxial multiswitch features K type connectors with a frequency range of DC to 40 GHz. Available actuator options include normally Open and TTL circuitry with integrated indicator circuits. Terminated models are also available with the 2.4 mm connector. This switch features an RF impedance of 50 ohms nominal; operating temperature of -35° to +85°C ambient; operating life of 1,000,000+ cycles; switching time of 15 mSec maximum; switching sequence: Break Before Make; and environmentally is designed to meet MIL-E-5400 and Mil-S-3928.

Ducommun Technologies,
Carson, CA (310) 513-7214,
www.ducommun.com.

RS No. 218

DC to 50 GHz Cable Assemblies

Electro-Photonics LLC announces the availability of ultra-flexible, low loss high frequency cable assemblies. The company's unique boot construction offers superior durability and ease of handling in all RF/microwave applications requiring excellent electrical performance, high mechanical endurance and repeatability. These low loss cable assemblies have excellent phase stability over temperature and flexure. The company's cables are used in military, commercial and wireless test applications.

Electro-Photonics,
Palm City, FL (772) 485-0927,
www.electro-photonics.com.

RS No. 219

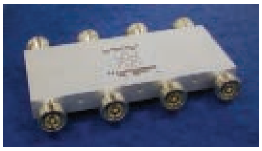
Hybrid Coax Drop-in Models

M2 Global has extended the frequency range of its hybrid coax drop-in models up to 14 GHz. The package size for these higher frequency units is 0.64" × 0.74" × 0.25", and can include a 50 W termination in the isolator configuration. With drop-in construction, these coax isolators and circulators are ideal for higher power applications with lower cost. Encapsulation is available for high peak power applications. Four-port versions are also available.

M2 Global,
San Antonio, TX (210) 561-4800,
www.m2global.com.

RS No. 220

4×4 Hybrid Matrix



Microlab announces the addition of new 4 × 4 hybrid matrices with exceptional 30 dB isolation and <-160 dBc PIM. This has been achieved with radical new circuitry, eliminating the signal path discontinuities of previous designs while having all inputs conveniently located on the same side. The CM-58D covers the 1710 to 2700 MHz band, which includes the new LTE and WiMAX band in the 2490 to 2690 MHz spectrum. The CM-58D is designed for up to 100 W average, 3 kW peak power per input, and may be moisture sealed to meet IP67, so is suitable for use in both outdoor and indoor applications such as radio base stations, in signal combiner boxes and in-building distribution systems. Similar units are available for other wireless bands, and with N connectors.

Microlab/FXR,
Parsippany, NJ
(973) 386-9696,
www.microlab.fxr.com.

RS No. 221

PIN Diode Switches

Micronetics' ES0339 family of PIN diode HF, VHF, UHF broadband high power switches are ideal for broadband T/R switches. Power levels of 1 kW CW into a 2:1 load are achievable over multiple octave bandwidths. These switches are multi-octave, well suited for jamming applications. The switches have an onboard FET driver for 2 uSec switching that features switch state sense TTL output and fault-detection. Lastly, these switches have an on-board DC-DC converter that converts low voltage bias to the high negative voltage required for high power PIN diode switches thus negating the need for a high voltage power supply.

Micronetics Inc.,
Hudson, NH (603) 883-2900,
www.micronetics.com.

RS No. 222

Hybrid Coupler

VENDORVIEW

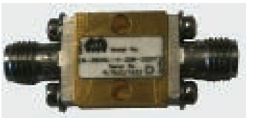
Narda introduced the 4034C miniature stripline coaxial microwave 90-deg. hybrid coupler that is extremely rugged, offers high isolation, and resists shock and vibration. The model 4034C offers a coupling of 3 dB, operates from 4 to 8 GHz, handles 50 W average and 5 kW peak power, and has isolation of at least 20 dB. Insertion loss is 0.3 dB or less, VSWR is 1.25:1 or less, amplitude balance is ±0.6 dB and phase balance is 10 deg. The hybrid measures 1" × 0.5" × 0.36", weighs 0.6 oz., and has female SMA connectors. The model 4034C meets military requirements for shock and vibration and has an operating temperature range of -54° to +105°C. The model 4034C is available from Narda for immediate delivery.

Narda,
Hauppauge, NY (631) 231-1700,
www.nardamicrowave.com/east.

RS No. 223

Ultra-small Limiter

Model LM-35D5G-14-20W-292FF is a high power limiter capable of withstanding an input power level of 20 W, 440 to 670 nsec pulse width, PRF 600 to 900 kHz, 40 percent duty cycle. This model operates in the 35 to 36 GHz frequency range, but can be used over the 24.5 to 38 GHz frequency range with degraded performance. The insertion loss is 3.0 dB maximum, VSWR of 2.0:1 and 250 nsec response time packaged in a small 0.50" × 0.50" × 0.22" housing.

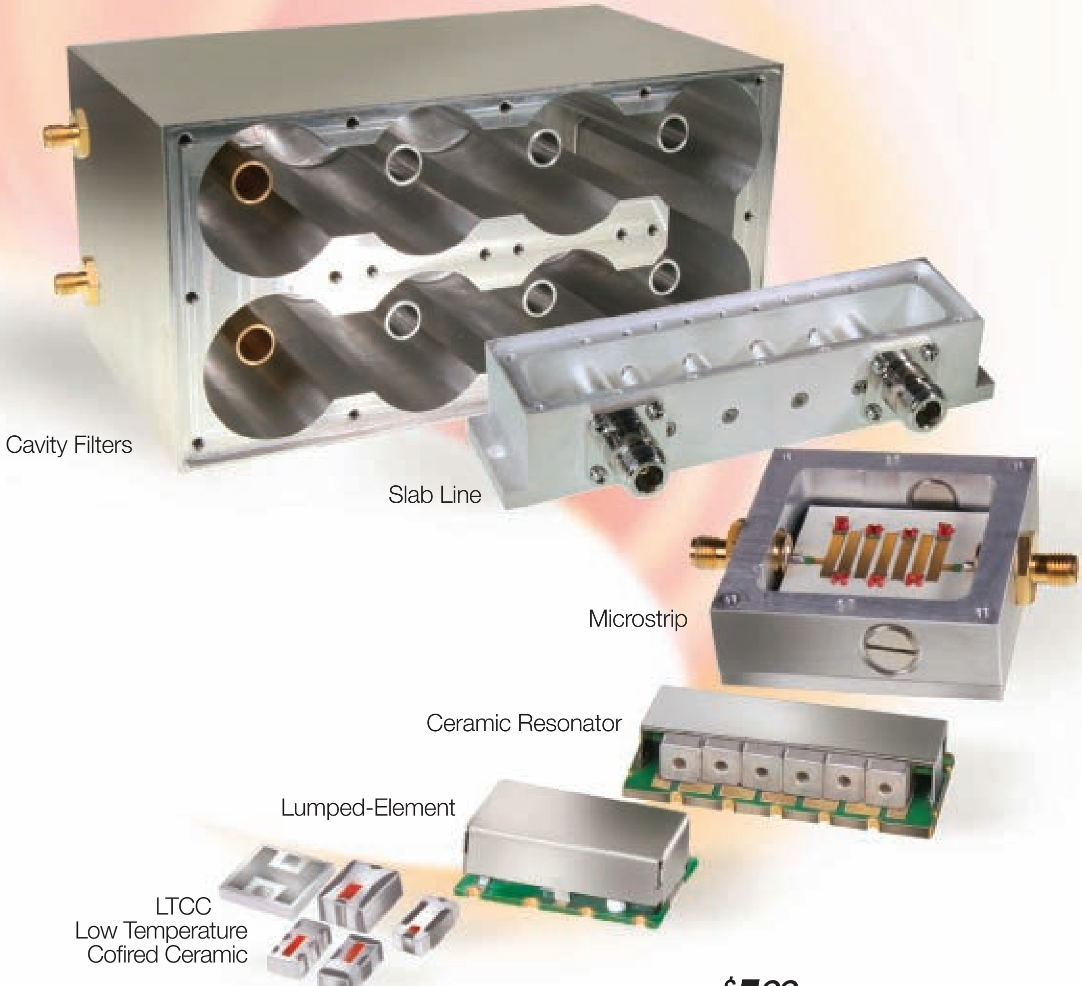


Planar Monolithics Industries Inc.,
Frederick, MD
(301) 662-5019,
www.pmi-rf.com.

RS No. 224

FILTER SOLUTIONS

DC to 15 GHz



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In Yoni2, you can enter the response type, connection option, frequency, insertion loss, or any other specifications you have. If a model cannot be found, we understand the sense of urgency. So contact us, and our engineers will find a quick, cost-effective, custom solution and deliver simulation results within a few days.

Yoni2® U.S. patent 7739260 ***The Design Engineers Search Engine...*** *finds the model you need, Instantly.*

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IF/RF MICROWAVE COMPONENTS

484 Rev. Orig.

Visit http://mwj.hotims.com/28498-52 or use RS# 52 at www.mwjournal.com/info

Amplifiers

Digital Attenuator

Pulsar model DAT-24-480/2S is an 8 bit, 0 to 32 dB digital attenuator that operates in a frequency range from 6 to 18 GHz with an LSB of 0.12 dB. Maximum insertion loss is 6 dB and the maximum VSWR is 2.0:1. Control logic is TTL and switching time is 500 nsec typical. Flatness is ± 2.0 dB at 32 dB.

Pulsar Microwave,
Clifton, NJ
(973) 779-6262,
www.pulsarmicrowave.com.

RS No. 225

Coaxial to Waveguide Adapters

RLC Electronics now offers coaxial to waveguide adapters in a variety of configurations for specific applications. Option A includes broadband adapters whose excellent electrical specs are maintained over the entire adapter bandwidth, while option B offers enhanced performance over a specific band of the adapters' bandwidth. Computer design and the latest in RF techniques coupled with precision assembly ensure optimal electrical performance in the recommended frequency ranges.

RLC Electronics Inc.,
Mount Kisco, NY (914) 241-1334,
www.rlcelectronics.com.

RS No. 226

Surface-mount Limiter Diode

VENDORVIEW

This high power surface-mount limiter diode is designed for receiver protection applications ranging from 10 MHz to over 6 GHz. This low capacitance, low thermal resistance silicon PIN limiter diode is designed as a shunt connected PIN diode and can be utilized in multiple markets, including infrastructure, military, consumer, land mobile radios, jammers and radar. This low loss, general market diode is ideal for high volume commercial and industrial OEMs, ODMs and contract manufacturers.

Skyworks Solutions Inc.,
Woburn, MA
(781) 376-3000,
www.skyworksinc.com.

RS No. 227

Battery Powered Wideband Amplifier

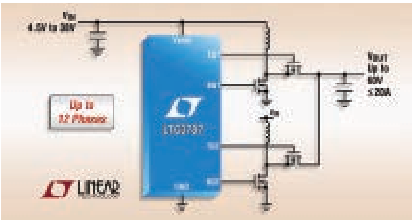
VENDORVIEW

The BOX-010200 self-contained battery powered amplifier provides a portable and rugged gain block for situations where cordless operation is either essential or preferred. The amplifier provides 25 dB of gain across the entire 1 to 20 GHz frequency range with typically +13 dBm output power at the 1 dB gain compression point and 3 to 5 dB noise figure. The MIC design utilizes GaAs PHEMT distributed amplifier MMIC technology, together with proprietary matching circuits within a robust die-cast aluminum alloy housing that also contains a rechargeable NiMH battery. A battery charger is supplied with each unit.

AtlanTecRF,
Braintree, UK +44 (0)1376 550220,
www.atlantecrf.com.

RS No. 228

Boost Controller



Linear Technology Corp. announces the LTC3787, high power, two-phase single output synchronous step-up DC/DC controller, which replaces the boost diodes with high efficiency N-channel MOSFETs. This solution eliminates the heat sink normally required in medium to high power boost converters. The LTC3787 can produce a 24 V at 10 A output from a 12 V input at up to 97 percent efficiency. The LTC3787's 135 uA standby quiescent current when configured for Burst Mode® operation makes it ideal for high power automotive audio amplifiers, as well as industrial and medical applications where a step-up DC/DC converter must deliver high power in a small solution size.

Linear Technology Corp.,
Milpitas, CA (408) 432-1900,
www.linear.com.

RS No. 229

5 to 20 GHz Wideband Microwave Amplifier

VENDORVIEW

The Mini-Circuits AVA-24+ is a surface-mount microwave amplifier and fully integrated gain block up to 20 GHz. It is packaged in Mini-Circuits' industry standard 3×3 mm MCLP (QFN) package, which provides excellent RF and thermal performance. The AVA-24+ integrates the entire matching network with the majority of the bias circuit inside the package, reducing the need for complicated external circuits. This approach makes the AVA-24+ extremely flexible and en-

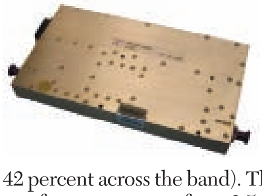
ables simple, straightforward use.
Mini-Circuits, Brooklyn, NY
(718) 934-4500, www.minicircuits.com.
RS No. 230

Waveguide LNA

VENDORVIEW

MITEQ's model AMFW-6F-18102120-120 is part of a new line of low profile, lightweight, small volume and high dynamic range Ka-band very low noise amplifiers. The new SATCOM LNA family offers a unique combination of features and performance in an extremely small footprint. Total weight is approximately 125 grams maximum, has a pressurizable waveguide at the input, and its package profile is 104 × 22 × 34.5 mm. The input conforms to WR42 and is available in grooved or flat flange. See Outline 165402 on the MITEQ website for more details. Numerous models cover 18.10 to 21.5 GHz in various sub-bands of 1 GHz and wider, with P1dB of 10 to 23 dBm across the full band.
MITEQ Inc.,
Hauppauge, NY (631) 436-7400,
www.miteq.com.
RS No. 231

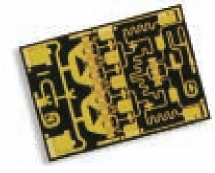
Solid-state Power Amplifier



Stealth Microwave introduces the SM2560-44GN, a 25 W GaN SSPA with industry-leading efficiency (32 to 42 percent across the band). This model operates in a frequency range from 2.5 to 6 GHz. The use of the latest GaN devices allows for superior gain flatness, along with an advanced RS-485 PA monitoring and control interface. MCU-controlled temperature compensation and gain control is standard and rugged construction allows for operation in harsh environments.
Stealth Microwave,
Ewing, NJ (609) 538-8586,
www.stealthmicrowave.com.
RS No. 232

GaN Power Amplifier

VENDORVIEW



TriQuint has released a new 30 W state-of-the-art gallium nitride (GaN) power amplifier with high power and efficiency for counter-IED (C-IED) and other EW (electronic weapons) systems. The TGA2576 delivers 30 W of saturated output power in the 2.5 to 6 GHz range. The new device is fabricated using TriQuint's production-released GaN on SiC process; it typically offers 30 percent PAE and 25 dBm of small-signal gain. Die-level samples of the TGA2576 are available; packaged samples are expected in early 2011.
TriQuint Semiconductor Inc.,
Hillsboro, OR (503) 615-9000,
www.triquint.com.
RS No. 233

Sources

Phase-locked Crystal Oscillator

The PLXO-100 is a phase-locked crystal oscillator operating at 100 MHz in a miniature connectorized package (1.5" × 2" × 0.6"), featuring exceptionally low phase noise (-125 dBc/Hz at 1 kHz). The device exhibits low spurs (-80 dBc), +7 dBm output power and supply voltage of +12 VDC, while locked to a 10 MHz external reference (or optional internal reference). EM Research offers the PLXO Series in a surface-mount or connectorized package at custom fixed-frequencies from 5 to 500 MHz. The PLXO series features low jitter (< 0.05 pSec; RMS at 100 MHz, typical), optional internal references and select supply voltages (+3.3, +5, +8, +12 or +15 VDC).
EM Research Inc.,
Reno, NV (775) 345-2411,
www.emresearch.com.
RS No. 234

MMIC Voltage-controlled Oscillators

VENDORVIEW

These two new SMT packaged MMIC voltage-controlled oscillators (VCO) are ideal for industrial/medical test & measurement equipment, military communications, EW, and ECM applications from 6 to 20 GHz. The HMC732LC4B and HMC733LC4B are wideband GaAs InGaP HBT MMIC voltage-controlled oscillators that incorporate the resonator, negative resistance device and varactor diode. These fully integrated MMIC VCOs provide output tuning ranges of 6 to 12 GHz and 10 to 20 GHz, respectively. The HMC732LC4B delivers high output power of +1 dBm and low SSB phase noise of -95 dBc/Hz at 100 kHz offset, while the HMC733LC4B delivers output power of +3 dBm and SSB phase noise of -90 dBc/Hz at 100 kHz offset from the carrier.
Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343,
www.hittite.com.
RS No. 235

Phase-locked Oscillator

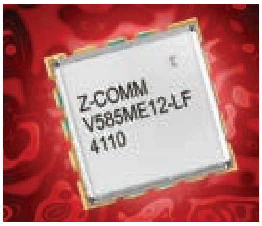
The PLS-4900-Q10E is a high performance, low noise, 4.9 GHz phase-locked oscillator (PLO). The design of this PLO's primary source consists of a low-noise, bipolar-silicon-transistor oscillator. In addition, a buffer amplifier in the output path provides the desired power output and load isolation. Power output is 17 dBm (typical) into a 50 ohm load. Phase noise at 10 kHz and 100 kHz offsets is -110 dBc/Hz and -130 dBc/Hz, respectively. The PLS-4900-Q10E requires a 10 MHz external

reference oscillator and is housed in a compact (4.5" × 2.25" × 0.63") connectorized package.

Phase Matrix Inc.,
San Jose, CA (408) 428-1000,
www.phasematrix.com.

RS No. 236

L-band Voltage-controlled Oscillator



The RoHS compliant voltage-controlled oscillator (VCO) model V585ME12-LF operates in a frequency range from 1500 to 1900 MHz with a tuning voltage range of 0.8 to 20 VDC. This VCO features a typical phase noise of -102 dBc/Hz at 10 kHz offset and a typical tuning sensitivity of 35 MHz/V. The V585ME12-LF is designed to deliver a typical output power of 5.75 dBm at 10 VDC supply while drawing 15 mA (typical) over the temperature range of 0° to 80°C. This VCO features typical second harmonic suppression of -10 dBc and comes in Z-Comm's MINI-14 package measuring 0.5" × 0.5" × 0.22".

Z-Communications Inc.,
Poway, CA (858) 621-2700,
www.zcomm.com.

RS No. 237

Test Equipment

Multi-harmonic Load-pull Tuner

Targeting applications where space is limited but still requiring the need for harmonic load-pull, such as on-wafer environments, the iMPT-C-Lite load-pull tuner brings all of the performance benefits of the iMPT-Lite in a package half the size and weight. In contrast to harmonic load-pull tuners based on bulky and expensive cascaded tuners, unable to fit on a probestation, the iMPT-C-Lite is based on Focus's proprietary MPT technology to advanced harmonic tuning in a single tuner. Offering all of the performance capabilities of the iMPT-Lite, including high VSWR tuning, superior accuracy bandwidth and ease of calibration, the iMPT-C-Lite covers 1.8 to 18 GHz.

Focus Microwaves Corp.,
Montreal, Canada (408) 891-1777,
www.focus-microwaves.com.

RS No. 238

Signal-to-Noise Generators

Noisecom has launched its new CNG-EbNo series of precision signal-to-noise generators. These analyzers are designed for Carrier-to-Noise (C/N), Carrier-to-Noise density (C/No), Signal-to-Noise (S/N), Carrier-to-Interferer (C/I) and Bit Energy-to-Noise density (Eb/No) analysis. The instruments are used for satellite communications, cable TV, telecommunications and many other critical applications that demand accuracy and repeatability in the analysis of data transmission systems.

Noisecom,
Parsippany, NJ (973) 386-9696,
www.noisecom.com.

RS No. 239

Frequency Converters

VENDORVIEW

The new R&S ZVA-Z500 frequency converters expand the frequency range of the R&S ZVA24, R&S ZVA40, R&S ZVA50, R&S ZVA67 and R&S ZVT20 high-end network analyzers to cover the 325 to 500 GHz range. The converters enable millimeter-wave measurements with

a typical dynamic range of > 65 dB and a typical output power of -24 dBm. They are suitable for research and development of components in the millimeter-wave range as well as for antenna measurements and microwave imaging. The R&S ZVA-Z500 can be used with a WR02 waveguide connector to analyze components such as amplifiers, mixers and filters, and is suitable for use with commercially available wafer prober systems.

Rohde & Schwarz,
Munich, Germany +49 89 4129 13774,
www.rohde-schwarz.com.

RS No. 240

Logic Analyzer

The TLA6000 series is a logic analyzer that brings powerful high-end debug and analysis to mainstream embedded systems designers. The TLA6000 series delivers performance and functional capability previously only found on the high performance TLA7000 Series of instruments at a much lower price point, while offering more capabilities than the portable TLA5000 Series models. Higher signal speeds and increased board densities often lead to signal integrity issues such as crosstalk, ground bounce, and ringing that manifest themselves in functional failures of the digital system. The TLA6000 Series gives engineers a complete toolset to help them quickly find, isolate and debug these hard-to-isolate issues.

Tektronix Inc.,
Beaverton, OR (800) 833-9200,
www.tektronix.com.

RS No. 241

IMS2011 in Baltimore: A Perfect Match

IEEE

Final Call for Papers

MTT-S

Deadline for Paper Submission: Friday, December 3, 2010

IEEE MTT-S 2011 International Microwave Symposium
Baltimore Convention Center
June 5-10, 2011
www.ims2011.org

The IEEE Microwave Theory & Techniques Society (MTT-S) International Microwave Symposium for 2011 (IMS2011) will be held in Baltimore, Maryland, as the centerpiece of Microwave Week 2011, and is scheduled from Sunday, June 5 through Friday, June 10, 2011.

IMS2011 offers technical paper sessions, interactive forums, plenary and panel sessions, workshops, short courses, industrial exhibits, application seminars, historical exhibits, and a wide array of other technical and social activities including a guest program. The Awards Banquet and Crab Feast are two of the highlights of the social activities. Collocated with IMS2011 are the RFIC Symposium (www.rfic2011.org) and the ARFTG Conference (www.arftg.org), which comprise the Microwave Week 2011 technical program.

PAPER SUBMISSION INSTRUCTIONS: Authors are invited to submit technical papers describing original work on radio-frequency, microwave, and millimeter-wave theory and techniques. The deadline for submission is **December 3, 2010**. **Late papers will not be reviewed.** Please refer to the IMS2011 website (www.ims2011.org) for complete submission information.

INVITATION TO SUBMIT PAPERS IN EMERGING TECHNICAL AREAS: IMS2011 enthusiastically invites submission of papers that report state-of-the-art progress in technical areas that are outside the scope of the listed areas below, or that may be new to the Symposium but are of interest to our attendees. Authors who have other original research results that are of interest are encouraged to submit to IMS2011 by selecting one of the Emerging Technical Areas.

STUDENT PAPER COMPETITION: Students are encouraged to submit papers which will be evaluated using the same standards as all contributed papers, and will be eligible for the Student Paper Competition. Please consult the IMS2011 website (www.ims2011.org) for full details.

INVITATION TO SUBMIT PROPOSALS FOR SPECIAL SESSIONS, WORKSHOPS, AND SHORT COURSES: The Symposium invites proposals for Special Sessions (including focused, honorary, etc.), Workshops, Panel and Rump Sessions, and Short Courses (ranging from introductory to expert level). Special Sessions on topics that will be of high interest to the Symposium or particular relevance to the microwave community in the Washington DC/Baltimore area are solicited. Please consult the IMS2011 website (www.ims2011.org) for instructions on preparing a proposal. Proposals must be received by **September 17, 2010.**

Some Important Dates

Sep. 17, 2010	Dec. 3, 2010	Jan. 31, 2011	Mar. 11, 2011	Mar. 18, 2011	Jun. 5-10, 2011
Friday	*Friday*	*Monday*	*Friday*	*Friday*	*Sun. – Fri.*
Proposal Submission Deadline	**Paper Submission Deadline**	**Paper Disposition Notification**	**Manuscript Submission Deadline**	**Notes Submission Deadline**	**Microwave Week**
for Workshop, Short Course, Special Session, Panel and Rump Session	*all submissions must be made electronically*	*authors will be notified via e-mail and on the website*	*for the final manuscript of accepted papers and copyrights*	*electronically upload both color and B&W versions of Workshop Notes*	*IMS2011, RFIC2011, 77th ARFTG, and Exhibition*

Visit www.ims2011.org
for an expanded description of these Technical Areas

Microwave Field and Circuit Techniques
1. Field Analysis and Guided Waves
2. Frequency-Domain EM Analysis Techniques
3. Time-Domain EM Analysis Techniques
4. CAD Algorithms and Techniques
5. Linear Device Modeling
6. Nonlinear Device Modeling
7. Nonlinear Circuit and System Simulation

Passive Components
8. MEMS Components and Technologies
9. Transmission Line Elements
10. Planar Passive Filters and Multiplexers
11. Non-planar Passive Filters and Multiplexers
12. Active, Tunable, and Integrated Filters
13. Ferroelectric, Ferrite, and Acoustic Wave Components
14. MEMS Components and Technologies

Active Components
15. Semiconductor Devices and Monolithic ICs
16. Signal Generation
17. Frequency Conversion and Control
18. HF, VHF, and UHF Technologies and Applications
19. Power Amplifier Devices and Circuits
20. High-Power Amplifiers
21. Low-Noise Components and Receivers
22. Millimeter-Wave and THz Components and Technologies

Systems and Applications
23. Microwave Photonics
24. Signal Processing Circuits at GHz Speeds
25. Packaging, Interconnects, MCMs and Integration
26. Instrumentation and Measurement Techniques
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28. Arrays as Antennas and Power Combiners
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33. High Power Microwave Industrial Applications

Emerging Technical Areas
34. RF Nanotechnology
35. New Technologies and Applications
36. Innovative Systems

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RF/Microwave Training Series
Presented by Besser Associates
Component Modeling – A look at the behavior and design considerations behind passive components at microwave frequencies where parasitic behavior greatly impacts electrical performance,
Live webcast: 12/14 • *Sponsored by AWR*

Innovations in EDA Series
Presented by Agilent
Accurate Modeling of Packages and Interconnects – Different methods of IC package and interconnect characterization are explored including equivalent circuit models, EM simulations, and measurements. Several case studies are presented to highlight the trade-offs of each.
Live webcast: 12/2 • *Sponsored by Agilent Technologies*

LTE Network Measurements
Presented by Rohde & Schwarz
Make your LTE Call Now! – Determine the end user performance of an LTE network using measurements and analysis of key performance indicators. Based on real life LTE network measurements, the coherence of test results will be explained and used to illustrate methods to solving potential issues.
Available: 12/1 • *Sponsored by Rhode & Schwarz*

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MMICs
Presented by Freescale
GaAs Low Noise Amplifier Design Trade-offs in the Working World – This presentation examines the engineering design decisions behind developing a new GaAs LNA MMIC. An example design will be presented and design trade-offs discussed as well as some RF performance attributes involving small signal linear driver amplifiers.
Live webcast: 12/7 • *Sponsored by Freescale Semiconductor*

HFSS 13.0
Presented by Ansoft Software (ANSYS Product Portfolio)
Transient FEM solvers and Hybrid FE/IE Methods – Finite Element Boundary Integral is a new technique for analyzing open boundary problems with HFSS, allowing antenna designers to solve large scale antenna, antenna placement and scattering problems with a high degree of accuracy and efficiency.
Live webcast: 12/8 • *Sponsored by ANSYS*

CST Studio 2011
Presented by CST
Integrating Simulation Technology – This preview of STUDIO SUITE 2100, which begins shipping in January, highlights the new features and workflow capabilities addressing 3D EM simulations for complex systems.
Live webcast: 12/9 • *Sponsored by CST*

Multi-physics Analysis
Presented by Dr. Philippe Masson, Advanced Magnet Lab
Creating Real-World EM Simulations – Physical effects, such as heat transfer and mechanical forces, can make a big impact on the performance of electromagnetic devices. This webinar presents the implementation of multi-physics simulation using a real-world example.
Live webcast: 12/15 • *Sponsored by COMSOL*

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Presented by Besser
- Communications System Design: RF/Wireless Signal Propagation Analysis
- MIMO and Other Multiple Antenna Techniques
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Innovations in EDA
Presented by Agilent
- Applying the latest Technologies to MMIC Design
- A Practical Approach to Verifying RFICs with Fast Mismatch Analysis
- Discrete Oscillator Design Tools & Techniques

Market Analysis
Presented by Strategy Analytics
MilSatcom Electronic Market Trends through 2020

Leadership in Education
- Cost-Effectively Build mmWave Applications with TriQuint's New TQP15 Process
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- A Systems Mentality Drives Next Generation MMIC Design
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Full Listing at: mwjournal.com/webinars

Nanotechnologies for Future Mobile Devices

Tapani Ryhänen, Mikko A. Uusitalo, Olli Ikkala and Asta Kärkkäinen

Nanotechnologies for Future Mobile Devices is not a book we would typically review because it covers many subjects not related to wireless technologies. It does, however, take a very interesting look at the future of connected devices, which should be of interest to many in our field. The chapters related to connected devices and the future of radio and communications are certainly of interest, as are some of the other discussions regarding energy, power, computing and sensing, thereby making *Nanotechnologies for Future Mobile Devices* an appropriate choice for the Bookend for our December issue on Industrial, Scientific and Medical (ISM) applications.

This book explores the potential for nanotechnologies to transform future mobile and Internet communications. Based on research collaboration between Nokia, Helsinki University of Technology and the University of Cambridge, leading researchers review the current state-of-the-art and future prospects for: Novel multifunctional materials, dirt repellent, self-healing surface materials and lightweight structural materials capable of adapting their shape; portable energy storage using supercapacitor-battery hybrids based on new materials, including carbon nanohorns and porous electrodes, fuel cell technologies, energy harvesting and more efficient solar cells; electronics and computing advances reaching beyond IC scaling limits, new computing approaches and architectures, embedded intelligence and future memory technologies; nanoscale transducers for mechanical, optical and chemical sensing, sensor signal processing, and nanoscale actuation; nanoelectronics to create ultrafast and adaptive electronics for future radio technologies; flat panel displays with greater robustness, improved resolution, brightness and contrast, and mechanical flexibility; and manufacturing and innovation processes, plus commercialization of nanotechnologies.

Certainly the most interesting chapter is about future radio and communications that includes discussions about wireless applications using carbon nanotubes, nanoelectromechanical systems, graphene transistors and other emerging technologies. This is a good book about future technologies and trends for the wireless industry and kicks off 2011 with some fresh ideas.

To order this book, contact:

Cambridge University Press
32 Avenue of the Americas
New York, NY 10013-2473
(212) 924-3900

268 pages; $56, £45 · ISBN: 9780521112161

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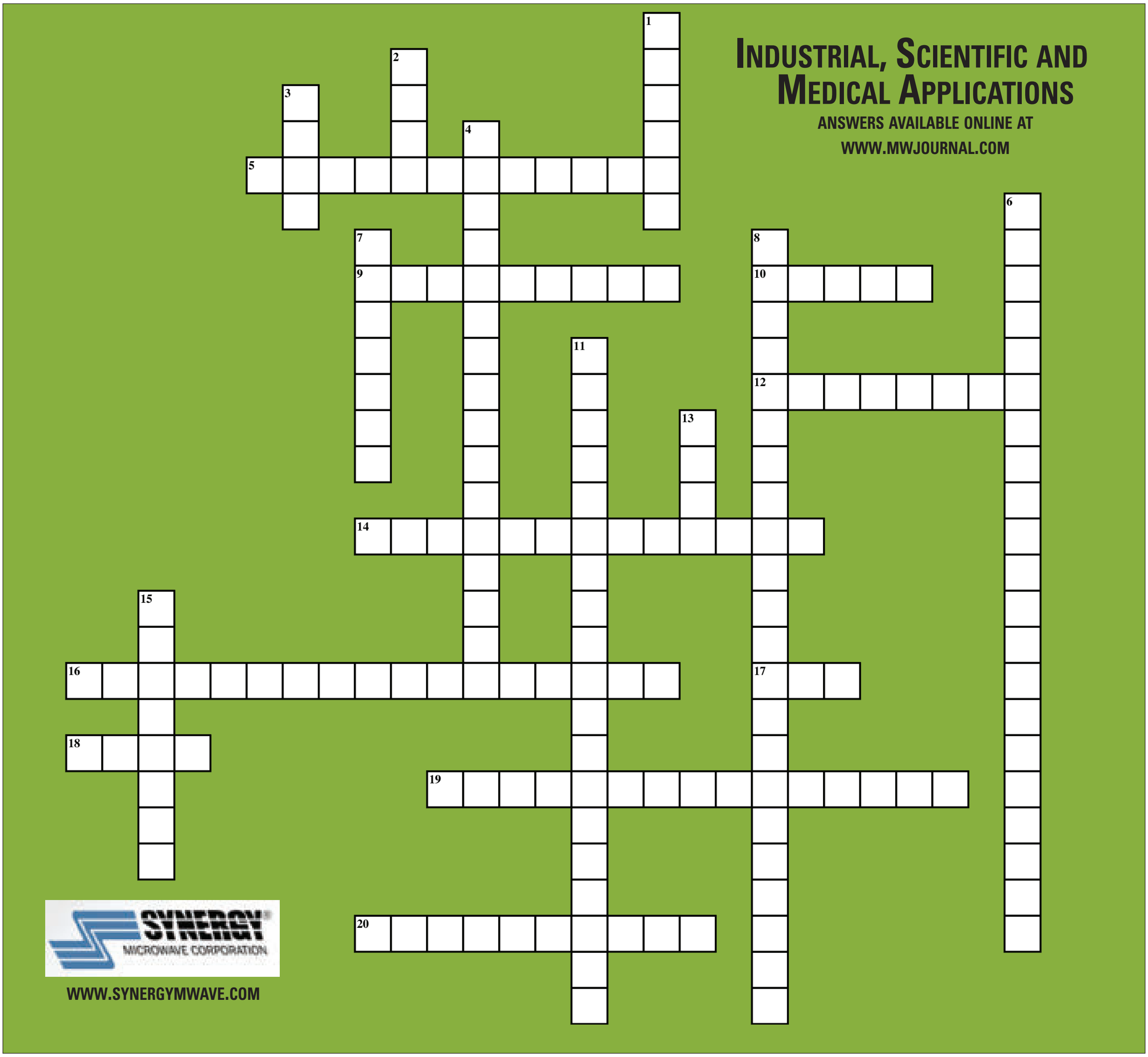

ACROSS

5 BER (3 words)

9 Electric grid with two-way communication capability to optimize energy consumption and delivery to the customer (2 words)

10 Laterally diffused metal oxide semiconductor

12 New type of light source that uses RF energy to ignite the gas mixtures in an electrode-less bulb (2 words)

14 UWB (3 words)

16 Microscopy technique that combines the capabilities of a VNA with the nanoscale spatial resolution and angstrom-scale positioning of an atomic force microscope (2 words)

17 Short for Atomic Force Microscopy

18 Input third-order intercept point

19 DUT (3 words)

20 Ability of a transistor to withstand "harsh" RF conditions is a measure of what

DOWN

1 A new __________ smart energy profile 2.0 is under development, supporting IP-based addressing, re-defining the layers above the MAC and PHY

2 A poorly matched load results in a high __________

3 Short for Radio Frequency Identification

4 Main competitor to RF solutions for smart grid applications (3 words)

6 Systems installed to automate the reading of electric, water and gas meters and to eliminate the need for humans to manually record consumption data (3 words)

7 Widely used frequency band for current meter reading applications (2 words)

8 Logical function that determines the current state of use of a wireless medium and aids in avoidance of used channels (3 words)

11 Microscopy that enables two-dimensional mapping of the carrier density across different regions of a semiconductor (2 words)

13 1 dB compression point

15 Process of varying the impedance seen by the output of an active device to other than 50 ohms in order to measure performance parameters (2 words)


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