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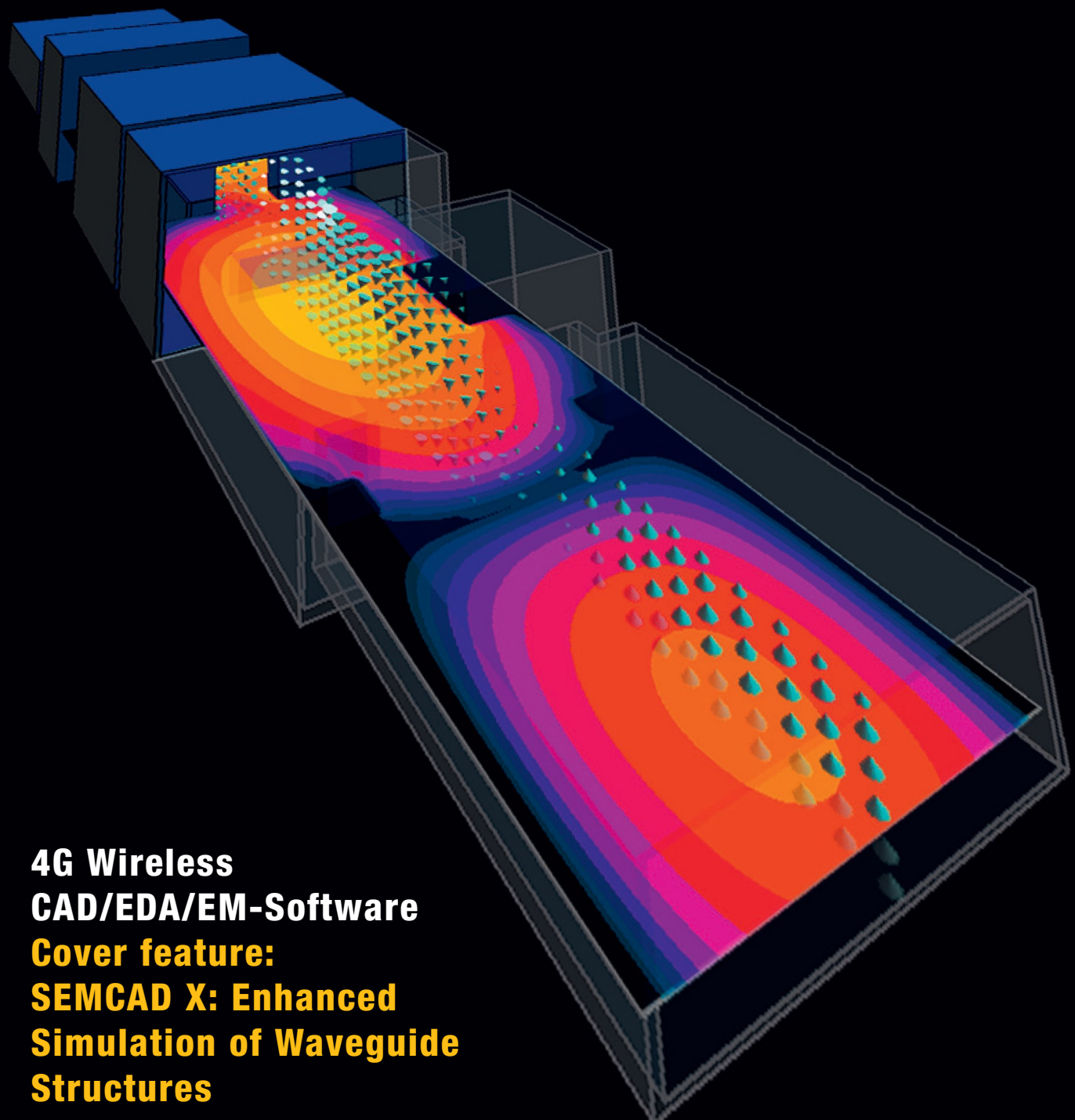

4G Wireless

CAD/EDA/EM-Software

Cover feature:

SEMCAD X: Enhanced Simulation of Waveguide Structures

www.microwave-eetimes.com

BPA WORLDWIDE BUSINESS

The European journal for the microwave and wireless design engineer

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Integrating antennas within clothes using metallic thread

To make communications devices more reliable, Ohio State University researchers are finding ways to incorporate radio antennas directly into clothing, using plastic film and metallic thread.

"Our primary goal is to improve communications reliability and the mobility of the soldiers," said Chi-Chih Chen, a research associate professor of electrical and computer engineering at Ohio State. "But the same technology could work for police officers, fire fighters, astronauts – anybody who needs to keep their hands free for important work."

For typical foot soldiers, mobility and communications are often at odds. An antenna can be a large and unwieldy addition to an already heavy load. The idea of embedding communications devices in clothing to address this problem is not new, Chen explained. The Ohio State system takes elements from previous research and combines them in a new way, with the addition of a unique computer control device that lets multiple antennas work together in a single piece of clothing.

The result is a communications system that can send and receive signals in all directions, even through walls and inside a building, without a need for the wearer to carry an external antenna.

When antennas make contact with the human skin, however, the body tends to absorb radio signals and form a short circuit – a fact driven home by the recent difficulties with the antenna placement on the iPhone 4. Also, if an antenna is improperly placed, a person's body can block it when he or she moves against a wall or other obstacles. The Ohio State system overcomes these problems by surrounding the body with several antennas that work together to transmit or receive a signal, no matter which way a person is facing. An integrated computer control device senses body movement and switches between the antennas to activate the one with the best performance given the body's position.

The engineers created a prototype antenna by etching thin layers of brass on a commercially available plastic film, called FR-4. The film is light and flexible, and can be sewn onto fabric. They attached it into a vest at four locations –chest, back, and both shoulders. The computer controller – a metal box a little smaller than a credit card and an inch thick – was worn on a belt. In laboratory tests, the experimental antenna system provided significantly greater signal strength compared to a conventional military "whip" antenna, enabling a range of communications four times larger.

They are partnering with an antenna design company, Applied EM of Hampton, VA, to commercialize the research, which was funded by a Small Business Innovation Research grant. Chen currently estimates that the antenna systems, as demonstrated in the prototype, would cost $200 per person to implement, but mass production would bring that cost significantly down. In the meantime, the engineers are working on printing antennas directly onto clothing, and embroidering antennas into clothing with metallic threads.

www.osu.edu

IN BRIEF

TMD to highlight TWT amplifiers at EMCUK 2011

A wide range of Travelling Wave Tube (TWT) amplifiers from TMD Technologies will be on show at the EMCUK 2011 exhibition and conference in Newbury this October. The UK manufactured broadband units are lightweight and compact, and benefit from TMD's extensive expertise in the design and manufacture of high power military radar amplifiers.

The company's standard amplifier range for EMC applications covers a wide frequency range of 1 to 40 GHz at up to 500/1000 W continuous wave and 40 kW pulsed. With a world-wide reputation for innovative design, the range includes many novel, high performance products.

Changing EMC testing standards continue to set new technical challenges — in particular the demand for higher powers over wide frequency ranges. TMD is well placed to meet this challenge, having successfully designed and manufactured a number of very high power TWTAs.

www.tmd.co.uk

Tensilica DSP core does 100 GMACs at 1 W

Tensilica has described a new integer DSP core for next-generation cellular applications that when made in a 28-nm process can compute 100 GMACs/s at less than a Watt. The BBE64 core is a new instruction set architecture based on the companies' current Xtensa LX4 core.

The BBE64 combines SIMD and VLIW concepts and lets designers configure processors for a range of handset and base stations uses. Chris Rowen, Tensilica founder and chief technologist said the core which runs at data rates of "a few hundred MHz" could process 2x2 MIMO LTE Advanced signals at 1 Gbit/s across 100 MHz of spectrum.

The company has completed the BBE64 programming model and generated RTL based on it.

www.tensilica.com

97 percent of smartphones to have touchscreens in 2016

By 2016, smartphones with touchscreens will account for 97 percent of all smartphone volume, up from 75 percent in 2010, according to market research firm ABI Research.

According to the firm, touchscreens deserve as much credit for the booming success of smartphones as 3G data speeds. Touchscreen smartphones accounted for only 7 percent of total smartphone volume in 2006, prior to the launch of Apple's original iPhone. Touchscreens have been a key driver of smartphone market growth of 325 percent between then and now, according to the firm.

More economical resistive touch technology has been almost universally replaced in smartphones with the more elegant projected capacitive technology that was first introduced in mobile phones through the iPhone, ABI said. Screen and touch technologies continue to evolve and are starting to reshape the markets for other classes of mobile devices, according to the firm.

"Low-cost capacitive touch controllers that use just a single layer of sensors instead of two, and save as much as 30 percent on the cost, are opening the market for lower-end feature phones," said Kevin Burden, vice president of mobile devices at ABI, in a statement.

www.abiresearch.com

Wireless packet core shipments to Asia Pacific boost market almost 40 percent

In its recently released report, Exact Ventures found the wireless packet core market, including evolved packet core (EPC), grew nearly 40 percent in the second quarter of this year over the same quarter last year.

This growth resulted primarily from a surge in PDSN shipments to CDMA operators in Asia Pacific, such as MTS in India, and to a lesser extent, large North American CDMA-based operators, such as Verizon Wireless and Sprint. The report indicated growth for the nascent EPC market temporarily slowed in the second quarter; however, it is expected to take off in the second half of the year due to scheduled EPC network launches.

"Wireless packet core equipment is critical for operators to develop revenue generating applications and services that differentiate network traffic content," stated Greg Collins, Founder and Principal Analyst at Exact Ventures. "This equipment, especially EPC equipment, helps operators increase their share of profits from the growth in mobile data traffic.

www.exactventures.com/wpc.html

Bluetooth-enabled device shipments expected to exceed 2 billion in 2013

Bluetooth continues to evolve and expand, taking advantage of the desirable attributes it possesses: small-form factor radio, low power, low cost, built-in security, robustness, ease-of-use, and ad-hoc networking abilities. The latest In-Stat research is forecasting continued success, with expected Bluetooth-enabled device shipments to exceed 2 billion in 2013.

"Bluetooth continues to gain design wins over a wide range of applications, with Bluetooth device shipments increasing by 23 percent between 2009 and 2010," says Brian O'Rourke, Research Director. "Bluetooth has been bolstered in the past year by the emergence of two new standards. Bluetooth 3.0 + High Speed (HS) combines classic Bluetooth and Wi-Fi to transmit large data files and Bluetooth 4.0, which offers much lower power consumption than classic Bluetooth and targets medical and fitness devices, as well as PCs and mobile phones."

www.in-stat.com

Freescale joins small-cell base station race

While cellular operators conducting a series of 4G trials in the United States and elsewhere in the world, Freescale has begun sampling new wireless base station SoCs designed for picocells and femto cells.

By using the company's QorIQ Qonverge family of processors, Freescale developed the new SoCs – dubbed as QorIQ Qonverge PSC9130/31 and PSC9132 – to be used for high-bandwidth and low-power baseband applications in LTE (FDD/TDD), WCDMA (HSPA+) and WiMAX base stations.

How big a market global demand for small-cell base stations may create remains unclear. But the competition among chip suppliers is already heating up. Freescale's move closely follows Texas Instruments, which announced just two months earlier its own small-cell base station SoCs designed for metro, pico and enterprise base stations.

Freescale's new SoCs, which share a common architecture with those used in metro and macro base stations, are based on Freescale's proven multi-core communication processor, multi-core DSPs and baseband accelerators. The QorIQ Qonverge PSC9130/31 SoCs are for femto cells, supporting performance and cost requirements for 8 – 16 simultaneous users. Freescale's QorIQ Qonverge PSC913, meanwhile, is designed for multi-mode picocell base stations, supporting up to 64 simultaneous users.

Cellular operators today, in the current 3G network infrastructure, are using small-cell base stations sparingly, "mainly to improve Quality of Service," said Scott Aylor, director and general manager of Freescale's wireless access division. But once operators upgrade their network to LTE, "small-cell base stations won't be an afterthought," he added. "In 4G networks, small cells will become a key part of their network architecture design."

However, Joseph Byrne, a senior analyst at The Linley Group, remained cautious. "I know the operators are looking at small base stations for LTE, but it is unclear how committed they are, and whether deployments would extend to residential femto cells."

As they build their own LTE network infrastructure, wireless operators are grappling with the right mix of small cells, their features, throughput and the number of users each small cell base station SoC should support.

If there is one thing SoC vendors could do to cope with this array of variables, it would be keeping their products flexible and scalable.

The Linley Group's Bryne stressed: "A key requirement for the base stations is cost, which directly impacts the chip suppliers. The ones that can reduce system cost (e.g., through integration) will be in a better position."

Meanwhile, Abhi Dugar, research manager at IDC, noted, "Operators will be stuck with supporting multi-mode networks for a while so small base stations will be part of their network architecture for LTE and 3G networks." Asked about key requirements operators are imposing upon small cells, he explained, "They are around multi-mode support, more integration to reduce BoM cost, lower power consumption, ability to source from multiple ODMs/OEMs, ease of installation/use at customer premise, minimal field support."

When asked to compare small-cell base station SoCs from TI and Freescale, the Linley Group's Byrne noted, "TI is targeting small-cell stations for the enterprise and larger." Meanwhile, "Freescale targets these with the PSC9132 but also targets residential femto with the PSC9130 and PSC9131."

In Byrne's opinion, "The closest comparison is between Freescale's PSC9132 and the TI's TCI6612. An important difference is that the Freescale part requires 40 percent less power. Freescale's chip (PSC9132), however, supports only LTE Category 4 (150-Mbps/75-Mbps), compared with LTE Category 5 (300-Mbps/150-Mbps) supported by the TI chip."

Many variables make the network architecture debate more complex. One of the issues is how to strike a balance between a throughput and a number of users supported by a small-cell base station. "It's because it all depends on the use case scenarios," said Scott Aylor, director and general manager of Freescale's wireless access division.

One of TI's small cell base station SoCs,TCI6614, for example, features quad C66x DSP cores and ARM Cortex-A8 and offers simultaneous dual mode, meaning that it can run two standards at the same time – LTE and WCDMA. That chip can support 128 users, according to TI.

Compared to that, Freescale's PSC9132 supports only 64 users. Asked about that difference, Freescale's Aylor noted: "We can absolutely support 128 users in our picocell SoC. But it all depends on the specific traffic patterns and the use case." He added, "We are quoting more realistic numbers based on a typical use case scenario."

It turns out that a YouTube download, the sort of activity often blamed for congestion on the wireless network, doesn't necessarily restrict the number of users a small-cell base station can support. Aylor explained, "Bigger packet applications like YouTube video are actually easy to deal with. Sure, big packets require a lot of data, but it is a simpler operation. It's not signaling intensive."

In contrast, GPS/Google Map search on a smart phone does not require a lot of data, but it creates heavy signaling stress on a base station, said Freescale's Aylor. "Functions like 'scheduling' can be better handled by a processor core in our SoC, rather than a DSP," he added.

Freescale has made the most of its knowledge of the wireless market and extensive IP portfolio to develop the new SoCs. The QorIQ Qonverge processors are built on market-tested Power Architecture cores, programmable StarCore DSP technology and baseband hardware acceleration engines already deployed in multiple LTE macrocell base stations around the world.

Leveraging StarCore SC3850 DSP and Power Architecture e500 MPU cores, "the new QorIQ Qonverge SoCs are distinguished by offloading Layer 2 processing and above to MPU cores instead of DSP cores, delivering significant efficiency advantages," according to Freescale.

www.freescale.com

IN BRIEF

Mobile phones beat dedicated navigation systems

German IT industry association Bitkom observes significant shifts in the market for navigation systems. The association expects that in the current year the number of dedicated navigation systems will decline by 11 percent; at the same time, the number of navigation apps for mobile phones and tablet computers will rise.

Bitkom believes that the industry will sell 3.1 million navigation systems in Germany in 2011, down from 3.5 million units in 2010. In other European countries, the trends are similar. The experts see two main reasons for the shift: Once, the market for dedicated systems is approaching saturation, and second, the navigation apps are increasingly powerful and at the same time very affordable. "Every third household already has a navigation system," Bitkom vice president Heinz Paul Bonn said. "In contrast, only on four percent of all smart phones such an app is installed".

www.bitkom.org

HiSilicon extends ARM licenses for 3G/4G

HiSilicon Technologies has licensed a range of ARM technology for use across the breadth of its communications chip design activities including: 3G/4G basestations, networking infrastructure and mobile computing applications.

HiSilicon (Shenzhen, China), which is linked to telecoms equipment maker Huawei, was already a licensee of the Cortex-A9 processor core from ARM Holdings plc (Cambridge, England) and had made extensive use of that license. The latest broad-ranging agreement includes licenses for the Cortex-A15 multiprocessing core, the CoreLink CCI-400 cache coherent interconnect fabric and the Cortex-M3 processor core.

Mali, ARM's graphics processing core family, was not mentioned as being a part of the deal.

www.hisilicon.com

CellGuide to use Baolab 3D NanoCompass in GPS chip

CellGuide has announced the selection of Baolab's award winning NanoEMS™ technology as a companion to its location and positioning solutions. CellGuide will add Baolab's recently launched 3D NanoCompass™ IC to their GPS chip, to create the CLIOX-C, the world's first fully integrated GPS and compass device.

Integrating the Compass and GPS together enables 'point and identify' augmented reality features to be easily incorporated in mobile devices, tablets, and cameras. The compass function further enhances the GPS system by providing immediate tunnel-exit and dead-reckoning features to assist in situations where the GPS signal is intermittent or not available.

The CLIOX-C GPS solution is based on CellGuide's proven host-based SNAP technology providing highly competitive performance, while minimizing system power consumption at an excellent cost/performance point. Baolab's electronic 3-axis CMOS MEMS NanoCompass technology inside the CLIOX-C is the first product made using its patented NanoEMS™ technology, to create nanoscale MEMS within the standard metal structure of a CMOS wafer using standard, high volume CMOS lines, that significantly reduces the cost of the compass by up to two thirds.

www.baolab.com/compass.htm

Rohde & Schwarz supplies emergency radios for aircraft carriers

Systems based on the Rohde & Schwarz M3SR Series 4400 VHF/UHF radio family are being used for the production phase of the VHF and UHF emergency radio system for both Queen Elizabeth Class (QEC) aircraft carriers being built for the UK Navy. A contract from the Aircraft Carrier Alliance (ACA) will see Rohde & Schwarz UK build two equipment racks for each vessel housing the V/UHF software defined radios from the company and recording equipment, incorporating the software and remote control.

The heart of the system is based on the M3SR Series 4400 VHF/UHF radio family and is designed for stationary air defense, civil and military air traffic control and shipborne applications. For civil applications, the 4400 systems were developed in line with international civil air traffic control guidelines (EN 300676) while integrating the requirements for the UHF Band I in line with EN 302617. It provides military customers with a range of interfaces and associated proprietary frequency hopping waveforms, as well as radio communications schemes that conform to NATO standards. Military data transmission methods such as LINK 11 and LINK 22 are also supported.

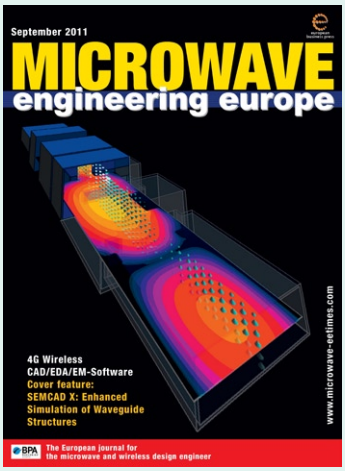
www.rohde-schwarz.com

WiMAX subscriptions surpass 20 million

The WiMAX Forum has announced that WiMAX technology has broken the 20 million global subscriber mark. According to Infonetics Research, WiMAX technology reached a total of 20 million subscribers at the end of 2Q 2011. This significant milestone comes among reports from operators around the world reporting dramatic subscriber growth.

"According to Infonetics Research, worldwide WiMAX subscribers passed the 20 million mark around the mid-point of 2011 and are on track to meet our forecast for around 25 million by the end of this year," said Richard Webb, Directing Analyst — WiMAX, Microwave & Mobile Devices at Infonetics Research. "Subscriber growth continues in all regions as WiMAX operators build their customer bases, but we have tracked notably strong growth in the U.S., the Indian subcontinent, and Latin America. With the levels of operator activity and device ecosystem growing, we forecast WiMAX subscribers to surpass 100 million by the end of 2015."

www.infonetics.com



This month's cover illustrates the SEMCAD X Mode-Matching solver from SPEAG. This tool delivers enhanced simulation of waveguide structures, combining the Mode-Matching technique with the Generalized Scattering Matrix to take EM simulation to the next level.

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IN BRIEF

IEEE publishes 'white space' WRAN standard

The Institute of Electrical and Electronics Engineers (IEEE) has published the 802.22 standard for Wireless Regional Area Networks (WRANs). The standard covers broadband wireless access at up to 22-Mbps per channel over distances up to 100 kilometers from a transmitter without interfering with terrestrial television broadcasts that use the same part of the spectrum.

The standard covers much the same ground as the Weightless standard being developed by Neul Ltd., (Cambridge, England) in that it is intended to provide a framework for "white space" reuse of UHF and VHF spectrum. However, while Neul's Weightless standard is intended to open up access for relatively small data payloads that are part of an internet-of-things, IEEE 802.22 is trying to provide secure high-speed broadband communications.

www.ieee802.org

Broadband comms from an LED ceiling light

With its Visible Light Communication (VLC) technology, the Fraunhofer Heinrich Hertz Institute intends to present a novel method of broadband transmission. Using standard off-the-shelf LED lights, broadband data streams are transmitted in visible light to computers and other end devices with communication-capability. The broadband transmission speed is 100 Mbits/s; in the lab speeds of up to 800 Mbit/s have already been achieved. This transmission technique, which uses the energy-efficient electronics of LED technology, is ideal for both distribution of broadband video streams and two-way communication – from internet usage to video conferencing, the researchers say.

The optical wireless technology can be deployed in situations where wireless LAN is uncalled for – for instance, in hospitals or manufacturing processes.

www.hhi.fraunhofer.de

U.S. could see $53 billion in 4G network investments by 2016

A new Deloitte report states that wireless telecommunications companies in the United States could invest $25 to $53 billion in fourth generation cellular wireless networks (4G) between 2012 and 2016, triggering $73 to $151 billion in gross domestic product growth and creating 371,000 to 771,000 jobs. Additional growth could occur as high-tech companies create new mobile broadband products and services, further changing the way people live, work and learn.

The Deloitte report, "The Impact of 4G Technology on Commercial Interactions, Economic Growth, and U.S. Competitiveness," investigates the economic dynamics surrounding 4G technology and explains how the U.S. can maintain the global leadership position in mobile broadband innovation it won during the 3G era.

The $25 billion figure assumes a baseline scenario in which U.S. 4G deployment proceeds at a moderate pace and the transition from 3G to 4G extends to the middle of the decade. Under these conditions, U.S. firms are vulnerable to incursions by foreign competitors capitalizing on aggressive efforts in their home markets to deploy 4G networks and develop 4G-based devices and services.

The $53 billion figure assumes a scenario in which U.S. carriers invest more rapidly in 4G networks and start to produce popular 4G-based offerings before global competitors gain traction. In this scenario, the demand stimulated by new offerings justifies more network investment, setting off a virtuous cycle of investment and market response that positions the U.S. to retain its mobile broadband leadership.

According to the report, more than 150 carriers in 60 countries are currently committed to 4G deployments and trials. South Korea, Sweden and China are examples of countries moving rapidly to reap the benefits of 4G technology.

www.deloitte.com/us/impactof4g

Microwave-based quantum computers to lower costs

The National Institute of Standards and Technology (NIST) recently demonstrated a microwave technique for performing quantum entanglement, opening the door for inexpensive quantum computers to perform what so far only been possible with expensive lasers. According to NIST, quantum entanglement will be the primary method for transporting information and performing error correction in future quantum computers.

Microwave technology—used to carry the signals sent and received by cell phones—is a mature semiconductor technology. NIST hopes to enlist that semiconductor expertise to build cheap quantum computers using existing microwave technologies. Microwaves have been shown in the past to have an effect on individual trapped ions, but NIST claims to be the first to demonstrate quantum entanglement using microwaves.

By positioning microwave ion traps just 30 microns apart, NIST's experimental setup was able to demonstrate entanglement. A laser was still needed to cool the device before use, but a cheap semiconductor version similar to those used in laser pointers was all that was needed. Ordinarily, quantum entanglement requires large, expensive lasers.

"Quantum computers could eventually look like a smart phone combined with a laser pointer-like device," said NIST physicist Dietrich Leibfried. "Sophisticated machines might have an overall footprint comparable to a regular desktop PC."

The microwaves in the NIST experiment were used to rotate and entangle the spins of magnesium ions, two operations that will be curtailed to performing logic operations in future quantum computers. The ions were held in place by electromagnetic fields generated by gold electrodes onto an aluminum nitride substrate. Microwave radiation was then applied in the 2-GHz band similar to that used by cell phones, resulting in controlled rotation and entanglement of their spins states about 76 percent of the time. The NIST team is now working to improve its success rate to above 99.3 percent, which is the best rate achieved with lasers to date.

www.nist.gov

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SP3T	2	DC to 3500	36	0 / +1.8	0.4	40	2.00	120	73	2.5 x 2.5 x 0.55	NOW	RF1603A
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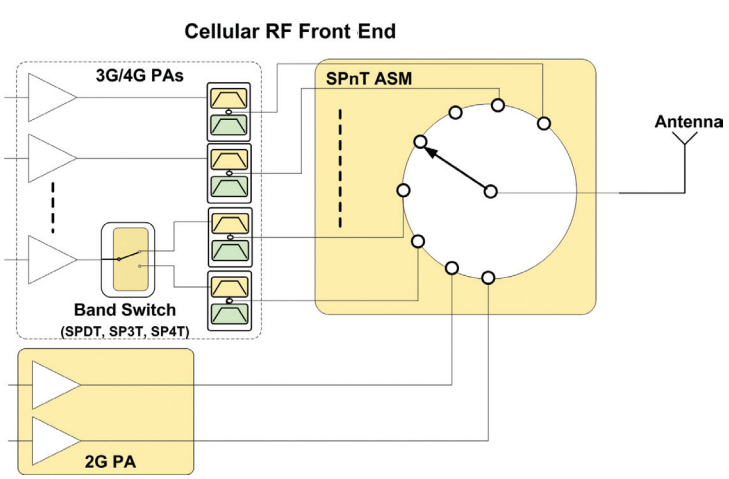

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Wireless spectrum efficiency could be 10x better

Steve Perlman, chief executive of Rearden Companies, a Palo Alto, CA incubator and one of the DIDO inventors has released a white paper describing a wireless technology that can deliver more than ten-fold increases in spectrum utilization compared to today's cellular systems. Known as the Digital Input, Distributed Output (DIDO) method, it can radically extend the range while decreasing the power consumption and silicon complexity of radios, its inventors claim.

The technique uses a data center as an intermediary for all wireless communications. The servers apparently compute waveforms specific to each wireless client's data request.

Each client receives a unique waveform with just that user's data. DIDO does this by synthesizing a private channel for each user, which is why each user gets 100 percent of the data rate of the spectrum, regardless of how many users share the spectrum, Perlman said.

Rearden has tested the technique with ten radios, each using the full data rate available for a given slice of spectrum in a site near Austin, Texas.

"We know we can get to one-hundred fold what today's cellular systems provide, and we are optimistic we can get to a thousand-fold," said Perlman in a recent talk at Columbia University where he first publically described DIDO. "We don't know what the limit is [because] this is all green-field" research, he added.

The average power is easily one-tenth that of cellular, and in many cases its one one-hundredth, Perlman said

"The patent reveals this to be a distributed MIMO approach," said Jan Rabaey, a professor at the University of California, Berkeley who heads a wireless research center there. "There has been a large amount of activity in this space over the past couple of years," he said.

"To be honest, I do not see that much new in this patent that was not known," Rabaey added. "Actually, LTE-Advanced does use similar approaches," he said.

The white paper can be found at http://rearden.com/DIDO/DIDO_White_Paper_110727.pdf.

This article has been contributed by Rick Merrit, EE Times.

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SEMCAD X Microwave: enhanced simulation of waveguide structures

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I. Introduction

SEMCAD X is a software framework with a high-end graphical user interface for electromagnetics and thermal simulations based on FDTD techniques that exploit both software and hardware acceleration strategies [1]. SEMCAD X incorporates a rich design and analysis environment by seamlessly combining modeling, simulation, optimization and postprocessing setups. To date, the FDTD techniques implemented in SEMCAD X have been successfully applied to a wide variety of both academic and industrial electromagnetic problems in a wide range of areas including antenna design, radiating/guiding microwave devices, electromagnetic compatibility, optics and bioelectromagnetics [2],[3]. Despite the versatility achieved with this pool of FDTD solvers, there is a growing demand for a platform that tackles each part of the problem with the most suitable method and processes the specific outputs into the overall result. A large number of the structures encountered in microwave applications, given its resonant nature, constitute a challenging test field for this approach. Thus, SPEAG has developed a new state-of-the-art solver based on the Mode-Matching Technique for the simulation of passive waveguide structures. This solver has been integrated into the existing SEMCAD X framework to provide the user with a common simulation environment that will abstract the method in which the solver has been implemented.

This paper presents an overview of the enhancements achieved in the simulation of mm-wave/microwave devices through a set of benchmarks, including dual-mode filters with rectangular and elliptical cavities and components for polarization discrimination.

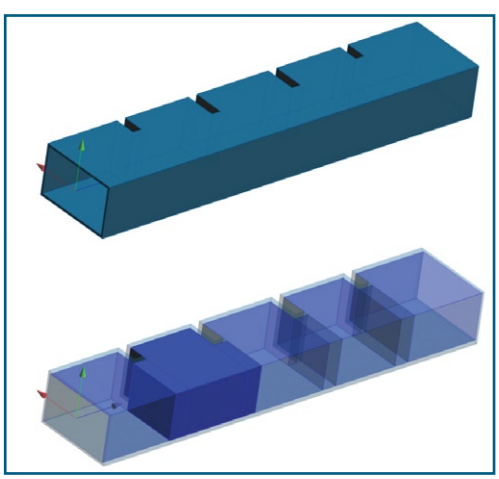
II. Mode-Matching solver

Mode-Matching (MM) techniques [4],[5] have proven to be one of the most efficient and accurate simulation methods with which to tackle waveguide structures. They have become a standard approach in the resolution of real industrial problems such as waveguide transformers, high performance filters, multiplexers, polarizers or ortho-mode transducers.

The key idea behind this method consists of the segmentation of the structure under analysis into individual waveguide regions. It is well known that the electromagnetic field at each of these regions can be expressed as a weighted superposition of the waveguide modes. The specific amplitude of each mode accounts for the boundary conditions between adjacent regions, as well as the excitation and load of the whole structure. In this sense, unlike other numerical methods, MM reduces the EM problem to a linear system on the amplitude of each waveguide mode (scalar complex numbers) rather than the vector fields at each point of a 3D mesh/grid discretization. This creates a considerable reduction in the number of unknowns as well as a more faithful representation of the EM fields, which leads to both a fast and precise resolution of the EM problem.

Taking as an example the structure of Figure 1, the aforementioned approach is implemented as follows. First, the structure under analysis is segmented into building blocks. These are typically discontinuities between waveguides and more complex junctions involving several waveguide ports. These building-blocks are then further divided into waveguide regions, where the EM field is theoretically expanded in the formulation of the algorithm as an infinite

Figure 1: Example of a microwave structure built with several inline rectangular waveguides. Views of the metallic shell (top) and the air volume inside of the structure (bottom).



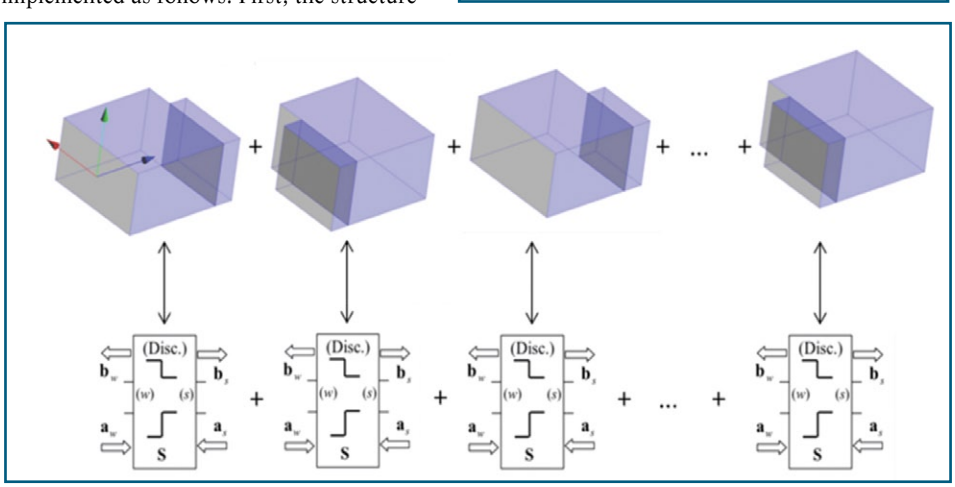


Figure 2: Building blocks of the previous structure. Each one is characterized by its GSM relating modal amplitudes at each side (denoted with a, b). At a final stage, the GSMs are cascaded, providing the system response.

series of propagating and evanescent modes. Obviously, for computational reasons, these series are truncated according to the degree of accuracy required. This is determined by the relative number of modes retained in each field expansion and the total number of modes used in the entire problem.

At the interface between adjacent regions, the modal series defined at each side have to be matched to fulfill boundary conditions. This leads to a linear system, whose solution determines the amplitude of the modes at each waveguide region. This is usually formulated using a scattering matrix formalism, although other approaches based on admittance or impedance matrices are also possible. Thus, the characterization of each building block results in the Generalized Scattering Matrix (GSM), which includes both propagating and evanescent modes.

Finally, the GSM of each building block is cascaded, providing the response of the entire structure. In this sense, the initial problem has been reduced to a multi-port circuit problem (one circuit port per mode), capturing at the same time all the EM interactions within the structure. The S-parameters of the modes at the input/output ports can be extracted from the final GSM.

Moreover, depending on the application, the analysis may require the computation of the EM fields at any point of the structure. In that case, the fields can be reconstructed summing up the modal series previously computed at each specific waveguide region. The main advantage of this approach is that it does not require of any additional interpolation procedure since the waveguide modes are known in an analytical or quasi-analytical form.

The current capabilities of the MM solver in SEMCAD X allow the simulation of structures composed of inline waveguide sections with rectangular, circular, elliptical and circular/elliptical coaxial sections. In addition, structures with N-furcations and cubic-junctions can also be tackled following a similar approach. The combination of these components provides a simulation toolset capable of efficiently and accurately solving a wide variety of waveguide problems such as those presented in the examples of the following section.

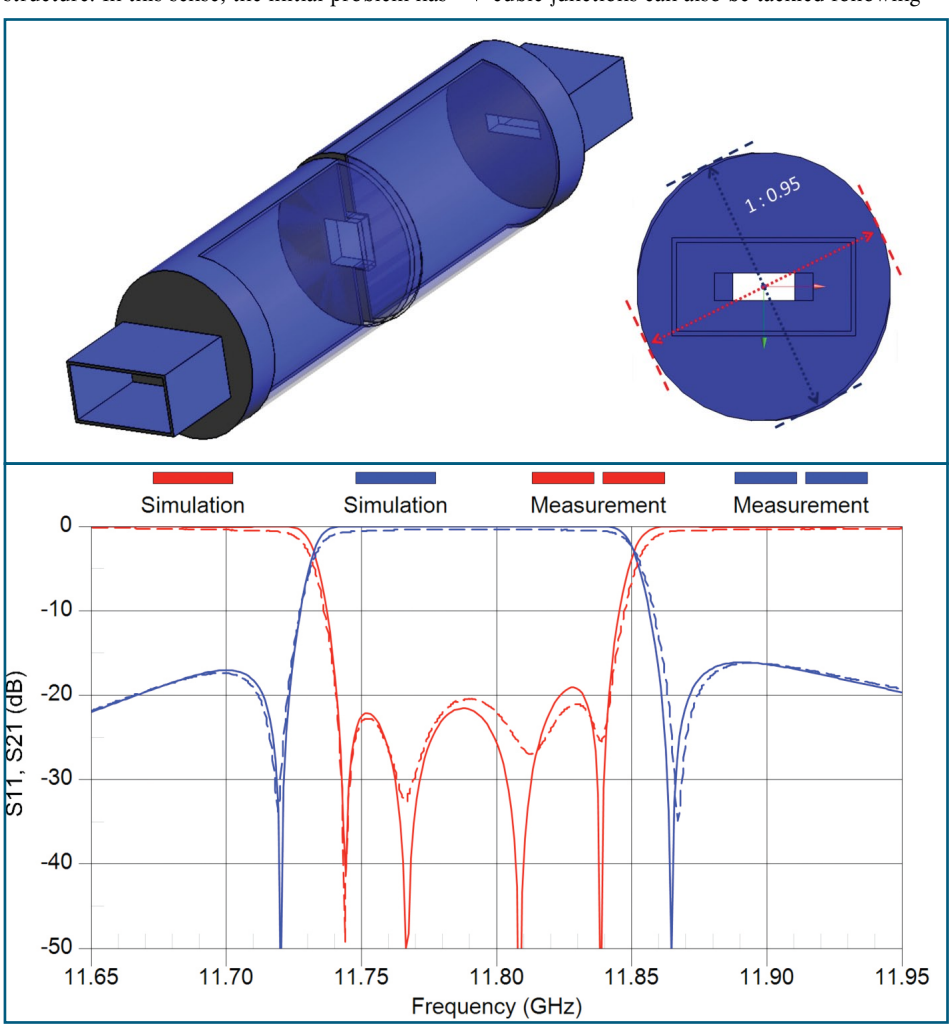
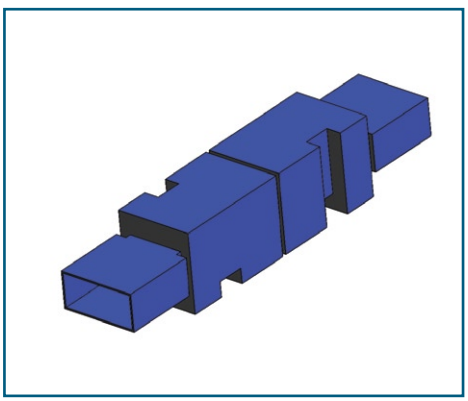


Figure 3: (a) (top) Dual-mode waveguide filter with elliptical cavities, (b) (bottom) simulated and measured response of the filter.

Figure 4: Dual-mode waveguide filter with rectangular cavities.



III. Results

Three different benchmarks were selected to outline and demonstrate the capabilities and performance of the new Mode-Matching solver for the simulation of microwave passive devices with practical interest for diverse real applications.

A. Dual-mode elliptical filter

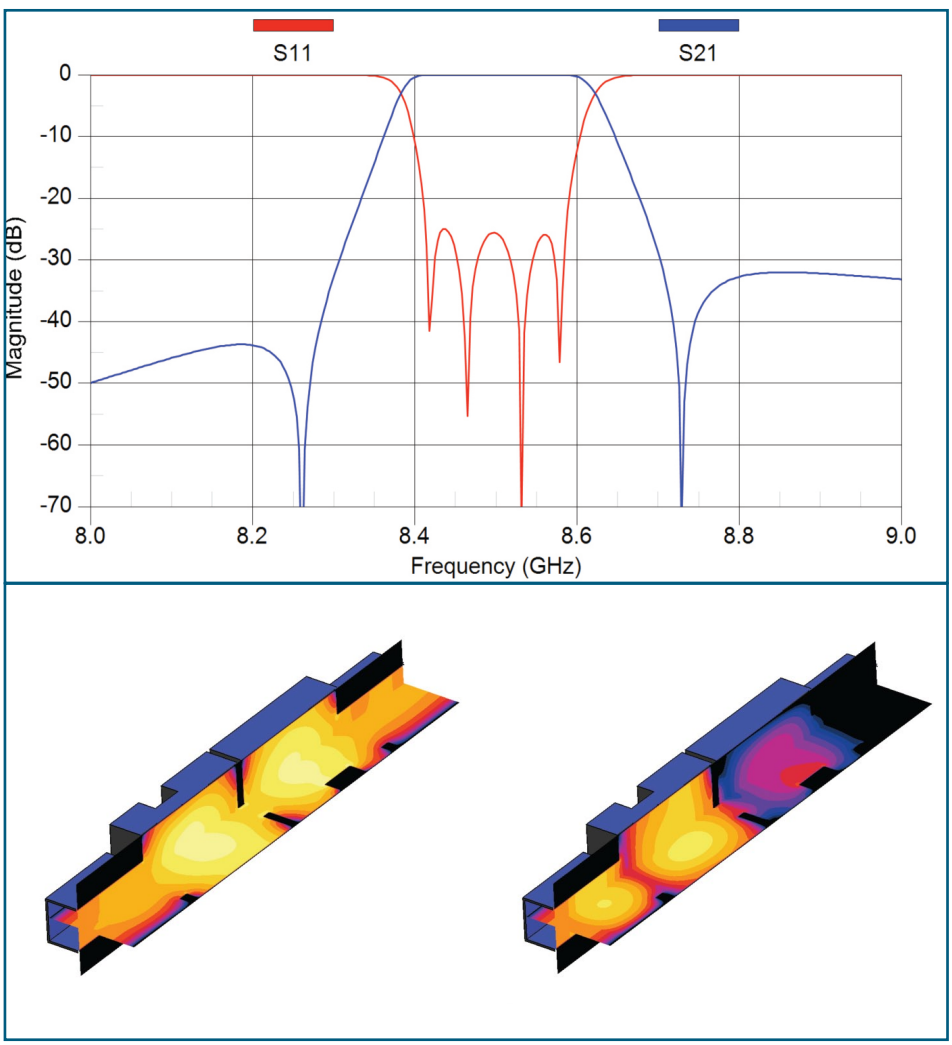
The first example is a dual-mode waveguide filter realized with elliptical cavities and rectangular irises as illustrated in Figure 3(a). The structure consisting of discontinuities between an elliptical and a rectangular waveguide was simulated using the SEMCAD X Mode-Matching solver. Figure 3(b) shows the computed response of the four-order elliptical filter in X band with a center frequency of 11.8 GHz and a bandwidth of 100 MHz. The filter has been fabricated and measured by the authors following the structure in [6]. The measured response shows good agreement with the computed response (Figure 3(b)).

B. Dual-mode rectangular filter

Another dual-mode waveguide filter based on rectangular cavities [7] was simulated to demonstrate the performance of the new solver. The structure shown in Figure 4 consists of two rectangular iris coupled dual-mode cavities with square cross-section. The cross-coupling between orthogonal modes is achieved by perturbations which result in square coupling sections. The SEMCAD X Mode-Matching solver takes into account the interactions

between all discontinuities of the structure via all higher order modes. The computed frequency response of the filter and the E-field distribution at the center frequency are shown in Figure 5. The filter achieves four poles and two transmission zeros with two dual-mode cavities with a center frequency of 8.5 GHz and a bandwidth of 170 MHz.

Figure 5: (a) (top) Simulated return loss and insertion loss response of the filter, (b) (bottom) vertical and horizontal slices of the magnitude of the E-field distribution at different frequencies in the passband (left) and at the transmission zero (right).



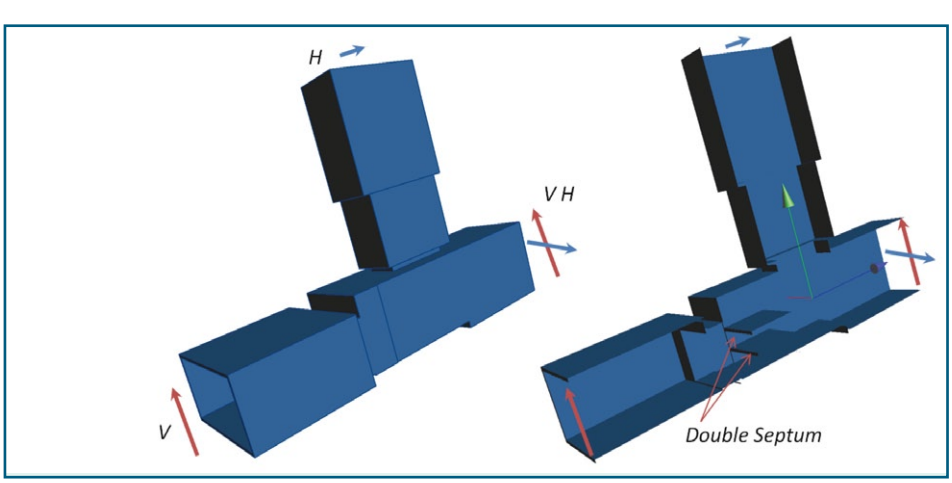


Figure 6: Orthomode Transducer (OMT) with double septum.

C. Orthomode Transducer

Finally, an Orthomode Transducer (OMT) was selected to illustrate the capabilities of the SEMCAD X Mode-Matching solver for multi-port and multi-mode configurations. The square waveguide constitutes the common port, where fields with perpendicular polarization coexist at the working frequency (degenerated modes). Each polarization is separated into the fundamental modes of the vertical and horizontal ports. The structure shown in Figure 6 has been designed as a Ku-band OMT for dual-polarization communication systems to fulfill different requirements for vertical and horizontal polarizations [8]. A double septum allows a shorter device as well as a better matching for the horizontal polarization. The structure has been built and measured to validate the design [8]. Figure 7 (a) presents the matching of both the vertical and horizontal ports showing good agreement between the computed and measured results. Furthermore, the E-field distribution at different cross-sections of the structure was computed at different frequencies and is presented in Figure 7 (b).

IV. Conclusions

In this article, we have introduced the main concepts of an integrated CAD tool combining advanced solvers based on the FDTD technique with a Mode-Matching solver to analyze microwave and millimeter-wave waveguide devices. The Mode-Matching technique combined with the Generalized Scattering Matrix (GSM) has been successfully applied in the analysis of many composite waveguide structures such as cavity filters, power dividers, E-plane filters, and has proved to be a power tool in the microwave industry. The performance and applicability of the SEMCAD X Mode-Matching solver was demonstrated in three specific high-end waveguide devices, highlighting another step forward in EM simulation technology.

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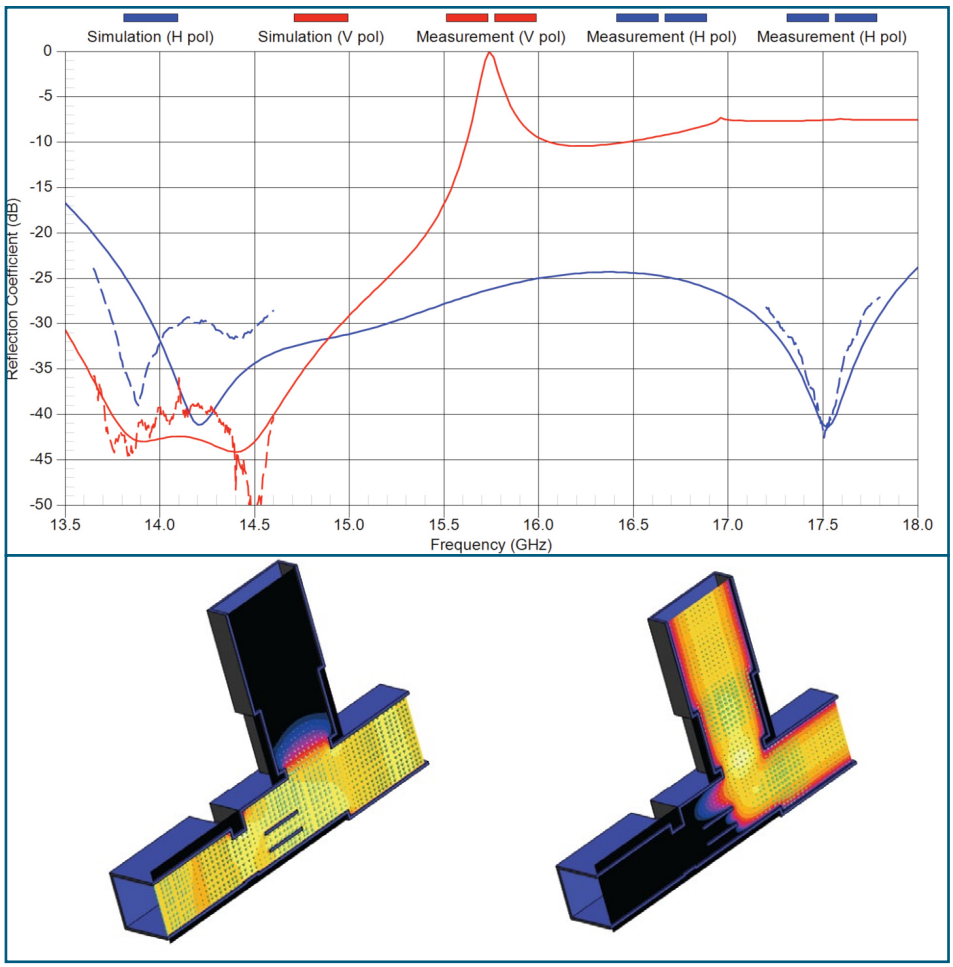
Figure 7: (a) (top) Simulated and measured return loss response of the OMT, (b) (bottom) slice and vector views of the E-field distribution at 14 GHz (V-pol, left) and at 17.5 GHz (H-pol, right).



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Technique discovered for drawing superconducting shapes for future microcircuits using an X-ray beam

A breakthrough in controlling defects could lead to new generation of electronic devices. Reporting in Nature Materials this week, researchers from the London Centre for Nanotechnology and the Physics Department of Sapienza University of Rome have discovered a technique to 'draw' superconducting shapes using an X-ray beam. This ability to create and control tiny superconducting structures has implications for a completely new generation of electronic devices.

Superconductivity is a special state where a material conducts electricity with no resistance, meaning absolutely zero energy is wasted. The research group has shown that they can manipulate regions of high temperature superconductivity, in a particular material which combines oxygen, copper and a heavier, 'rare earth' element called lanthanum. Illuminating with X-rays causes a small scale re-arrangement of the oxygen atoms in the material, resulting in high temperature superconductivity, of the type originally discovered for such materials 25 years ago by IBM scientists. The X-ray beam is then used like a pen to draw shapes in two dimensions.

A well as being able to write superconductors with dimensions much smaller than the width of a human hair, the group is able to erase those structures by applying heat treatments. They now have the tools to write and erase with high precision, using just a few simple steps and without the chemicals ordinarily used in device fabrication. This ability to re-arrange the underlying structure of a material has wider applications to similar compounds containing metal atoms and oxygen, ranging from fuel cells to catalysts.

Prof. Aeppli, Director of the London Centre for Nanotechnology and the UCL investigator on the project, said: "Our validation of a one-step, chemical-free technique to generate superconductors opens up exciting new possibilities for electronic devices, particularly in re-writing superconducting logic circuits. Of profound importance is the key to solving the notorious 'travelling salesman problem', which underlies many of the world's great computational challenges. We want to create computers on demand to solve this problem, with applications from genetics to logistics."

www.london-nano.com
www.phys.uniroma1.it

Electronics enters era of 'systemic risk'

By Rick Merritt, EE Times

The electronics industry has entered an era of "systemic complexity" where growing ecosystems of companies need to collaborate closely, according to a panel of chief executives.

"We're not just dealing with silicon scaling complexity but with a kind of systemic complexity where being best-in-class in one area is not sufficient to avoid risk and risks are going up," said Aart de Geus, chief executive of Synopsys in a panel at the annual GlobalFoundries conference.

Business success requires companies not only collaborate to develop chips but Web-enabled systems and network services. If any link in the chain fails, all the players risk failure.

"It's a winner-takes-all situation with whole ecosystems racing to high volume systems, so value chains become very important," de Geus said.

"As products get more complex, no one company can provide everything, but some can provide a great deal of the system," said Warren East, chief executive of ARM in a tip of the hat to Apple.

Under heated competition, "sometimes it's difficult to share information with each other but we have to have deeper cooperation and wider ecosystems," said Robert Hum, general manager of the deep submicron division at Mentor Graphics, standing in for CEO Wally Rhines.

In chip design, "data sets and process complexity are becoming enormous and the number of design-for-manufacturing rules is going through the roof," Hum said.

Process technology tolerances are edging closer to design rule margins, affecting chip yields which can be in single digits as new nodes first come up. That means changes in IC design can more readily impact manufacturing yields, said de Geus.

The use of design abstractions and modeling has helped reduce complexity in the digital realm, but not in analog design, said Hum.

"We have to figure out what we can do to increase efficiency of analog design," he said. "The digital world has had tremendous progress, but there's still a lot to be done in the analog world," he added.

De Geus compared the job of companies like GlobalFoundries to high tech restaurants that must serve large numbers of guests meals from a diverse menu on a coordinated schedule. "The kitchen costs a few billion dollars so you want to make sure the food is really good, and people still don't always appreciate the difficulty of what you do," he said.

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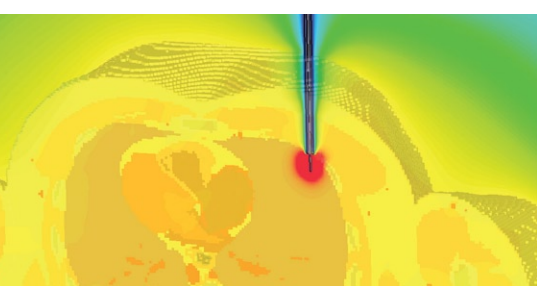

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CHANGING THE STANDARDS

Miniature plays a 'big role' in delivering wireless coverage indoors

By Håkan Samuelsson, CTO, Axell Wireless

Håkan Samuelsson, the CTO of Axell Wireless, discusses how wireless operators can overcome cost-based and technical challenges to deliver multi-band coverage to a wide range of indoor locations, with a 'miniature' solution that covers every nook and cranny.

Delivering a consistent user experience for mobile devices continues to present operators with significant challenges, particularly now that mobile broadband and data usage has increased with subscribers expecting to be able to access data services and applications on their devices any time, and anywhere. This is certainly the case in urban and metropolitan areas where there is a great demand for wireless services in-building. We take it for granted that we can use our mobile devices in the home or at work, but signal strength is dependent on a number of factors such as the topography of a building and the proximity to the nearest base station. For superstructures such as shopping centres and airports, particularly in the Europe and the U.S., wireless access is now considered to be standard, and a consistent mobile experience is expected, but not always delivered.

However, up until recently small-to-medium sized venues have been rather neglected by mobile operators in terms of coverage. The latest developments in coverage technology for in-building applications has enabled subscribers in these locations to use their mobile devices confidently and with the same efficiency as they would if they were operating on a macro network, in some cases with even greater signal strength than they would usually expect from their provider. Previously, operators struggled to provide consistent coverage in venues of this size because affordable solutions with the scope to cover smaller geo-locations, which could add the additional capacity required, simply did not exist. As a result operators were not prepared to invest in plugging the 'coverage gaps' as there wasn't a worthwhile business case to support these small-scale deployments.

Barriers to indoor coverage

As far as the operators were concerned a small-to-medium sized venue, such as a gym, the floor of an office block or a department store did not justify deploying a dedicated base station, despite the fact it would house multiple subscribers within an enclosed space. This issue was compounded by the fact that there was no cost effective coverage solution for operators to deploy as a viable alternative. There are a number of small cell solutions on the market, but as indicated here the range of solutions that are available do not cater to the needs of small-to-medium sized structures:

- **Femtocells** — Suitable for small venues where there are no more than around four to five subscribers needing to access mobile services. The femtocell was originally developed as a solution for coverage inside private homes with one or two users, with the home broadband connection acting as the backhaul for the femtocell. Today, femtocells with larger capacities (and higher price tags) are available but this also puts tougher requirements on the backhaul, normally not available for standard private broadband connections.
- **Picocells** — Are adequate for hotspot provision but like femtocells they are also capacity limited and prone to overload if too many users require access at the same time.
- **Dedicated base station for 3G or 4G** — For a small-to-medium sized location, deploying a full sized base station either for a single operator, or to cater for multiple operators, is a very costly and time consuming approach, and not usually recommended.

Miniature systems for indoor deployments

New production methods and the ability to scale down core components required for in-building wireless technology has resulted in the emergence of cost-effective coverage solutions that can be applied to small-to-medium sized venues. As the demand for data services increases, the introduction of this new technology is well timed, especially considering technologies such as cloud computing which demand constant connections to portable computers, regardless of the user's location, resulting in even more focus on in-building coverage.

Cost-effective repeater solutions that provide in-building coverage for small-to-medium sized venues have historically been designed using analogue technology. The more flexible digital solutions based on Software Defined Radio (SDR) technology have been too expensive and consume too much power for smaller scale deployments. The most recent developments in analogue-to-digital and digital-to-analogue components and Digital Signal Processors (DSPs) have finally made it possible to design a solution which is compact and has low power consumption.

The cellular network operator now has access to a compact system for smaller scale indoor coverage projects which offers a high level of flexibility. This solution has manifested itself in the shape of a low cost cellular repeater, which solves a wide range of issues related to the provision of indoor coverage. It is designed to be reprogrammable so it can be used for the frequency band and wireless technology used

by the operator today, and in the future. If the operator decides to increase the capacity of the serving base station by changing the bandwidth, the repeater can be reprogrammed to pass the increased bandwidth remotely. This method provides the operator with a cost effective solution that is able to cater for the increased demand for cellular coverage in a wide variety of indoor locations.

This new technique is future-proof against technology changes (longer life time) and it offers the same, or better, performance than the previous deployments based on analogue technology. All this can be achieved at the same cost level and same power consumption as the traditional analogue systems.

The design specification of these new systems makes it possible to manufacture a digital repeater product range in large volumes, which can be tailored to meet specific operator requirements by programming defined parameters into the repeater. The operator has at their disposal a system that can be modified using software updates (without the need for any hardware upgrades) according to any changes of technologies (from GSM to UMTS or LTE) or a mix of technologies. This software enabled repeater technology is transparent to changes of cellular technologies and meets the requirements of low cost indoor coverage projects.

Multiple-band coverage

A coverage solution with built in SDR capabilities enables an operator to specify and change sub-band allocation using software updates. A single device, or a network of devices, controlled using simple "auto configuration" settings accessed via a web interface, and it can be activated and fully functional within a few minutes.

Cellular repeaters with digital capabilities also cater to operators who work across several sub-bands in a much cheaper way when compared to previous analogue technology. Operators can now rely on a system that provides up to six sub-band filtering per unit. In terms of total coverage ability, a single digital repeater with 20 dBm per band output power can provide coverage in a building space of up to 2,500 square metres, and it can be installed simply on a wall, or in a rack. By adopting this approach an operator can cater for 2G, 3G and 4G, and fully support LTE without the cost associated with deploying multiple network equipment. Although LTE has been deployed in select markets around the World, predominantly in the U.S., mass market LTE deployments are still a few years away, by deploying a multi-band solution an operator's future investment will not be wasted.

SDR was a high cost solution associated with large scale indoor deployments, such as a shopping centre or an office block. Advances in technology have enabled the use of SDR in products that previously used cheaper analogue solutions. Specifically, the technology advances in A/D converters, D/A converters and FPGAs have led to higher bandwidths, higher capacity and lower power consumption, and consequently, lower prices for these components. In addition, with previous analogue solutions each repeater needed to be manufactured to cater for one sub-band depending on the respective spectrum occupied by each operator. Therefore, each analogue repeater would require a different 'surface acoustic wave' (SAW) filter.

A solution that only requires a few sub-bands needs fewer components so the conversion from analogue to digital now costs less than it did previously. The latest technology has optimised the size of the digital signal processing (DSP) because it does not have the complexity of the DSP for a larger scale deployment, and the power amplifier components also cost less. In the past the cheapest

option for the operator was limited to a single band analogue repeater, using one sub-band and requiring a SAW filter.

Analogue systems have difficulties in handling the entire 1800 MHz band in one SAW filter – and one of the main reasons why operators were reluctant to deploy repeaters to address wireless coverage in-building was because they were difficult to regulate. In some cases analogue repeaters would end up supporting, or amplifying, another operator's frequency band. However, a system with digital capabilities allows the operator to configure the unit to set the bandwidth and support specific (multiple) frequencies.

Piggy-backing signals

Concerns surrounding cost and the lack of a business model were two key factors that prevented operators from investing in coverage technology for small-to-medium sized venues. Another major concern was the issue of traditional analogue systems inadvertently supporting multiple operator signals. Previous in-building solutions were not selective about which signals to boost, an analogue repeater would amplify a local signal in order to enhance capacity and coverage within a given area. In many cases network equipment would be responsible for boosting a competitor signal. As a result competing operators could enhance their coverage for no extra charge. Of course this process is considered illegal in a number of different countries and has become an unfortunate by-product of an aging technology.

The ideal filter for repeater applications should have a flat, low loss pass, band over all frequencies belonging to the operator, but should reject all other frequencies. At the same time, the propagation delay through the filter should be minimal with very low ripple within the pass band. If more than one pass band needs to be amplified (several operators share one repeater or one operator has more than one allocation of spectrum), the repeater must be equipped with several SAW filters working in parallel which amplifies the potential issues. SDR technology meets all the requirements to make it possible to design frequency-stable filters with performance far exceeding analogue SAW filters and which are also programmable in centre frequency and bandwidth.

Migration to LTE

Earlier this year the Global Mobile Suppliers Association (GSA) revealed that up to 200 mobile operators globally are now investing in LTE. The GSA confirmed that in Europe alone over 64 LTE network deployments are currently being planned or implemented. This was put into perspective by corresponding figures from the research firm iSuppli, which estimates that LTE global spend will reach £17bn by 2014, as operators' ramp up their migrations to all-IP 4G networks. The migration to LTE will require a network redesign at every level, including the coordination of indoor coverage, to provide coverage and capacity for the delivery of high-speed mobile broadband data and applications.

With discussions of LTE mounting, operators are investigating the best methods for provisioning and upgrading their networks to offer an enhanced customer experience, this discussion will also need to extend to in-building coverage. Customers expect ubiquitous coverage regardless of whether they are using their mobile devices indoors or outside. However, the same old problems that impact on 2G and 3G networks (the connection rates available on a mobile device), most notably the signal degradation and deflection caused by solid objects, also affect LTE. If you're standing outside and you have 'line of sight' to the cell tower that isn't going to be a concern. If you're indoors however, it's an entirely different matter. Research conducted by Analysys Mason estimates that by 2016 over 80 per cent of global wireless data traffic will be generated indoors. The demand for high speed mobile broadband and data services will be concentrated to public spaces, such as coffee shops, shopping malls or offices, where people have the opportunity to stop and browse the internet, check emails and stream video.

For operators this trend means that LTE services are going to have to find a way through brick, concrete, steel and glass. Operators must deploy robust systems that are capable of dealing reliably with multiple users, within walls and under roofs, all wanting to access and transmit large amounts of data – photos, audio and video.

Consequently, operators are turning to sophisticated digital repeaters connected to a Distributed Antenna System (DAS) that propagates signal throughout the building. A single repeater linked to a roof mounted donor antenna can 'drive' a DAS providing coverage for 100,000 ft^2. The result is a cost effective solution that provides universal coverage for mobile equipment users and data transfer capabilities that are the equal of uninterrupted outdoor connections. Users remain 'on-network' with no requirement to configure a connection for data offload onto a fixed line network and, if properly configured, there is no danger of network overload.

Migration to LTE requires significant investment, so operators are looking at cost effective strategies that will allow them to support LTE and squeeze more capacity out of existing spectrum allocations. This has led to a technique called "re-farming" where existing 2G or 3G spectrum is in part re-allocated for 4G services.

Digital multi-band repeaters, employing SDR, are changing the way operators address in-door coverage for commercial environments. The multi-megabit connection requirements for LTE are demanding, but they can be effectively and efficiently addressed by an established mobile network technology that has now been significantly enhanced. Individual operators can deploy the equipment for their own dedicated use but equally, it opens the door to innovative micro-network sharing arrangements, common in the European market, in which operators make use of the same in-building infrastructure but retain direct access to their consumers and control over the network.

Ubiquitous indoor coverage

A recent forecast from analyst house ABI research demonstrates that 'in-building wireless' (IBW) systems are showing solid adoption rates and that we should expect £6 billion worth of deployments over the next 12 months. The demand for ubiquitous indoor coverage is growing driven by smartphone adoption, the influx of tablets and other connected devices and a generation of subscribers that expect immediate access to mobile broadband and data services. Indoor coverage solutions based on digital repeaters with SDR capabilities are central to the provision of in-building coverage. Deployed strategically they can support a wide range of installations. A network of repeaters connected to a DAS can deliver wireless coverage to a superstructure such as a shopping mall or airport. The compact miniature solutions can be deployed to cover small-to-medium sized venues that operators previously regarded as insignificant, or too costly to cater for. Advances in technology that have allowed SDR, and other core components, to be manufactured at higher volume provide the economies of scale needed to justify small scale deployments. With the ability to remotely configure a network of digital repeaters that can support a range of frequencies and sub-bands, operators are now able to plug every conceivable indoor coverage gap. At a time when ARPU is in decline, and the need for high quality coverage and consistent user experience is growing, the need for comprehensive in-building coverage has become critical.

Mixed domain oscilloscope delivers functionality of an oscilloscope and a spectrum analyzer

Touted as the world's first instrument to combine the functionality of an oscilloscope and a spectrum analyser, Tektronix has introduced the MDO4000 series. It builds on the company's mixed signal oscilloscope range, the MSO4000, and it believes it has the potential to become the company's most popular spectrum analyser.

The mixed-domain oscilloscope adds a single channel spectrum analyser to what is essentially a mixed-signal oscilloscope. The result is a spectrum analyser that can be triggered by the oscilloscope while providing correlation between all signals captured, whether that be in the time domain using the oscilloscope or the frequency domain using the spectrum analyser.

More than 60 percent of oscilloscope users also use a spectrum analyzer to troubleshoot embedded system designs with integrated wireless functionality, requiring them to work in both the time and frequency domain. Traditionally, an engineer was either a mixed signal/digital engineer or an RF engineer. But with wireless becoming more commonplace, design engineers must often work in both domains. Consequently, the MDO4000 is the first oscilloscope ever to integrate the functionality of a spectrum analyzer to provide a unique toolset which will save days or even weeks of debug time.

And the MDO4000 goes well beyond typical spectrum analyzer functionality by allowing users to capture time-correlated analogue, digital and RF signals across 4 analogue, 16 digital and 1 RF channel. The RF input frequency range extends up to 6 GHz and provides a capture bandwidth of ≥ 1 GHz at all centre frequencies, 100 times wider than typical spectrum analyzers. Users can even see up to 4 decoded serial and/or parallel buses at one time on the same display. Due to this time correlation between domains, engineers can now make accurate timing measurements to understand delays and latencies between command/control events in their design and changes in the RF spectrum.

In another industry first, the MDO4000 allows designers to see the RF spectrum of a signal at any point in time within a long acquisition to see how the spectrum changes over time or with device state. By simply moving the unique and patent pending Spectrum Time throughout the time domain acquisition, designers can see the RF spectrum for any point in their acquisition while simultaneously seeing their analogue, digital and/or decoded buses at the same point in time.

Similarly, RF time domain traces are used to show how the amplitude, frequency or phase of the RF input signal changes relative to time.

www.tektronix.com

Apparent dielectric constant of high-frequency PCBs

By John Coonrod, Rogers Corporation, Advanced Circuit Materials Division

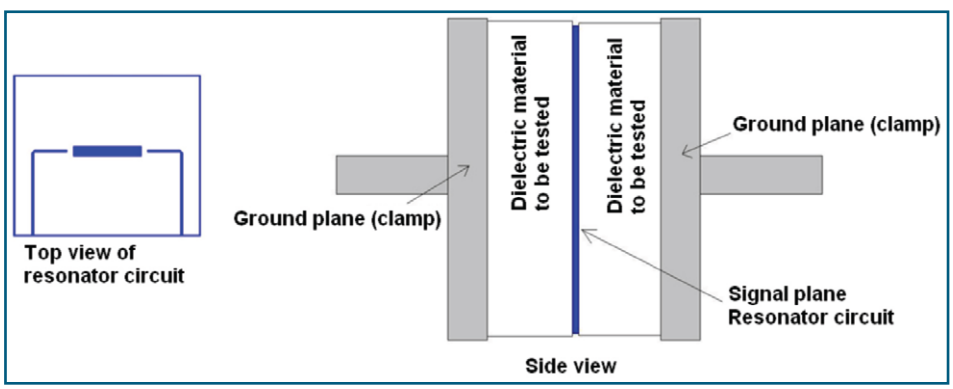
Designing a microwave printed-circuit board (PCB) requires some understanding of the circuit material's relative dielectric constant, ε_r, also known as its relative permittivity. Unfortunately, over the years some designers have become suspicious of the ε_r values printed on data sheets for circuit-board materials. In fact, the values included for circuit materials by most materials manufacturers are accurate, but apply only to specific test methods and at specific test frequencies. They may not relate well to an actual circuit design. Understanding how ε_r values are determined for different materials can help designers relate those values to actual circuits and applications, and how those values relate to different circuit configurations.

Test methods used by circuit material manufacturers are selected for specific reasons. The measurements are intended to verify product uniformity, ensure product quality and, hopefully, to do so quickly for large quantities of materials. Materials suppliers may need to test ε_r values for several hundred samples each day. For such quantities, it is not practical to design, model, fabricate, test, and characterize a microwave circuit for one particular material.

The X-Band Clamped Stripline Resonator Test is the most common test method used by RF/microwave circuit-board suppliers to evaluate their products. The test is defined by the IPC (www.ipc.org) as IPC-TM-650 2.5.5.5c. The method was widely adopted by the industry because it is repeatable, accurate, and fast. Samples of high-frequency laminates can be tested within just a few minutes, after they have been properly prepared.

Microwave PCB materials can be characterized by means of two different test approaches: a resonator method and a transmission/reflection method. Resonator methods are usually very accurate, although narrowband in their responses. Transmission/reflection methods are less accurate, but can yield ε_r results over a wide range of frequencies. The IPC clamped stripline resonator test is designed for use at node 4, which is at about 10 GHz. The test can be altered to test in one-half-wavelength increments of that frequency, although many PCB material data sheets provide ε_r values at 10 GHz.

Figure 1: Clamped stripline resonator configuration used to test high-frequency laminates.



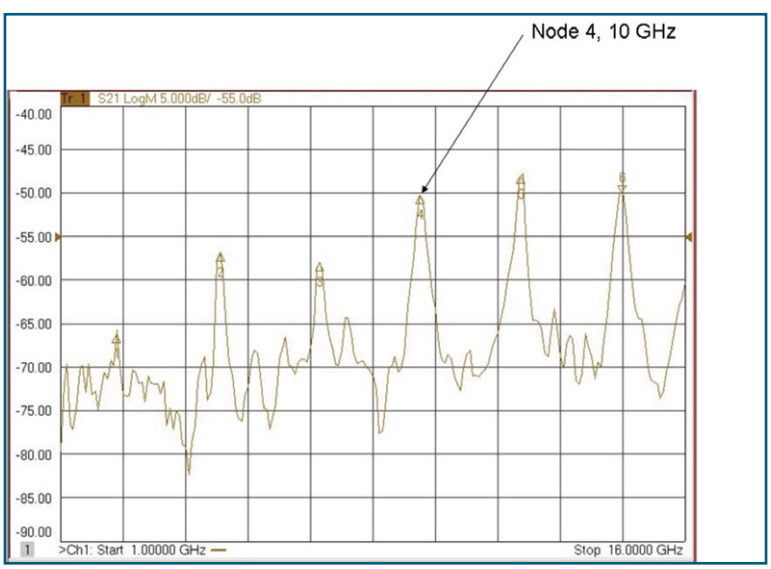


Figure 2: This VNA screen shows material being tested per the clamped stripline resonator test. Although this is a wideband view, node 4 (marker 4) is generally tested under narrowband conditions.

The clamped stripline test, as the name suggests, is not true stripline but a stripline structure that is formed by means of a clamping mechanism. The outside ground planes are the plates used to apply pressure for the clamp. A thin resonator copper circuit sits in the middle of these plates. Sandwiched on both sides of the resonator is the raw dielectric material to be evaluated. This approach supports the creation of a test fixture (Figure 1) where the clamping mechanism can be opened and closed for a series of production-line tests.

The resonator circuit is loosely coupled in order to better realize the quality factor (Q) of the material under test as opposed to the Q of the circuit itself. The resonator element is designed to be two wavelengths long at 10 GHz, based on the assumed ε_r value of the material being tested and the stripline thickness. The ε_r value is determined by:

$$\varepsilon_r = \left[\frac{nc}{2f_0(L+\Delta L)}\right]^2$$

where n is the node, c is the speed of light in free space, f_0 is the resonant frequency, L is the physical length of the resonator element, and ΔL is the added length due to the fringing effects in the gap coupled areas. Figure 2 shows the screen of a commercial vector network analyzer (VNA) for dielectric material being evaluated by means of the clamped stripline resonator test.

The clamped stripline test is well suited to high-volume material testing, but has some

issues that do not relate to practical PCBs. For one thing, the clamped structure is susceptible to having air entrapped within it. For another, anisotropic effects of the material being tested can influence the EM fields in the loosely gap coupled area. Entrapped air, with an ε_r value of 1, can lower the ε_r value measured in the clamped stripline test. The amount of entrapped air can vary from one type of material to another, causing variations in the test results. The surface of the material being tested is not smooth and varies from material to material, causing further variations in the amount of entrapped air. To begin the test, the copper is etched off of a copper clad laminate. The copper is etched off in preparation for the clamped stripline test. The copper that was etched off had a surface roughness, and that removed copper leaves behind that surface roughness image on the material sample. A sample that was a copper-clad laminate with rough-surface copper will leave behind a rougher dielectric surface and therefore more surface area to entrap air. Additionally, the copper surface roughness will vary from lot-to-lot of the different copper lots used so the surface roughness and sample surface area will have some natural variation.

Conformance can be another problem with the clamped stripline resonator test. The resonator circuit has an etched copper pattern that is slightly raised off the surface of the thin resonator circuit. Different types of material will conform differently in the fixture. A soft material will conform closely to the raised resonator circuit pattern, with less air pockets around the resonator element's image. A more rigid material will not conform as well to the resonator image, with more air pockets around the resonator image.

Entrapped air is a concern because it will likely be in the gap coupled area, where the electric field concentration is higher, causing a shift in the reported ε_r value. A worst-case scenario, leading to the greatest amount of entrapped air, is testing rigid substrates materials with very rough copper surface.

Another problem with the clamped stripline resonator test is that anisotropic effects of the material being tested can alter the reported ε_r value. In the gap coupled area, there is a concentration of electric fields and in that area, where the copper is etched away, the x-y plane of the material being tested will affect the fields. Some PCB materials have significant anisotropic ε_r characteristics which can alter reported ε_r values. The clamped stripline test was designed to characterize a material's ε_r value in the z axis, through the thickness of the material. Due to the gap coupled area being sensitive to the ε_r of the material under test in the x-y plane, the ε_r value determined from the test for the z axis can become distorted. Many microwave applications have electric fields that primarily use the z-axis of the material so when the clamped stripline test reports a value that has some variance due to anisotropy effects, the circuit design may not perform as expected.

A worst-case scenario for the clamped-stripline test would be evaluating a material that was rigid, very anisotropic, and with significant conductor surface roughness. At the other extreme would be a soft PTFE material with low ε_r. Most PTFE materials with a low ε_r value are less anisotropic and are soft. When clad with copper having a smooth surface and evaluated with the clamped stripline test, the measured ε_r value can be quite accurate compared to an actual stripline circuit.

Microwave PCBs come in many forms. For the sake of this discussion regarding ε_r values in relation to PCB design, three types of

transmission lines will be considered: microstrip, stripline, and coplanar waveguide. Microstrip is probably the most widely used microwave transmission line, and found on a large number of different PCB configurations. The microstrip typically has a quasi-TEM propagation mode with the z-axis of the laminate primarily used by the electric fields. Depending upon the circuit design, fringing effects are more or less a concern. When creating a microstrip PCB, a designer must have accurate knowledge of the laminate's ε_r value in the z-axis. Data from the clamped stripline resonator test for ε_r may or may not be appropriate. For a PTFE substrate with low ε_r value and smooth copper conductors, the stripline test may offer more meaningful data. For a different material, an alternative test method may be more appropriate.

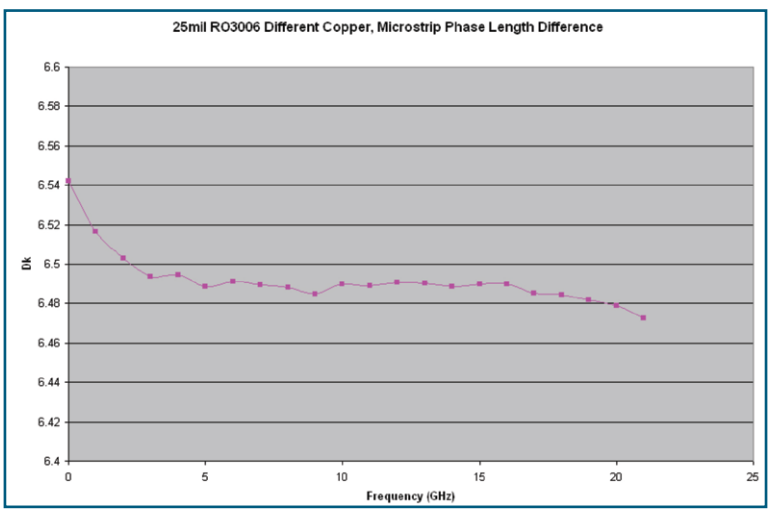


Figure 3: Microstrip differential phase length test method results on a ceramic filled PTFE substrate.

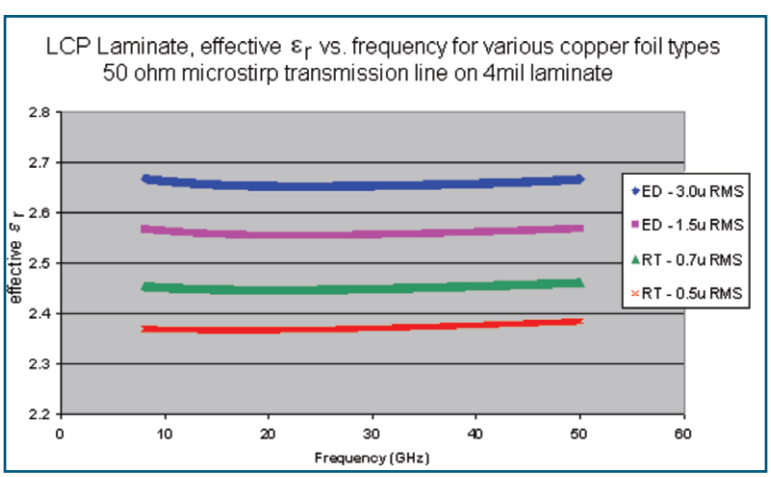


Figure 4: Microstrip differential phase length testing showing copper roughness effect on the effective ε_r value of the microstrip transmission line.

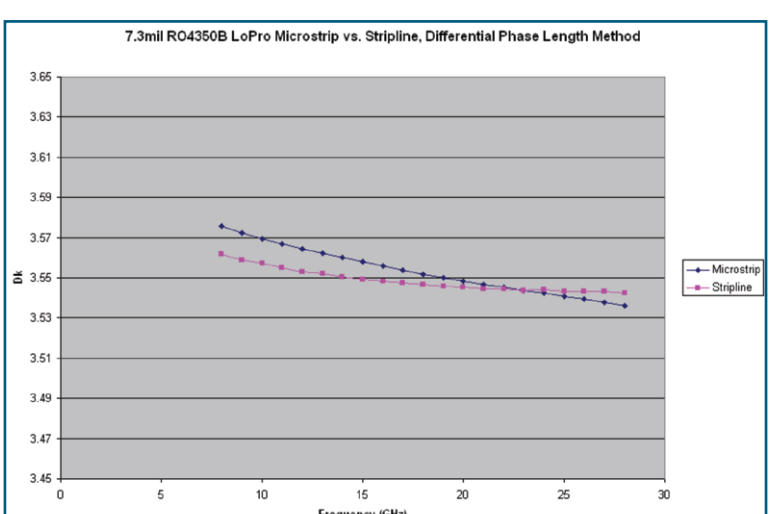


Figure 5: Stripline and microstrip comparisons using the same material and thickness, with the differential phase length test method.

The microstrip differential phase length test is a transmission/reflection method that can yield ε_r values over a wide range of frequencies. The approach involves fabricating two microstrip transmission lines, on the same material and in close proximity to each other, and evaluating the two circuits for differences in their phase responses (if the circuits are identical, their phase responses should be identical). The two circuits are made identical in every way except in length, with one circuit significantly longer than the other. The microstrip phase response formula is used, solving for the effective ε_r value and using a software EM field solver or other tool to calculate the ε_r value of the laminate from the phase response measurements. The phase response formulas are as follows:

$$\Phi = 2\pi f \frac{\sqrt{\varepsilon_{eff}}}{c} L$$

$$\Delta\Phi = 2\pi f \frac{\sqrt{\varepsilon_{eff}}}{c} \Delta L$$

$$\varepsilon_{eff} = \left(\frac{\Delta\Phi c}{2\pi f \Delta L} \right)^2$$

where $\Delta\Phi$ is the differential phase angle and ΔL is the differential physical length. This method has been used to successfully determine ε_r values for several different materials. The results of measurements on circuits made on a ceramic-filled PTFE laminate are shown in Figure 3.

When the same material evaluated in Figure 3 was tested using the clamped stripline resonator approach, it was found to have an ε_r value of 6.15 at 10 GHz. Typically, the clamped stripline resonator test will yield ε_r values which are lower than those from the microstrip differential phase length test. The differences in ε_r values may be due to a number of factors, including entrapped air, conformance issues, and anisotropic effects impacting the stripline test. Other issues relate to the physical differences of the stripline resonator compared to the response of a microstrip transmission line.

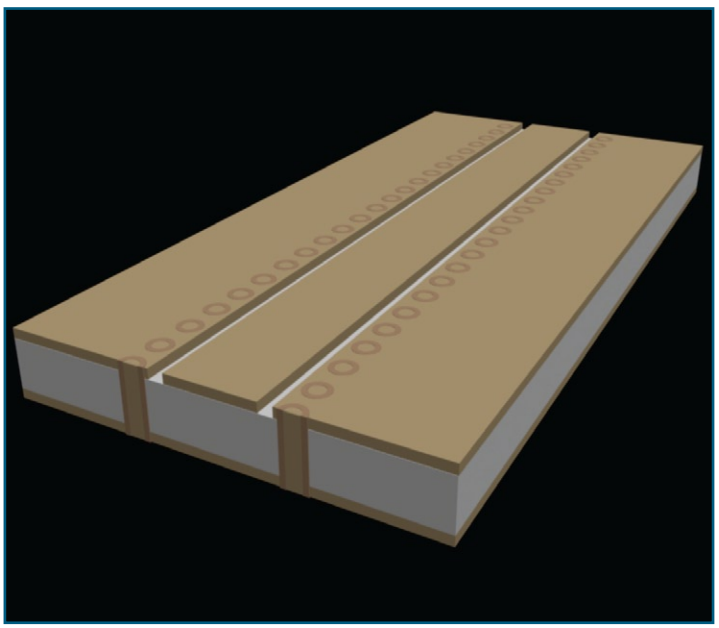
The effects of conductor surface roughness for a PCB have been found to impact the propagation constant of a microstrip transmission line. [1] Compared to a smooth

copper conductor surface, a conductor with a rough surface will alter the apparent ε_r value of a microstrip transmission line and measurements will reveal a higher ε_r value. It has been found that the apparent ε_r value of a given microstrip transmission line will change in two cases when using the same PCB material, but with different thicknesses of the material. It has also been found that the effects of copper conductor surface roughness on the apparent ε_r value of a laminate is dependent on the thickness of the laminate. Copper conductor surface roughness will have greater impact on a circuit using a thinner laminate than on a thicker laminate. But when the laminate thickness is held constant, and only the copper conductor surface roughness is varied, the apparent ε_r value will increase as the copper conductor surface roughness increases (Figure 4).

The effect of copper roughness on the apparent ε_r value can be different with different microwave structures. Since the copper roughness affects the propagation constant of the transmission line, different transmission lines may be affected differently. Figure 5 shows the slight differences in apparent ε_r values between microstrip and stripline transmission lines fabricated on the same RO4350B™ LoPro™ circuit material.

As Figure 5 reveals, the microstrip circuit exhibits more dispersion than the stripline circuit, even though an ideal stripline circuit should have no dispersion. It can be theorized that the stripline circuit suffers small amount of dispersion due to the effects of the copper conductor surface roughness, which is not the same on all four copper-substrate interfaces. The three interfaces which make up the laminates are the same roughness, however, the copper roughness at the bond layer of the stripline will be different. The copper roughness difference on this interface

Figure 6: This drawing illustrates a simple CBCPW transmission line.



is thought to affect the phase velocity and ultimately the dispersion characteristics.

Figure 6 shows a conductor-backed coplanar-waveguide (CBCPW) transmission line. It has a different response than the stripline and microstrip transmission lines regarding the effects of copper conductor surface roughness on the apparent ε_r value, and also different loss characteristics.

Since a CBCPW transmission line can have tight or loose coupling between the signal conductor and the adjacent ground planes on the same layer, this can offset the effects of the copper roughness. A tightly coupled coplanar signal-ground configuration will minimize the effects of copper conductor surface roughness on the apparent ε_r value. In comparison, a loosely coupled signal-ground configuration may allow the effects of copper conductor surface roughness to be more significant on the apparent ε_r value. The same can be said regarding conductor losses for CBCPW transmission lines and circuits.

Understanding the test procedure used by a PCB laminate supplier to determine ε_r value is beneficial in achieving expected performance for a particular circuit configuration and application. A number of different circuit material characteristics can impact the ε_r value determined for a given laminate material, including material thickness, anisotropy, and conductor surface roughness. PCB material data sheets offer ε_r values based on specific tests at specific frequencies, although designers can also contact a laminate supplier when trying to determine the best material for a particular transmission-line technology, circuit configuration, and application.

References

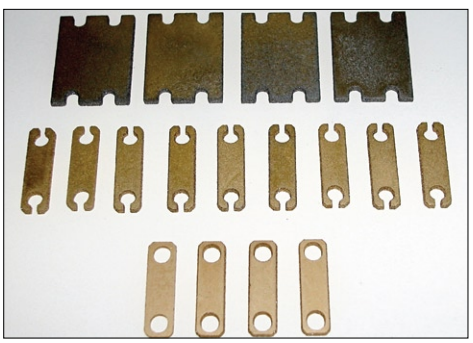
1. J.W. Reynolds, P.A. LaFrance, J.C. Rautio, and A. F. Horn III, "Effect of conductor profile on the insertion loss, propagation constant, and dispersion in thin high frequency transmission lines," DesignCon 2010.

Aluminum diamond heat spreader material for GaN devices

Nano Materials International Corporation (NMIC) claims to have introduced the first commercial device-level solution for dissipating the heat generated by high-density semiconductor devices such as gallium nitride (GaN) RF power transistors.

When used as a heat spreader integrated with a device, NMIC's new aluminum diamond metal matrix composites (MMCs), have demonstrated their ability to reduce device junction temperatures by up to 25%, allowing the devices to generate their full power output at their highest efficiency and potentially extend their operating life. NMIC's aluminum diamond MMC material is the first aluminum diamond MMC material to be economically viable in high volume at a cost that adds minimally to each GaN device.

GaN is the latest advancement in compound semiconductor technology for use in generating high levels of RF power over broad frequency ranges well into the millimeter-wave range. GaN devices have much higher power density than other technologies such as gallium arsenide (GaAs), silicon, and silicon germanium (SiGe) as measured by the amount of power they can generate in given amount of device gate periphery. However, this power density also results in the production of large amounts of waste heat that must be removed from the



device, a challenge that must be effectively met if GaN technology is to achieve its full potential.

Diamond has the highest thermal conductivity of any substance on Earth. When made as an aluminum-diamond composite and used as a heat spreader material, this property remains about 80% higher than its nearest competitor, copper-molybdenum-copper, which is widely used for this purpose. Aluminum diamond also has a coefficient of thermal expansion (CTE) close to that of silicon carbide (SiC), which is essential as most GaN devices employ SiC as their substrate material. NMIC's aluminum diamond also has metallization properties well suited for die attach, along with excellent dimensional tolerance and material stability.

www.nanomaterials-intl.com

Source modules with optional attenuation are RoHS compliant

OML has enhanced its millimeter wave source modules to address feedback from engineers characterizing the linearity of their devices. In addition, OML is proud to announce the availability of source modules that satisfy the EU Directives on Restriction of Hazardous Substances (popularly known as RoHS compliance). While others seek exemptions, OML innovates by developing the industry's first eco-friendly source module that satisfies RoHS compliance directives.

When used with modern microwave signal generators, the SxxMS series of source modules will expand frequency coverage to millimeter and sub-millimeter wave outputs in the 50 to 325 GHz range. Without attenuation, source modules are available from OML to 0.5 THz. The supported waveguide bands include: WR-15, WR-12, WR-10, WR-08, WR-06, WR-05, WR-03, and WR-02.2.

With new optional attenuation, mechanical output power control is possible over a 25 dB dynamic range. For reducing output power, the integrated attenuator simplifies setups and improves overall power control when compared to using external components. When controlling output power, the attenuator employs a patented micrometer feature that offers repeatable settings with minimal passband flatness degradation.

www.omlinc.com

GaN wideband pulsed power amplifier

RFMD's RFHA1023 is a 36 V 225 W high power discrete amplifier for L-Band pulsed radar, air traffic control and surveillance, and general purpose broadband amplifier applications. It is a high terminal impedance matched power transistor providing 225 W with 55 percent drain efficiency, packaged in a hermetic, flanged ceramic package that provides excellent thermal stability. Ease of integration is accomplished via single, optimized matching networks that provide wideband gain and power performance in a single amplifier covering the 1.2 GHz to 1.4 GHz. An evaluation board layout is available optimized for 50 Ω operation. Other specifications include a pulse width of 1ms, a duty cycle of 10 percent, and a small signal gain of 15 dB

www.rfmd.com

Extensive line of hermetic connectorized modules

Twelve standard connectorized module product lines are avaialble and include: amplifiers, attenuators, dielectric resonator oscillators (DROs), frequency dividers and detectors, frequency multipliers, high speed logic, mixers, phase shifters, SDLVAs, switches, VCOs and Microsynth®. Broad selection and availability make Hittite's connectorized module products ideal for quickly assembling specialized test and measurement equipment or prototype subsystems for use in the laboratory or in the field.

Specified for temperatures as wide as -55 °C to +85 °C, these module products are found in high performance microwave and millimeterwave test racks, and are commonly used to validate and benchmark complex microwave and millimeterwave subsystem designs. The connectorized module products utilize flanged, hermetically sealed, gold plated housings which are designed to be mechanically fastened to the mounting surface. Field replaceable coaxial connectors are provided to allow mating with standard RF/microwave cable assemblies.

www.hittite.com

DC to 4 GHz packaged power pHEMT

low noise and high linearity for 3G/4G applications

The TGF2021-04-SD is a high performance pseudomorphic High Electron Mobility GaAs Transistor (pHEMT) housed in a low cost SOT89 surface mount package.

The device's ideal operating point for low noise operation is at a drain bias of 5 V and 150 mA. At this bias at 900 MHz when matched into 50 ohms using external components, this device is capable of 16 dB gain, 0.6 dB noise figure, and 39.5 dBm output IP3. Other specifications include P1dB of 26.5 dBm, input return loss of -8 dB and output return loss of -18 dB.

Typical applications include cellular base stations, WiMAX, wireless infrastructure, and low noise amplifiers. The combination of high gain, low noise, and excellent linearity makes this an ideal component for use in a 3G or 4G receive chain. Evaluation boards at 900 MHz are available.

www.tqs.com

High-power PIN diodes

target T/R switch applications

Skyworks Solutions has introduced a high-power, series PIN diode for large signal transmit and receive switching applications. This high thermal-dissipative diode combines low insertion loss, very good isolation, fast switching, excellent power handling and low distortion in a very small surface mount package. This diode is ideal for infrastructure, homeland security, first responder and military markets. The SMP1345-087LF is a surface mountable PIN diode suitable for use in an RF switch or attenuator circuit. Maximum resistance at 10 mA is 2 Ω and maximum capacitance at 5 V is 0.2 pF. The combination of low capacitance, low parasitic inductance, low thermal resistance, and nominal 10 µm I-region width, makes the device useful in large signal switches and attenuator applications.

www.skyworksinc.com

Digital phase shifters

fast switching speed and low phase error

M/A-COM Technology Solutions has introduced a set of GaAs pHEMT 4-bit and 6-bit digital phase shifters for communications, EW, and radar applications.

The MAPS-010143 is a 4-bit digital phase shifter that provides 360° phase shift range with a step size of 22.5°. It is controlled with a single +5.0 V serial or parallel control line. Its insertion loss is 3.2 dB, with a ±0.5 dB attenuation variation and ±2.0° phase accuracy over the 1.4 to 2.4 GHz.

The MAPS-010163 6-bit digital phase shifter provides 360° phase shift range with a step size of 5.625°. Its insertion loss is 5.0 dB, with a low ±0.8 dB attenuation variation and ±4.0° phase accuracy over the 1.4 to 2.4 GHz.

www.macomtech.com

Switchable LTE antenna

tablet applications, measures 65- x 12- x 1-mm

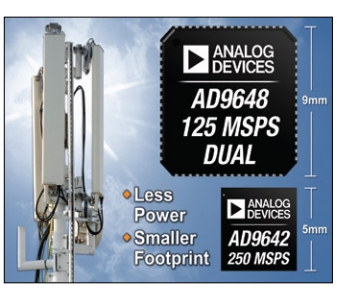
Pulse Electronics' 700-LTE (long term evolution) low profile switchable antenna is designed for mobile connected PCs and is only 1 mm high. It enables four states for low band: 700-750 MHz (LTE low), 750-790 MHz (LTE high), 820-900 MHz (GSM850), and 880-960 MHz (GSM900), and covers 1800/1900/2100 for high band applications, with switching implemented directly from the device's display area. The LTE antenna measures 65- x 12-mm, enabling design flexibility as the length can be varied according to customer requirements.

The antenna can be adjusted for various display sizes, as long as good grounding to the display shield can be provided. Because the antenna pattern is basically planar, it can be installed at the furthest point from the body, which makes it favourable for SAR-sensitive applications. It is compatible with metal tablet holders and with several antenna manufacturing technologies, such as LDS, flex, and sheet metal.

www.pulseelectronics.com

ADCs target 4G/3G infrastructure

consumes 102 mW/channel at 125 MSPS



Analog Devices has released single- and dual-channel 14-bit high speed A/D converters that are said to meet the performance and size requirements of 3G and 4G multi-standard cellular infrastructure equipment, such as CDMA2000, WB-CDMA, LTE, TD-SCDMA and multi-carrier GSM.

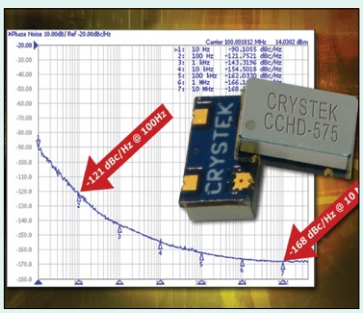
The dual channel AD9648 consumes 102 mW/channel at 125 MSPS and features SFDR (spurious-free dynamic range) performance of 91 dBc at 70 MHz. With IF sampling frequencies up to 200 MHz it may appeal to designers looking for a dual high-speed A/D converter to build multimode digital receivers. The AD9648 is pin compatible with many of ADI's 16-, 14-, 12- and 10-bit A/D converters, enabling migration between 10-bit and 16-bit converters sampling from 20 MSPS to 125 MSPS.

The single channel AD9642 is housed in a 5- x 5-mm package, which is claimed to be 30 percent smaller than competing products, and offers IF sampling frequencies up to 350 MHz supporting wide bandwidths up to 125 MHz. It features an SNR of 72.2 dBFS and SFDR of 90 dBc at base band, while consuming 360 mW at 250 MSPS. The A/D converters feature multi-stage, differential pipelined architectures with integrated output-error-correction logic.

www.analog.com

Ultra-low phase noise CMOS oscillator

provides 168-dBc/Hz noise floor



Crystek Corporation has launched an ultra-low phase noise CMOS oscillator providing a -168 dBc/Hz noise floor. Compact and powerful, the CCHD-575 claims to offer the industry's lowest-jitter clock oscillator in a small 5 x 7.5 mm package.

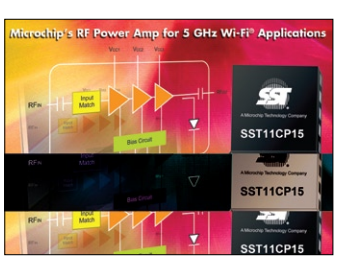
The CCHD-575 features a typical phase jitter of 82 fs RMS at 100 MHz. Close-in phase noise is -90 dBc/Hz at 10 Hz, while its floor is at -168 dBc/Hz. The low phase noise performance is useful in applications such as: DACs, ADCs, low phase signal sources, and test and measurement.

The CCHD-575 generates frequencies between 50 MHz and 130 MHz. The device's output driver is capable of driving ±24 mA, translating to a rise/fall time of ~600 ps at 100 MHz with a 15 pF load. Input supply voltage of 3.3 Vdc consuming 15 mA of current is required. Extended temperature operating range of -40 to +85°C is also available.

www.crystek.com

Compact, high-efficiency RF power amplifier

supports 5-GHz Wi-Fi applications



Microchip Technology has introduced the SST11CP15 RF power amplifier for 5 GHz IEE 802.11a/n WLAN embedded applications. The device operates on the 4.9 to 5.9 GHz band, and offers a wide operating voltage of 3.3 V to 5 V.

The SST11CP15 features a high linear output power of 18 dBm at 2.5 percent EVM, using 802.11a OFDM 54 Mbps at 3.3 V, and 20 dBm at 5.0 V, and offers an output power of 23 dBm at mask compliance of 6 Mbps, at 3.3 V. The device is offered in a compact, 2 mm x 2 mm x .55 mm, 12-pin QFN package. It is ideal for 5 GHz WLAN applications where small size and high-efficiency are required, such as in wireless multimedia and MIMO applications for broadband gateway and consumer-electronics equipment.

The SST11CP15 meets the needs of designers who must reduce DC current consumption in their portable multimedia and MIMO applications. With its high power-added efficiency, the device reduces battery current drain and extends battery operation. The device's 4.9 to 5.9 GHz linear operation enables 802.11a/n operation and increases data rates, while its small size is ideal for space-constrained applications. An evaluation board which is available now.

www.microchip.com

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4G World 2011
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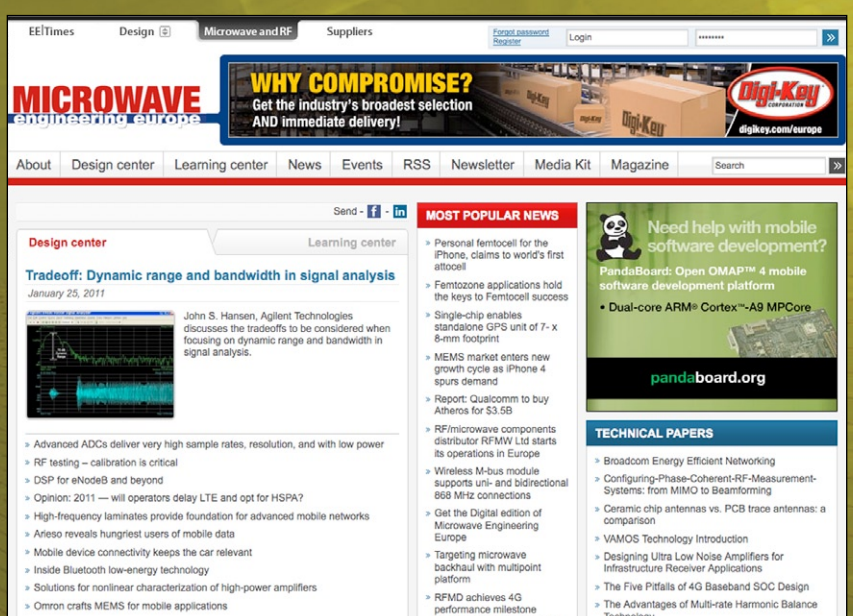

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