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Electrical Specifications (1 Meter of Fiber)										
	Noise Input Power Spurious Free Phase Group				_	Available Wavelengths				
Carios	Eroguoney	Gain	Figure	@ P1dB	Dynamic Range			VSWR	Standard	Optional
Series	Frequency	(dB)	(dB)	(dBm, Min.)	(dB/Hz, Typ.)	(dBc, Typ.)	(ns)	(In/Out)	(nm)	Wavelengths
Transmitters and Receivers										
SLL	5 kHz - 2.5 GHz	12	18	-14	103	>100	0.2	2:1	1550/1310	18 CWDM Ch
	100 MHz - 2.5 GHz	12	18	-14	103	>100	0.2	2:1	1550/1310	18 CWDM Ch
LBL	50 KHz - 3 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
	50 KHz - 4.5 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
	10 MHz - 3 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
	10 MHz - 4.5 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
LBL-HD	950 MHz - 2.5 GHz	0	22	7	114	>100	0.2	2:1	1550/1310	18 CWDM Ch
SCML	50 kHz - 6 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz - 6 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz -11 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz -13 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz -15 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz - 18 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	10 MHz - 18 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
HRL	50 KHz - 6 GHz	20	12	-14	103	>100	0.2	2:1	1550	1310/1490 nm
High Gain Broadband Receivers										
DR-125G-A	30 KHz - 12.5 GHz35 O/E (or TIG = 2800 ohms)							2:1		1280-1580
SCMR-100K20G	OG 100 KHz - 20 GHz32 O/E (or TIG = 2000 ohms)							2:1		1280-1580

CWDM: Course Wavelength Division Multiplexing, DWDM: Dense Wavelength Division Multiplexing

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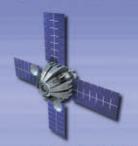


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SEPTEMBER 2012 VOL. 55 • NO. 9

NOTE FROM THE EDITOR

20 Eye on EDI CON

David Vye, Microwave Journal Editor

Highlights the EDI CON 2013 conference and trade show that will take place in Beijing in 2013

COVER FEATURE

24 The European Spectrum Capacity Crunch

William Webb, Neul Ltd.

In-depth look at the European spectrum capacity crunch, why it has happened and how it might be resolved

PERSPECTIVE

36 RF Industry Apps Improve Efficiency

MegaPhase

Melissa Cortez, with sales and marketing at MegaPhase, discusses how mobile apps are changing the way we conduct business

EUROPEAN MICROWAVE WEEK 2012

58 Welcome to European Microwave Week 2012

Bertram Arbesser-Rastburg, General Chairman, EuMW 2012; Ivar Bazzy, President, Horizon House Publications

62 Attending European Microwave Week 2012

Richard Mumford, Microwave Journal International Editor

74 The 2012 EuMW Defence, Security and Space Forum

Richard Mumford, Microwave Journal International Editor

78 Companies Compete for Gold at EuMW

David Vye, Microwave Journal Editor

184 EuMW 2012 Exhibitor List

185 EuMW Product Showcase

SPECIAL REPORT

86 Microwaves in Europe: Winning Ways?

Richard Mumford, Microwave Journal International Editor

Microwave Journal's annual overview of the current state, areas of activity and trends of microwave technology in Europe

TECHNICAL FEATURES

104 Harmonic Suppression of Edge Coupled Filters Using Composite Structures

John Coonrod, Rogers Corp.

Outlines the design process, defines models and the circuit performance for harmonic suppression of microstrip edge coupled bandpass filters using composite structures



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116 An Input Matching Network Without Gain Trade-Off for a Low-Power CMOS LNA

Thi Thu Nga Tran, Chirn Chye Boon, Manh Anh Do and Kiat Seng Yeo, Nanyang Technological University

Features a capacitive feedback circuit along with a $\pi\text{-matching}$ network to achieve the input matching condition without gain trade-off for the common-source LNA

130 Simplified Power Handling Analysis of Microwave Filters

Morten Hagensen, Guided Wave Technology ApS; and Anders Edquist, ANSYS Inc. Presents a detailed step by step approach for accurate power handling analysis of microwave filters based on 3D EM analysis on a single cavity plus knowledge about the filter obtained through circuit analysis

144 Ultra-Wideband Nonlinear Modeling of W-Band Schottky Diodes

Jiang Liu, Hugo Morales, Thomas Weller and Larry Dunleavy, Modelithics Inc.; and Gerhard Schoenthal, Virginia Diodes Inc.

Presents an ultra-wideband nonlinear model, for a W-Band Schottky diode, and validates it against multiple measurement datasets

150 Compact UWB Antennas with Dual Band-Notched Characteristics

Bing Li and Jing-Song Hong, University of Electronic Science and Technology of China

Presents a dual band-notched ultra-wideband printed monopole antenna with a simple structure and small size operating from 2.7 to 41 GHz

PRODUCT FEATURES

162 Carrying Microwave Precision Into the Field

Agilent Technologies

168 Compact Radio Channel Emulator for MIMO Verification *EB* (*Elektrobit*)

172 Ka-Band VSAT Chipset Family

TriQuint Semiconductor

176 Precision and Lab Adapters

Maury Microwave

TECH BRIEFS

178 OSLT Calibration Kits with Extended Frequency Range SPINNER GmbH

180 USB Style RF/Microwave Components

Planar Monolithics Industries Inc.

181 High Power IC Package

StratEdge Corp.

Departments

17...Mark Your Calendar

18... Coming Events

41... Defense News

45...International Report

49... Commercial Market

52... Around the Circuit

182...Web Update

190...The Book End

192...Ad Index

192... Sales Reps

194...MWJ Puzzler

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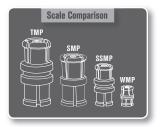
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July Survey

"My Most Productive Month is..."

August:

Left alone, supervisor is on vacation

[13 votes] (28%)

December:

Shipping products before they close the books for the year

[5 votes] (11%)

May.

Leading up to multiple trade shows, need products for demo [7 votes] (15%)

Januarv:

Well rested after the holidays and ready to work

[7 votes] (15%)

March:

It's dark outside, the weather stinks and might as well work [15 votes] (32%) $\,$

White Papers

Testing New-Generation Wireless LAN White Paper, Agilent Technologies

Load-Pull in the 21st Century: A Review of the Past and Look to the Future John Sevic, Focus Microwaves

Using RF Power Meters for EMC Testing White Paper, Wireless Telecom Group

TriQuint's New GaN Amplifiers and Switches Offer System Engineers a Way to Reduce RF Board Space and System Prime Power Grant Wilcox and Dean White, TriQuint Semiconductor Presented by: Richardson RFPD

Solutions for Enabling Fast, Accurate and Efficient Testing of Voice Quality in LTE User Equipment
White Paper, Agilent Technologies



Executive Interview

Pete Page, General Manager of Times Microwave Systems talks about the cable market, new products and overall business outlook.



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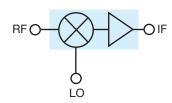
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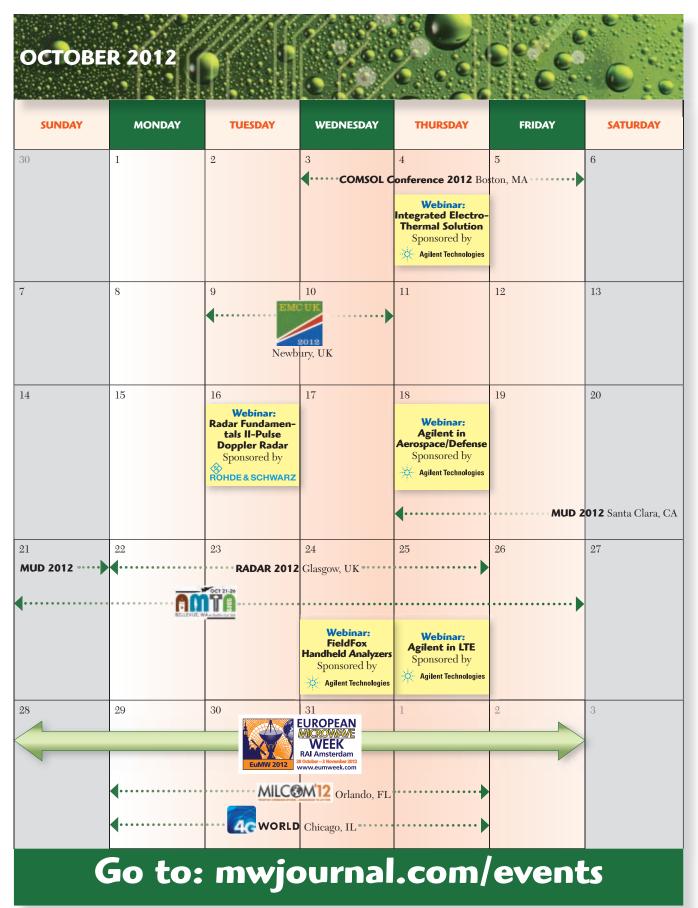
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EuMW 2012

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IEEE MEMS 2013

26th IEEE International Conference on Micro Electro Mechanical Systems

January 20–24, 2013 • Taipei, Taiwan www.mems2013.org

FEBRUARY

ISSCC 2013

IEEE INTERNATIONAL SOLID-STATE CIRCUITS CONFERENCE

February 17–21, 2013 • San Francisco, CA http://issec.org

NATE 2013 CONFERENCE & EXPOSITION NATIONAL ASSOCIATION OF TOWER ERECTORS

February 18–21, 2013 • Fort Worth, TX http://natehome.com/annual-conference

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MARCH



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March 11–15, 2013 • Las Vegas, NV www.iwceexpo.com

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ELECTRONIC DESIGN INNOVATION CONFERENCE

March 12–14, 2013 • Beijing, China www.ediconchina.com

SATELLITE 2013

March 18–21, 2013 • Washington D.C. www.satellitetoday.com/satellite2013

APRIL

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IEEE INTERNATIONAL WIRELESS SYMPOSIUM April 13–18, 2013 • Beijing, China

April 13–18, 2013 • Beijing, China www.iws-ieee.org

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Eye on EDI CON

he idea for an Electronic Design Innovations Conference (EDI CON) began with a conversation between this magazine and leading vendors operating in China. To keep our readers up-to-date, discussions on how to better communicate information about technology, products and services are common. While print is our primary means to inform readers, other forms such as webinars, videos and live technical panels have increasingly been added to the mix. So, as the Journal was launching a new China media channel along with plans to create a microwavecentric conference/exhibition, we had the opportunity to rethink the aim and approach of such an event. The resulting concept will leverage a high-level of collaboration between event organizer and the commercial sector of the industry to identify the interests and needs of the intended audience. With the companies that serve this regional market assuming a significant role in defining the scope of EDI CON, the technical program would align attendee interests with those of the supporting exhibitors. Thus EDI CON will focus on supporting the continuing professional development of microwave engineers with information developed and provided by the industry from its knowledge of where technology is going and what engineers need to facilitate its development.

Microwave engineering is all about physical design and the foundation of microwave design lies in the models and formulas that are used in simulation at the circuit or system level. These models come from electromagnetic simulation, measurement based S-parameters and compact transistor models also derived from measurement. Because of the importance of simulation software and test and measurement equipment in the design process, the state of these tools and their use will be a central theme of the EDI CON technical program. The importance of these tools is rep-

resented by the participation of EDI CON's platinum and gold sponsors, including leading RF/microwave test equipment manufacturers and software providers such as Agilent, Rohde & Schwarz, Anritsu, AWR/National Instruments, ANSYS and CST. To solicit and vet content related to design, measurement and modeling, senior technologists from these companies have volunteered their expertise to serve on the technical advisory com-Joining these technical advisors are measurement and simulation experts from Auriga Microwave, Maury Microwave, Spirent Communications, and 2COMU (GEMS). These contributors will review papers on measurement and modeling techniques from the most basic components, such as on-chip passives and nonlinear devices through system-level characterization, such as over-theair channel emulation and test. The measurement/modeling track will be co-chaired and moderated, in part, by a ranking expert from the Chinese Research Institute for microwave metrology and measurements.

Knowledgeable microwave system design and integration requires expertise in materials, semiconductors, interconnect systems (cables/ connectors) and component modules. Most systems are comprised of customized parts, specialized interconnects and the optimum semiconductor technology for the job at hand. EDI CON is collaborating with technical experts from leading RF/microwave integrated device suppliers such as Skyworks, RFMD, TriQuint, Mini-Circuits and others as well as compound semiconductor foundries such as Win Semiconductors and OMMIC. Rogers Corp. and LPKF will be among the companies providing expertise in PCB properties, characterization, best design practices and the latest in RF PCB design prototyping.

Our technology's history is a time line of new materials and structures supporting increasingly complex systems. By developing new transmission mediums, from waveguide to miniaturized coaxial interconnect systems to planar strip-line and micro-strip technologies to high-frequency semiconductors such as MMICs and RFICs to advanced over-the-air techniques such as beam forming and MIMO based spatial diversity, our engineers have always looked for better ways to get microwave energy from point A to point B. With these advances, we have developed systems that defend societies from potential enemies, guide our air traffic, provide life saving weather prediction and tracking, directional information in our cars and medical imaging, and even allow mobile access to voice and Internet data with devices that fit in our pockets.

Clearly, modern societies rely on communication infrastructure powered by microwave technology. Our job is to keep advancing the state of the art that supports new generations of such systems. Critical to that pursuit is the development of international engineering resources. This pool of talent needs to be global. Globalization promotes diversity in the worldwide approach to problem solving and proximity to regional challenges fuel localized innovation, expanding overall knowledge and fostering new ways of thinking. Up until now, individual companies have been independently serving this need through their Chinabased operations. EDI CON unites their efforts to support and grow the local China microwave community, providing education from a commercial perspective in the language and setting that allows these engineers to learn and the experts to inform.

DAVID VYE
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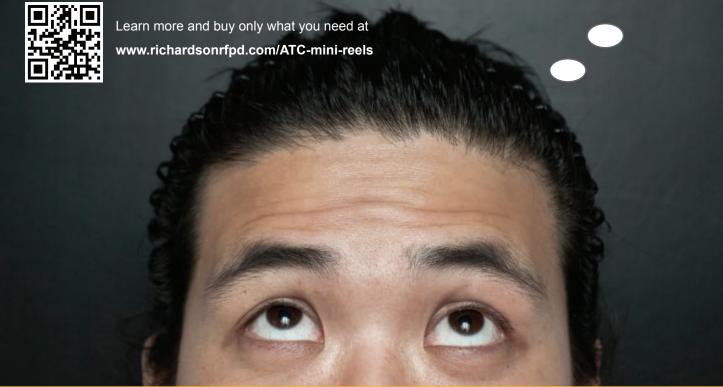
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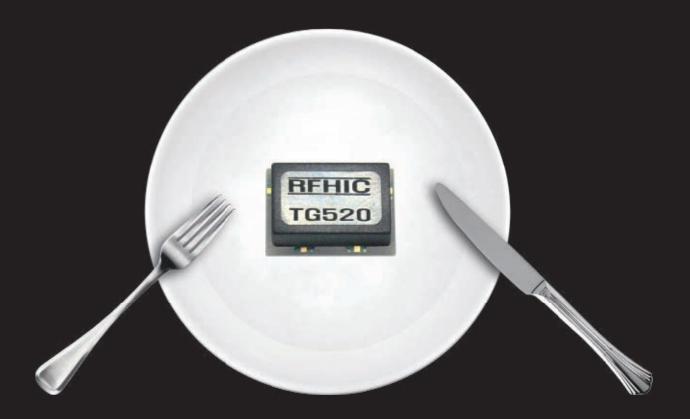


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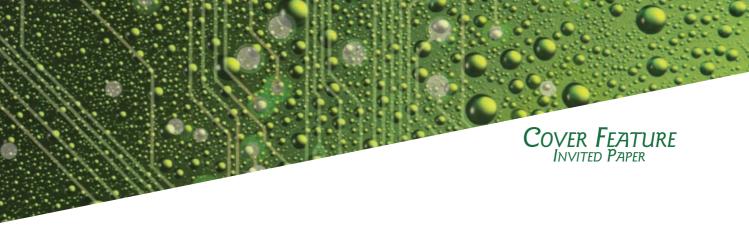


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The European Spectrum Capacity Crunch

There has been much talk about the spectrum capacity crunch. In the U.S., 500 MHz of spectrum has been approved to be freed up for cellular. A similar approach has been adopted in a number of European countries. Cellular operators are lobbying hard for more spectrum and recently the World Radio Congress decided that the 700 MHz band should become a cellular allocation throughout Europe.

The reason for all this is, of course, the rapidly growing mobile data usage, driven initially by the introduction of the iPhone and then, increasingly, other smartphones, tablets and so on. By providing a simple way to select, access and view data while mobile, these devices have dramatically changed the attractiveness of using mobile data and hence the demand. The speed at which this demand grew caught many mobile operators by surprise, resulting in severe network congestion. This led, for example, to O₂ adding another 500 cells to its network in London. Where all this is heading is unclear, but Cisco forecast in the region of 18 times growth in mobile traffic between 2011 and 2016, 1 fuelled predominantly by mobile video.

A crunch occurs when the demand outstrips the supply. The worry in the industry is that it will not be possible to meet this increased demand cost-effectively and as a result there will be congestion, higher prices, diminished user experience or some mix of these. This article, based in part on the 7th Annual European Spectrum Management Conference in Brussels in June 2012, looks at what can be done to meet demand and whether a crunch is really likely.

IS IT REALLY A SPECTRUM CRUNCH?

Mobile network capacity is determined by three factors – the amount of spectrum, the efficiency of the technology and the number of cells deployed. Capacity scales approximately linearly with spectrum and technology, so doubling the spectrum provides double the capacity. Likewise, doubling the technical efficiency doubles capacity. Capacity actually scales faster with smaller cells. When, say, a single cell is replaced by four smaller ones, there is a four times gain just from reusing the spectrum more efficiently.

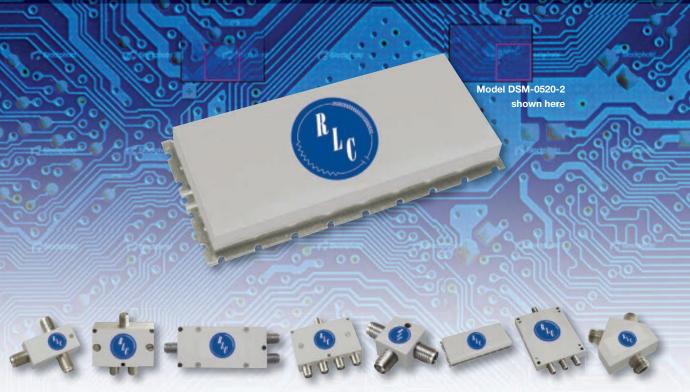
Also, because mobiles are now closer to their nearest base station, they can typically make use of more efficient modulation modes such as more QAM levels. This increases the cell throughput. The actual gains will vary dramatically from technology and depend on the deployment conditions, but an estimate of the effect can be seen in *Figure 1*.

In this case, if the cell size was originally 5 km radius and it was replaced by 6 cells of 2 km radius, the red line shows a capacity gain of six times from the frequency reuse but the blue line shows around 25 times in total, taking modulation efficiency improvements into account. A mobile operator would logically deploy the lowest cost option(s) to increase network capacity, until the point at which supply and demand bal-

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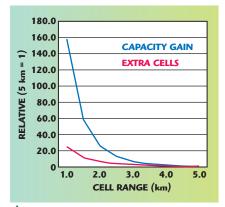
ance. As mentioned previously, ${\rm O}_2$ selected smaller cells.

So the answer, in principle, to the question as to whether it is a spectrum crunch is "no." It is a capacity crunch and there are three levers – spectrum, technology and cell size – that can be used to address this. But how practical are each of these levers?

CAN WE FIND MORE SPECTRUM?

It is often said (by Americans) that, "spectrum is like real estate – they just

don't make it any more." That is partly true, but land can be reclaimed and taller apartments can be built. Similarly spectrum can be reclaimed from other uses, such as broadcasting, or used more efficiently with techniques such as 'white space access.' But before looking into these, let us take a step back to understand the scale of what is needed. If an 18 times growth is expected by 2016 (and the predictions are still ramping in 2016, so it is likely that there will be even more growth



▲ Fig. 1 Effect of adding cells with lower radius (Source: W. Webb, "Understanding Weightless").

beyond this) and using spectrum alone to resolve it, then the operators will need at least 18 times more spectrum than they currently have.

The amount currently available varies from country to country and depends on whether, for example, the 2.6 GHz band has been auctioned yet, but is in the region of 300 to 400 MHz in total. Taking the mid-point suggests 6.3 GHz of spectrum would be needed by 2016. Since operators require spectrum below 3 GHz to achieve viable propagation, this is clearly impossible. So there is no way whatsoever that the capacity crunch can be wholly addressed by using more spectrum.

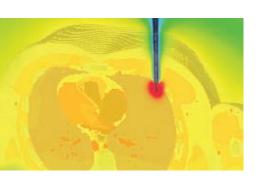
In fact, one can be fairly sure about what spectrum might be reclaimed between now and 2016, since the process takes at least five years. Immediately, it is the 800 MHz and 2.6 GHz bands - already auctioned in many European countries. This comes to approximately 250 MHz of spectrum. After 2020, approximately 100 MHz might be added to that in the 700 MHz band and perhaps the 2.3 GHz band. Some release of military spectrum in some countries is possible, but unlikely to be of much use unless globally harmonized. So even assuming twice an increase in reclaimed spectrum is optimistic.

The other option is to make better use of what is already available, using 'white space' concepts whereby secondary users can temporarily use spectrum that the license holders are not using themselves. Much work has been done on accessing the white space in and around TV transmitters and this looks very promising for a range of new technologies including





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machine-to-machine systems, based on the emerging Weightless standard.

But, at best, there is approximately 100 MHz of white space available in the TV bands and there are many locations where this falls to 10 to 20 MHz. This is fine for M2M but of no real value to cellular. Of course, white space access could be extended to other bands, could be used in an unlicensed or licensed format (the latter sometimes known as authorized shared access or ASA) and will be extremely

valuable in stimulating innovation and new applications, but it is not the savior that cellular needs. So, broadly, spectrum can provide at best twice the gain. There is a complication here that cellular traffic could be offloaded into other spectrum, using Wi-Fi bands, which will be considered later.

ARE THERE TECHNICAL SOLUTIONS?

So if not spectrum, can technology take the strain? Radio systems are of-

ten measured in bits/Hz/cell. If the efficiency could be doubled, could twice as many bits/Hz and twice the capacity be obtained? Could some new technology improve capacity by 18 times?

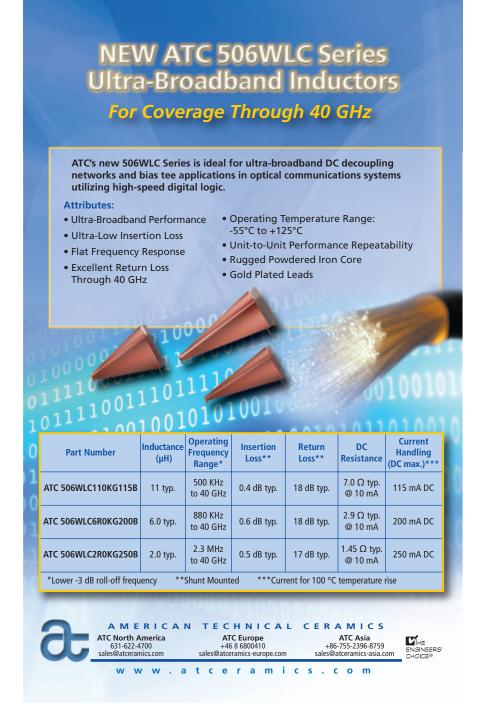
There are many contenders for improvements in efficiency. Multiple antenna or MIMO systems hold the most promise, with apparently large gains possible, if large numbers of antennas can be supported – this is a key ongoing area of research for many in the RF community.

In particular, finding ways to embed two, four or even eight antennae into a mobile device in a way that each is relatively independent of the other, while still being able to handle multiple frequency bands, is extremely challenging, but ultimately the key mechanism where gains will be realized. Methods to deploy large numbers of antennae unobtrusively on base station towers are also called for.

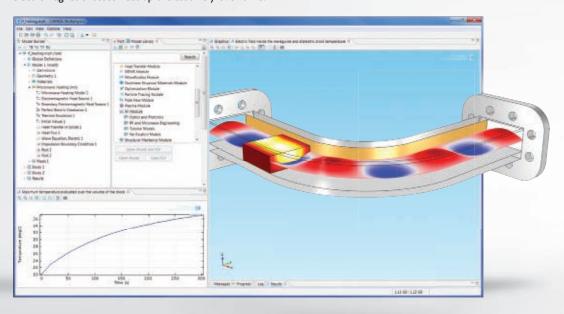
Another approach is transmissions from multiple cells – called coordinated multi-point transmission (CoMP) in 4G. Here, the same signal is sent simultaneously to a mobile from multiple nearby base stations, allowing it to aggregate the signal level. This can bring benefits by enabling higher modulation modes or lower levels of error correction to be used. Carrier aggregation is also part of LTE, whereby a device can simultaneously use multiple bands of frequencies to deliver higher data rates.

While not directly impacting capacity, it might make smaller bands of spectrum more viable than would otherwise be the case. This leads to further problems. Making handsets that can work across large numbers of bands is very challenging. There are now some 40 bands identified for 4G – it seems unlikely that any handset could support them all. So improvements, particularly in RF technologies, to facilitate wider band RF frontends, better isolation between different bands and broadband antennas will be critically important.

Even with all these enhancements, cellular systems are pushing hard against the boundaries of physical limits and most estimate that practical 4G systems will be about twice better than current 3G systems. Even that may come at some cost in terms of complexity, device form-factor, battery life and more.



MICROWAVE HEATING: An RF waveguide bend with a dielectric block inside is modeled. Results show how the electromagnetic losses heat up the assembly over time.



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At the 7th Annual European Spectrum Management Conference, panelists from a number of European companies offered a range of other ideas. One suggested using satellite to broadcast the most popular video content, thus avoiding sending it individually to multiple devices. But this requires handsets to have satellite antennas and that many users watch the same content simultaneously, which is likely on home TV screens but less so on mobile devices.

Another looked at developments in small cells and suggested very small form-factor base stations linked by fiber optic cable. The base station then essentially becomes an upconverter, taking the signal on the fiber and amplifying and transmitting as RF. This is one way to realize small cells cost-effectively but does require widespread low-cost fiber deployment, which is often not available. A strong theme from many was sharing spectrum using innovative new access techniques as

mentioned above. So, that gives twice from spectrum and twice from technology, neither quite arriving by 2016 – for a total of four times. That is still a long way from the 18 times needed.

SO WHAT ABOUT SMALLER CELLS?

Unlike spectrum, which "they don't make any more" and technology, which is limited by Shannon's Law of transmission capacity, cell sites are unlimited. The only constraining factor is cost (it can be difficult to find sites and to get permission to use them, but typically time and enough money can overcome these issues). This is why over the last few decades most of the gains in capacity have come from more cell sites.

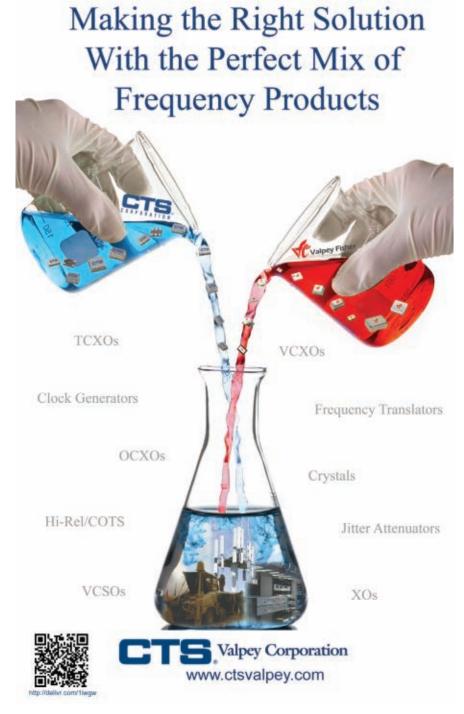
For example, Marty Cooper, in forming Cooper's Law, noted that wireless network capacity world-wide improved about 1 million-fold from 1950 to 2000. This comprised 15 times from more spectrum, 25 times from more efficiency and a massive 2,700 times from more cells.

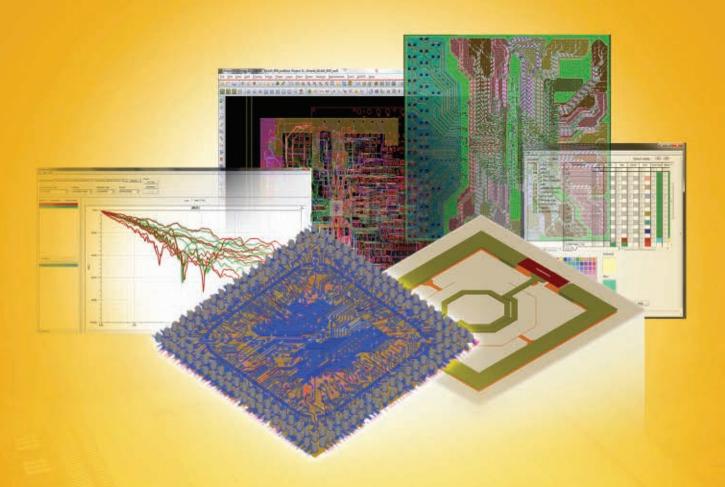
If the 18 times demand growth forecast is assumed, then with at best twice the spectrum and twice the efficiency, approximately five times the cell numbers are needed – trivial compared to historical standards. Or alternatively, operators could opt for once the spectrum, twice the efficiency and six times the cell count or any other combination. This shows that whatever happens, a large increase in cell numbers is needed to meet predicted demand growth.

So the number of small cells is limited only by cost. Cost is far from a trivial factor, of course, and especially important when the expectation (strangely) is that the 18 times increase in capacity will be delivered without changing the average revenue per user (ARPU) much. Above all, low-cost and widely available backhaul will be needed to enable such small cell deployment.

BUT WE HAVE LOTS OF THEM!

Actually, there are small cells – lots of them – in the form of Wi-Fi in homes, offices, shops, restaurants and many more locations. In a typical European country, each mobile operator has approximately 15,000 base stations but, in the UK, BT has collected over 3 million Wi-Fi nodes together under its sharing project called FON, where





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home owners open up their Wi-Fi in return for free access to other home owners who do the same. So BT has assembled two orders of magnitude more cells than mobile operators.

Simply finding a way to seamlessly integrate Wi-Fi cells and femtocells into mobile networks would mostly solve the mobile data crunch, assuming a reasonable degree of correlation between demand and Wi-Fi hotspots (which seems likely in all but a few special cases such as trains). Such an

approach might require some regulatory change, a small amount of standardization of 'feed-in' capacity and modifications to the cellular value model, but these are relatively minor compared to the difficulties involved in repurposing spectrum.

This has not escaped the notice of cellular operators. Most 'cellular' traffic is already offloaded onto Wi-Fi – for example *Figure 2*, from a recent study, shows the split of traffic from smartphones in Europe on a typical

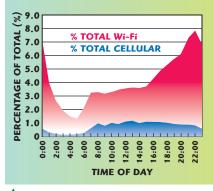


Fig. 2 Split of traffic from smartphones in Europe on a typical weekday (Source: Richard Thanki).

weekday. Clearly, something like 5 to 10 times as much traffic is being handled via Wi-Fi as cellular. This offloading is only likely to grow as more Wi-Fi nodes are added and initiatives such as HotSpot 2.0 make it seamless to log onto nearby Wi-Fi base stations.

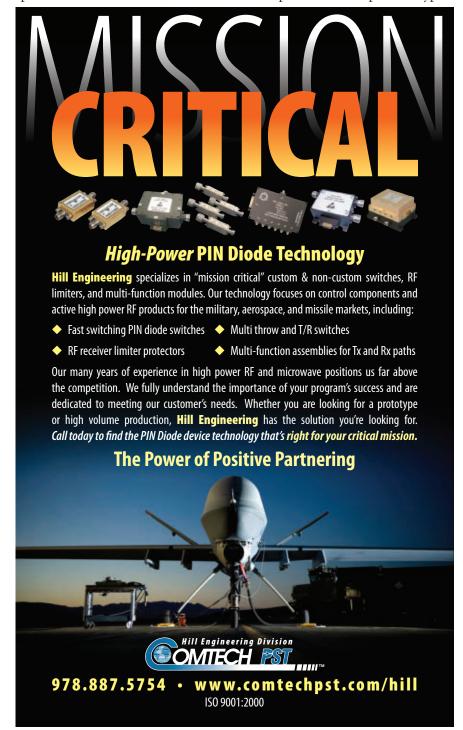
WHAT IF WE DO NOT RESOLVE IT?

So, demand for mobile data might grow hugely if it were essentially free. However, mobile operators face a cost in enhancing their networks to increase capacity, either in technology upgrade, spectrum auction fees or cell deployment costs. They will select the lowest cost option first, then the next lowest and so on.

So, it will become progressively more expensive to grow capacity. Since operators are generally not philanthropists, their data charges must grow to meet these costs. Increased costs will dampen demand and equilibrium will prevail. There will be no more data crunch problems. Where this balance might fall is hard to predict and likely to change over time as new, more valuable, applications emerge.

All of this is really basic economics and engineering. Issues become more complex when some argue that mobile broadband is too important to be left to markets alone. They suggest that its value to society in enabling innovation, productivity, social inclusion or other important goals is so great that price should not be allowed to restrict demand.

This is somewhat akin to saying that electricity is so important to society that all homes should be supplied with all they want at a flat rate. Few would accept flat-rate electricity is appropriate. With mobile devices predominantly used for entertainment, it is hard to



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see how important societal goals are achieved, other than enabling new high scores on Angry Birds.

Let us assume that there were important societal reasons for delivering unlimited mobile broadband. Governments could achieve these goals through indirect subsidies – predominantly via the provision of more spectrum at low cost – or direct subsidies – paying mobile operators to provide flat rate services. The latter is akin to the subsidies paid to rail operators by

some governments to provide low-cost (although not unlimited) train travel.

Economists are clear that direct subsidies are preferable to indirect subsidies. Spectrum should be used efficiently and by the entity that values it the most, but not necessarily as a policy tool in delivery of socially valuable objectives. So, if governments really considered mobile broadband an important social good, they should subsidize mobile operators to provide it.

In some cases, markets are not perfect. In the case of mobile broadband, users have limited awareness of their usage and so can find it difficult to adapt their behavior according to price. This is why most prefer bundles, which simplify and provides certainty in their bill. This does complicate supply and demand somewhat but is not insurmountable in markets such as electricity, where users generally do not understand exactly how much each appliance uses, but have developed a sufficiently good approximation that they are rarely surprised by bills.

HOW IT WILL LIKELY PLAY OUT

As is often the case, the solution is likely to be to scrape through. Operators will get more spectrum (twice), will progressively deploy LTE (twice) and will deploy a few new cells (probably more than twice). They will use ever more Wi-Fi offload (perhaps four times) or more likely users will arrange this for themselves. All of this likely will not be quite enough and will be expensive, so data costs, especially for heavier users, will rise. This may not be because operators raise their prices per GB, they may in fact reduce them, but because they will not reduce them by 18 times, the net effect to end users is an increased cost. This will dampen demand somewhat so it reduces back towards the economically sensible supply.

Resolving the mobile data crunch may not be so difficult after all! ■

Reference

 Cisco's "Mobile Visual Networking Index," published March 2012.



William Webb has a first class honors degree in electronics, a PhD and an MBA. He is CTO and one of the founding directors of Neul Ltd., a company developing machine-to-machine technologies and networks, which was formed at the start of 2011. Prior to this, he was a director of technology at Ofcom, where he managed

a team providing technical advice and performing research across all areas of Ofcom's regulatory remit. He also led some of the major reviews conducted by Ofcom including the Spectrum Framework Review, the development of Spectrum Usage Rights and most recently Cognitive or White Space Policy, Previously, Webb worked for a range of communications consultancies in the UK in the fields of hardware design, computer simulation, propagation modeling, spectrum management and strategy development. He also spent three years providing strategic management across Motorola's entire communications portfolio, based in Chicago.





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RF Industry Apps Improve Efficiency

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obile apps are changing the way we conduct business, research products and find the fastest way to solve a problem. Mobile apps are now emerging as a new tool for engineers in the RF/microwave industry who find themselves in need of applications that can meet their demands from research to production. There is a market for apps within the RF/microwave industry as we notice that engineers, both experienced and novice look for more accessible learning tools versus the standard textbook. These apps for operating systems, such as iOS and Android, can be employed to retrieve data, evaluate designs and obtain test results or quickly make calculations with a tap on a screen. These applications have presented a shift in the methods that are used to acquire information on all technological avenues. Subsequently, speeding the process associated with receiving, sending and conducting research and data analysis.

Technology by today's standards dictates efficiency in everyday business, from engineers in the lab to R&D to manufacturing. Advancements in technology have changed drastically from Generation X to Generation Y; all generations struggling to keep up with the demands of being the next innovators or keeping up with the changing dynamics of fast mov-

ing markets. Be it in the RF industry, electronics, defense, or telecommunications, the technology world is moving at a rapid pace and increasing the need to require more industries to stay relevant if not be at the forefront of new developments.

Many companies have released applications through the Apple iTunes store that pertain to the RF industry, such as Agilent Technologies, JDSU, National Instruments, Oscium, and Xilinx. Agilent Technologies has developed many apps for engineers including Engineering Calc (EC) this is an application intended to be used as a field calculator for electrical values based on Ohm's Law, simulate a Smith Chart diagram and determine the resistor and capacitor values based on their color codes. The JDSU app DSAMobile Lite is an iPad application that is used wirelessly in conjunction with the JDSU Digital Service Analysis Meter (DSAM) CATV test instrument; which features a full scan of channels from 50 MHz to 1 GHz in a single view and utilizes pass/fail analysis based on the configuration of the DSAM instrument.

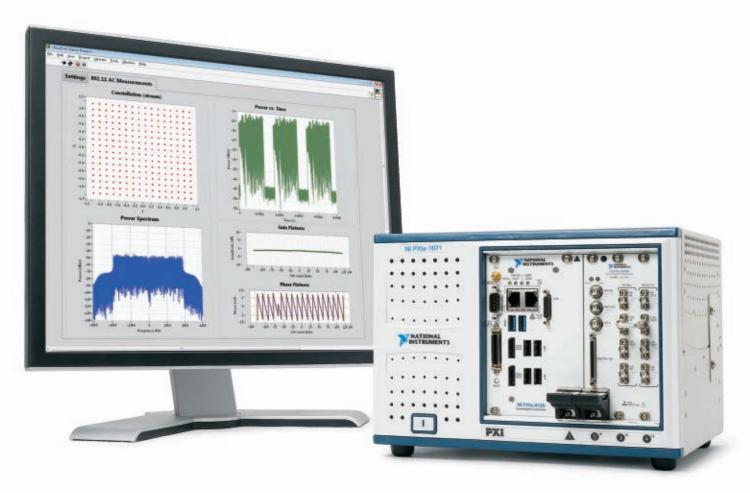
Other examples include National Instruments that has developed many apps including Data Dashboard Mobile. Data Dashboard Mobile app is essential for on-the-go engineers to access custom and portable views of

National Instruments LabVIEW applications by displaying the values of network published, shared variables and/or web services on charts, gauges, text indicators and LEDs. Oscium developed iMSO, which allows users to analyze one analog and up to four digital signals using the iMSO-104 mixed signal oscilloscope hardware. Xilinx developed Pocket Power Estimator (PPE) which is a high-level power estimation application that enables designers to quickly perform whatif power analyses based on specific design scenarios. Each one of these companies are moving towards the trend of high-tech driven individual's demands of instant service and user friendly tools to enhance daily operations and work more efficiently.

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Perspective



▲ Fig. 1 MegaPhase App start screen.

quotes. Phone calls and emails can be made directly through the app for any inquiries or questions for an instant response.

The MegaPhase app was developed for engineers, customers, representatives and employees. The thought process behind the development of the app was to acknowledge every demographic in MegaPhase's target audience - this app is user friendly while still being a reliable source for RF/microwave components and calculations. The MegaPhase app caters to the tech-savvy individuals that are emerging within the RF sector, whether that is instrumentation, airborne, spacecraft, telecom or defense industries.

MegaPhase developed this app as a new tool for engineers designing and building RF/microwave systems and components. It is a dependable source of technical information that is easy to use even with the advanced technical capabilities it contains. Engineers and technicians are now able to order replacement cables or design new ones with a few taps on their device while inside the lab, while performing tests or other tasks. The trend is clear testing engineers can now download a variety of free apps to simplify daily calculations and estimates. We look forward to a wide variety of new applications hitting the RF industry in the coming years.

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OCTAVE BAND LOW NOISE AMPLIFIERS									
Model No. CA01-2110 CA12-2110 CA24-2111 CA48-2111 CA012-3111 CA1218-4111 CA1826-2110	Freq (GHz) 0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0 8.0-12.0 12.0-18.0 18.0-26.5	Gain (dB) MIN 28 30 29 29 27 27 25 32	Noise Figure (dB) 1.0 MAX, 0.7 TYP 1.0 MAX, 0.7 TYP 1.1 MAX, 0.95 TYP 1.3 MAX, 1.0 TYP 1.6 MAX, 1.4 TYP 1.9 MAX, 1.7 TYP 3.0 MAX, 2.5 TYP D MEDIUM POV	Power-out @PI4 +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN	+20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm	VSWR 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1			
CA01-2111 CA01-2113 CA12-3117 CA23-3111 CA23-3116 CA34-2110 CA56-3110 CA78-4110 CA910-3110 CA12-3114 CA34-6116 CA56-5114 CA812-6115 CA812-6116 CA1213-7110 CA1213-7110 CA1722-4110	0.4 - 0.5 0.8 - 1.0 1.2 - 1.6 2.2 - 2.4 2.7 - 2.9 3.7 - 4.2 5.4 - 5.9 7.25 - 7.75 9.0 - 10.6 13.75 - 15.4 1.35 - 1.85 3.1 - 3.5 5.9 - 6.4 8.0 - 12.0 8.0 - 12.0 12.2 - 13.25 14.0 - 15.0 17.0 - 22.0	28 28 25 30 29 28 40 32 25 25 30 40 30 30 28 30 25	0.6 MAX, 0.4 TYP 0.6 MAX, 0.4 TYP 0.6 MAX, 0.4 TYP 0.7 MAX, 0.5 TYP 1.0 MAX, 0.5 TYP 1.0 MAX, 0.5 TYP 1.2 MAX, 1.0 TYP 1.4 MAX, 1.2 TYP 1.6 MAX, 1.3 TYP 4.0 MAX, 3.5 TYP 5.0 MAX, 4.0 TYP 4.5 MAX, 3.5 TYP 5.0 MAX, 4.0 TYP 6.0 MAX, 4.0 TYP 5.0 MAX, 4.0 TYP	+10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +33 MIN +35 MIN +30 MIN +33 MIN +33 MIN +33 MIN +33 MIN +31 MIN +31 MIN +31 MIN	+20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +21 dBm +41 dBm	2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1			
Model No. CA0102-3111 CA0106-3111 CA0108-3110 CA0108-4112 CA02-3112 CA26-3110 CA26-4114 CA618-4112 CA618-6114 CA218-4116 CA218-4110 CA218-4110	Freq (GHz) 0.1-2.0 0.1-6.0 0.1-8.0 0.1-8.0 0.5-2.0 2.0-6.0 2.0-6.0 6.0-18.0 2.0-18.0 2.0-18.0 2.0-18.0	Gain (dB) MIN 28 28	2.0 MAX, 1.5 TYP 5.0 MAX, 3.5 TYP 5.0 MAX, 3.5 TYP	Power-out @ P14 +10 MIN +10 MIN +10 MIN +10 MIN +22 MIN +30 MIN	## 3rd Order ICP #20 dBm #20 dBm #20 dBm #32 dBm #40 dBm	VSWR 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1			
Model No. CLA24-4001 CLA26-8001 CLA712-5001 CLA618-1201	Freq (GHz) 1 2.0 - 4.0 2.0 - 6.0 7.0 - 12.4 6.0 - 18.0	-28 to +10 d -50 to +20 d -21 to +10 d -50 to +20 d	Range Output Power II Bm +7 to +1 Bm +14 to +1 Bm +14 to +1 Bm +14 to +1 ATTENUATION	l dBm 8 dBm 9 dBm	wer Flatness dB +/- 1.5 MAX +/- 1.5 MAX +/- 1.5 MAX +/- 1.5 MAX	VSWR 2.0:1 2.0:1 2.0:1 2.0:1			
Model No. CA001-2511A CA05-3110A CA56-3110A CA612-4110A CA1315-4110A CA1518-4110A	Freq (GHz) 0.025-0.150 0.5-5.5 5.85-6.425 6.0-12.0 13.75-15.4 15.0-18.0	Gain (dB) MIN 21 23 28 24 25 30	Noise Figure (db) Pow 5.0 MAX, 3.5 TYP 2.5 MAX, 1.5 TYP 2.5 MAX, 1.5 TYP 2.5 MAX, 1.5 TYP 2.2 MAX, 1.6 TYP	+12 MIN +18 MIN	in Attenuation Range 30 dB MIN 20 dB MIN 22 dB MIN 15 dB MIN 20 dB MIN 20 dB MIN	VSWR 2.0:1 2.0:1 1.8:1 1.9:1 1.8:1 1.85:1			
Model No. CA001-2110 CA001-2211 CA001-2215 CA001-3113 CA002-3114 CA003-3116 CA004-3112	Freq (GHz) (0.01-0.10 0.04-0.15 0.04-0.15 0.01-1.0 0.01-2.0 0.01-3.0 0.01-4.0	Gain (dB) MIN 18 24 23 28 27 18 32	Noise Figure dB 4.0 MAX, 2.2 TYP 3.5 MAX, 2.2 TYP 4.0 MAX, 2.2 TYP 4.0 MAX, 2.8 TYP 5.10 meet your "exact" requires	Power-out @ PI-dB +10 MIN +13 MIN +23 MIN +17 MIN +20 MIN +25 MIN +15 MIN	3rd Order ICP +20 dBm +23 dBm +33 dBm +27 dBm +30 dBm +35 dBm +25 dBm	VSWR 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1			
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Dan Massé, Associate Technical Editor



Cassidian's SmartRadar Opens New Opportunities in Airborne Ground Surveillance

assidian, the defense and security division of EADS, has developed an airborne ground surveillance radar that, through use of the newest ultra-high-resolution radar technology, can monitor wide areas with stationary targets, while at the same time detect and track moving targets at great distances. The utilization of a special modular architecture permits scalability of bandwidth, frequency band and processing performance. Rapid adaptation to new operational requirements through simple, configurable firmware and software together with a variable cooling design make "SmartRadar" (Smart = Scalable Modular Aerospace Radar Technology) suited to a wide range of manned and unmanned platforms.



The novel technological design in conjunction with the innovative and extremely powerful real-time modes has already undergone various successful tests on behalf of the German Federal Office of Defense Technology and Procurement (BWB). Recently, outstanding reconnaissance results were obtained during airborne testing at Goose Bay, Canada, in June 2012.

"Our SmartRadar offers higher reconnaissance performance in less time than other airborne surveillance radars currently available and can be rapidly adapted to various customer requirements and platforms," says Elmar Compans, head of the Sensors & Electronic Warfare unit at Cassidian. "The sensor's real-time information needed today for protecting our troops and combating possible threats is unsurpassed in its quality and low latency."

One version of Cassidian's SmartRadar is integrated into a pod equipped with an autonomous cooling system, making possible immediate adaptation to various mission aircraft. The high performance of the radar is largely due to state-of-the-art Active Electronically Scanned Array (AESA) technology, which uses a large number of transmitter and receiver (T/R) modules in the antenna. These modules, which are made from special HF-capable materials, are developed and manufactured by Cassidian in its own facility, known as the "Microwave Factory." Cassidian is the pioneer of this technology in Europe and delivers similar T/R modules for

2000 border surveillance radar, among others.

Pooing Toom Demonstrates Eveneded

Boeing Team Demonstrates Expanded Control of Unmanned Aircraft Swarm

oeing and the Johns Hopkins University Applied Physics Laboratory (JHU/APL) have demonstrated that an operator on the ground, using only a laptop and a military radio, can command an unmanned aerial vehicle (UAV) "swarm." Despite limited flight training, the operator was able to connect with autonomous UAVs, task them and obtain information without using a ground control station.

The team conducted flight tests in Oregon for several days in June, using two ScanEagle UAVs manufactured by Boeing subsidiary Insitu and swarm technology developed by JHU/APL. The technology allows UAVs to perform similarly to a swarm of insects, completing tasks more quickly and efficiently by communicating and acting together. Boeing and JHU/APL conducted two tests last year in which dissimilar unmanned platforms across air, land and sea domains collaborated to autonomously conduct searches and communicate information.

"This swarm technology may one day enable warfighters in battle to request and receive time-critical intelligence, surveillance and reconnaissance information directly from airborne UAVs much sooner than they can from ground control sta-

tions today," said Gabriel Santander, program director of Advanced Autonomous Networks for Boeing Phantom Works. "Swarm network technology has the potential to offer more missions at less risk and lower operating costs."

The demonstrations are conducted under a collaborative agreement between Boeing and JHU/APL, a university

The technology allows UAVs to perform similarly to a swarm of insects, completing tasks more quickly and efficiently by communicating and acting together.

affiliated research center and a division of Johns Hopkins University that has been addressing critical national challenges through the innovative application of science and technology for nearly 70 years. It maintains a staff of about 5000 on its Laurel, MD campus. UAV swarm technology is one of Boeing's many C4ISR capabilities that provide a seamless flow of information – from collection to aggregation to analysis – for customers' enduring need for situational awareness. The breadth of these capabilities will be on display at the AUVSI Unmanned Systems North America 2012 conference and can be experienced online at www. boeing.com/advertising/c4isr.



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Defense News

Northrop Grumman G/ATOR System Delivered to Wallops Island for the Start of Government Developmental Testing

orthrop Grumman Corp.'s AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR) system has been delivered to Surface Combat Systems Center (SCSC) Wallops Island in Eastern Virginia for the government to begin its first and second phases of Developmental Test (DT). The final phase of DT and the Operational Assessment for G/ATOR will be conducted in Yuma, AZ. Currently under development for the U.S. Marine Corps, G/ATOR is the first ground-based, multirole radar to be developed for the U.S. Department of Defense.

At Northrop Grumman's Baltimore facility, the G/ATOR system has already completed part one of the System Performance Qualification Testing in addition to rigorous performance verification testing at the system and subsystem levels. G/ATOR accumulated a significant number of hours of live aircraft testing during that time. This live target testing provided an added measure of confidence that G/ATOR performance is consistent with performance requirements against a wide array of target types and sizes, speeds, ranges and trajectories.

"Throughout these tests, G/ATOR has demonstrated

an unprecedented ability to provide enhanced information and surveillance data to the warfighter," said Steve Mc-Coy, vice president for tactical sensor solutions Northrop Grumman. "With G/ATOR's modular, scalable architecture, we can get that capability into the field sooner and at lower cost to the Department of Defense."

With its ability to intelligently and adaptively allocate its myriad of sensor capabilities, G/ATOR is With its ability to intelligently and adaptively allocate its myriad of sensor capabilities, G/ATOR is designed to detect and track a wide variety of threats, including manned aircraft, cruise missiles and unmanned autonomous systems.

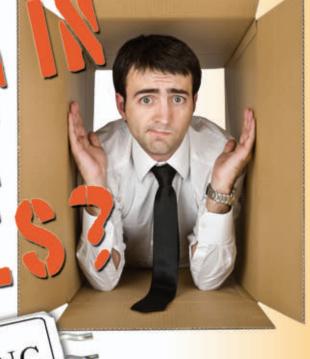
designed to detect and track a wide variety of threats, including manned aircraft, cruise missiles and unmanned autonomous systems. G/ATOR is built with an open, scalable architecture to enable digital interoperability and allow new capabilities to be added through software-only updates.



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International Report

Richard Mumford, International Editor



ITU and Nexpedience Team up to Boost African Broadband

he International Telecommunication Union (ITU) and Nexpedience are partnering to bring broadband access to Africa. Under the terms of the agreement, Nexpedience, one of the world's leading suppliers of proprietary point-to-multipoint broadband infrastructure, will provide 180 new Expedience base stations worth \$1 million, to be deployed in six nations across the continent.

ITU's Wireless Broadband Network in Africa project aims to develop and implement wireless broadband connectivity and applications that will provide free or low-cost digital access for schools, hospitals, and under-served populations in rural and remote areas Africa-wide.

Designed to withstand extreme meteorological condi-

"...this new partnership will accelerate broadband uptake right across the African continent..."

tions and capable of providing up to 32 kilometres of sector coverage, Nexpedience's base stations have been specifically designed for rural deployment. The first nation to benefit from the new infrastructure is Burundi, with deployments also

planned for Djibouti, Burkina Faso, Malī, Ŕwanda and Swaziland.

Brahima Sanou, director of ITU's Telecommunication Development Bureau (BDT) emphasized the need to make developing countries part of the global broadband revolution: "This partnership represents another important element in ITU's efforts to bring broadband technology to the world – even in the poorest nations. I am confident that this new partnership will accelerate broadband uptake right across the African continent, bringing the power of high-speed connectivity to users everywhere, from big cities to small villages."

Kiriako Vergos, CEO of Nexpedience said: "Giving access to broadband technology to underserved populations in Africa is of great importance to us. There are enormous benefits to be derived from a 'broadband-seed' deployment strategy, and we decided to partner with ITU because we know that the organization has the team in place to get it done."

ICT Standards Development Organizations Launch oneM2M

even of the world's leading information and communications technology (ICT) Standards Development Organizations (SDO) have launched one M2M, a new global organization to ensure the most efficient deployment of machine-to-machine (M2M) communications sys-

tems. The new organization will develop specifications to ensure the global functionality of M2M, enabling a range of industries to effectively take advantage of the benefits of this emerging technology.

The seven ICT SDOs that launched oneM2M are: the Association of Radio Industries and Businesses (ARIB) and the Telecommunication Technology Committee (TTC) of Japan; the Alliance for Telecommunications Industry Solutions (ATIS) and the Telecommunications Industry Association (TIA) of the USA; the China Communications Standards Association (CCSA); the European Telecommunications Standards Institute (ETSI); and the Telecommunications Technology Association (TTA) of Korea. The members are devoted to developing technical specifications and reports to ensure M2M devices can successfully communicate on a global scale.

The number of worldwide M2M connections is growing exponentially, with some forecasts as high as 50 billion by 2020. The specifications developed by oneM2M will provide a common platform to be used by communications service providers to support applications and services as diverse as the smart grid, the connected car, eHealth and telemedicine, enterprise supply chain, home automation and energy management, and public safety.

The initial goal of one M2M will be to confront the critical need for a common M2M Service Layer, which can be readily embedded within various hardware and software, and relied upon to connect the myriad of devices in the field with M2M application servers worldwide. With an access independent view of end-to-end services, one M2M will also develop globally agreed-upon M2M end-to-end specifications using common use cases and architecture principles across multiple M2M applications.

Ultimately, the work of one M2M will drive multiple industries towards the goals of lowering operating and capital expenses, shortening time-to-market, creating massmarket economies of scale, simplifying the development of applications, expanding and accelerating global business opportunities, and avoiding standardization overlap.

EC Targets Barriers to Single Market for Research and Innovation

he European Commission has set out concrete steps Member States should take to achieve the European Research Area (ERA), a Single Market for research and innovation in Europe. The goal is to enable researchers, research institutions and businesses to better move, compete and co-operate across borders. This will strengthen Member States' research bases, increase their competitiveness and allow them to work together more effectively to tackle major societal challenges.

To help achieve the European Research Area, the Commission has also signed a Joint Statement and Memorandums of Understanding (MoU) with organisations representing key



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International Report

research organisations and research funding bodies. The proposals are a response to the deadline set by EU leaders to make the European Research Area a reality by 2014.

European Commissioner for Research, Innovation and Science Máire Geoghegan-Quinn said: "We cannot continue with a situation where research funding is not always allocated competitively, where positions are not always filled on merit, where researchers can rarely take their grants or have access to research programmes across borders, and where large parts of Europe are not even in the game. Talk to any business leader and they will tell you that the quality of the research base is a major factor in their investment decisions. In today's economy, no Member State or region can afford to neglect its knowledge base."

When asked, almost 80 percent of the research community indicated that lack of open and transparent recruitment hinders international mobility. Member States are therefore asked to remove barriers to cross-border research careers in Europe, step up the pursuit of joint research agendas, enhance competitive funding for institutions and projects and invest efficiently in world-class facilities.

Research stakeholder organisations are urged to define and implement principles for accessibility and portability of national grants, to publish job vacancies on a common internet portal, to fill research positions according to transparent, open and merit-based recruitment procedures and to step up links between industry and academia.

Daresbury Rebrands as Sci-Tech Daresbury

he Daresbury Science and Innovation Campus, UK, has been rebranded as Sci-Tech Daresbury, after becoming an Enterprise Zone. The change coincides with an extensive survey that profiled 84 of the 113 high-tech companies on site, which reported a combined turn-over of £28 million last year, despite the economic downturn, with two thirds reporting significant business growth. Sixty two full time positions were created on-site in 2011 and tenant companies are also forecasting recruitment of a further 60 people in 2012.

The survey also revealed that investment in Sci-Tech Daresbury businesses rose substantially in 2011, with companies securing a total of £75 million from a number of primarily private sources, a rise of £10.7 million on investment in 2010.

Sci-Tech Daresbury is one of only two National Science and Innovation Campuses in the UK, providing companies with access to world-class science facilities, and includes the Science and Technology Facilities Council's (STFC) Daresbury Laboratory which is celebrating its 50th anniversary this year. The site, which took on Enterprise Zone status in April 2012, is set to expand over the next twenty years to become a 'technology village' which will deliver as many as 15,000 highly skilled jobs and attract new international technology businesses to the northwest of England.

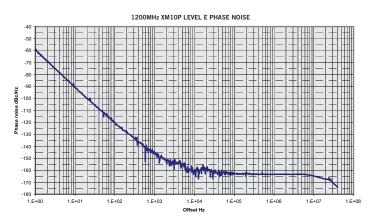
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Commercial Market

Dan Massé, Associate Technical Editor



600 Million Smartphones Will Have Gesture Recognition Features in 2017

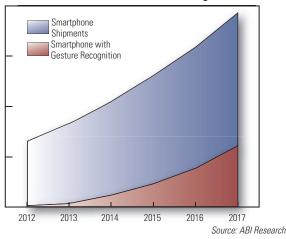
estures are ingrained in human communication and it is virtually impossible to communicate with someone without moving your hands or gesticulating with your fingers while in conversation. Gesture recognition technology adds another dimension to our interactions with machines, devices or computers. A new study from ABI Research forecasts 600 million smartphones will be shipped with vision-based gesture recognition features in 2017.

"Gesture recognition is a very exciting prospect, particularly for smartphones and tablets," says ABI Research senior analyst Josh Flood. "These devices are already heavily entrenched into peoples' lives and another communication interface is always very welcome."

Camera-based tracking for gesture recognition has actually been in use for some time. The leading game consoles Microsoft Xbox and Sony PlayStation both have gesture recognition equipment: Kinect and PlayStation Eye, respectively. These devices are in their seventh and eighth generation. Several challenges remain for gesture recognition technology for mobile devices, including effectiveness of the technology in adverse light conditions, variations in the background, and high power consumption. However, it is believed these problems can be overcome with different tracking solutions and new technologies.

Qualcomm has been heavily promoting its Snapdragon chipset processors' visional gesture recognition technology in 2012. Intel has primarily focused upon touch capabilities for its notebooks and ultrabooks this year. Nevertheless, the company's senior management has acknowledged gesture and voice recognition will be a "big deal" in the computing sector next year. Currently, only a small number of the smartphones shipped have gesture recognition. Pantech, a Korean smartphone OEM,

Penetration of Gesture Recognition Technology in Smartphones World Market, Forecast: 2012 through 2017



began selling its Vega LTE handset in Korea during November 2011 with gesture recognition technology using camera-based Qualcomm's ing. Snapdragon processor will offer smartphone OEMs the ability to have camera, infrared, and ultrasound based tracking. These tracking solutions give smartphone OEMs and app

Senior
management
[at Intel] has
acknowledged
gesture and voice
recognition will be
a "big deal" in the
computing sector
next year.

designers some attractive techniques for new interactions and enhancing the users experience. Additionally, gesture recognition will be useful for media tablets, portable media players, and portable game players. It is projected a higher percentage of media tablets will have the technology than smartphones.

Tower Top RF Electronics for Wireless Infrastructure Should Exceed \$4.5 B by 2017

s the mobile network struggles to cope with the growing level of traffic and pressures on CAPEX, the RF electronics of a typical base station design are subject to great innovation, namely in the form of tower mounted amplifiers, remote radio heads, and active antennas. Tower mounted amplifiers represent one of the best values for improved base station performance for service providers. Balancing the system link budget equation can now be easily accomplished at nominal cost, however, remote radio heads (RRH) will represent a threat to TMA market growth. In turn, RRHs have become one of the most important subsystems of today's new distributed base stations. The remote radio

head contains the base station's RF circuitry plus analog-to-digital/digital-to-analog converters and up/down converters. Active antennas, especially for wireless infrastructure base station applications, utilize the latest technology and will allow beam forming and shaping that will help

Tower mounted amplifiers represent one of the best values for improved base station performance for service providers.

today's crowded conditions in a data-rich signal environment. Active antennas could themselves affect the RRH market as that function is now incorporated into the active antenna.

Go to mwjournal.com for more commercial market news items

Commercial Market

Lance Wilson, research director for mobile networks at ABI Research, states: "Tower top active RF electronics will become more important as LTE rolls out over the next few years. This will be especially true for remote radio heads and active antennas."

All three of the above major RF electronics subsystems have therefore become intertwined as functions start to converge. This data package details tower mounted amplifier and remote radio head revenue and shipments by air interface, frequency, technology, type (TMA), output power (RRH) and configuration. Total revenue, shipments and ASP trends are also presented for the period 2012 to 2017. In addition, the study reports vendor market share for 2012. Active antennas, which are just emerging, are examined for 2012 to 2017 sales and ASP trends. The effect that active antennas could have on RRH sales is also reviewed for 2012 and 2017. This market data package will also be important for RF component manufacturers, base station OEMs, wireless infrastructure subassembly builders and service operators. These findings are part of ABI Research's Tower Top RF Electronics Research Service which includes additional competitive analyses, vendor matrices, market data and insights.

Asia-Pacific Responsible for 50% of 200 Million Unit Set-Top Box Market from 2013

jump in cable and satellite set-top box shipments in Asia-Pacific markets is being driven by cable digitization in India and China, as well as China's rollout of digital satellite boxes to its rural households. "Digital transitions are bringing consumers access to hundreds of international channels and a few HD services for the first time. Asia-Pacific and eastern Europe's growth in set-top box units will outstrip those of the rest of the world in the next five years," according to Sam Rosen, practice director of TV and video at ABI Research.

Operators in these developing markets are looking for very low cost boxes. Set-top box manufacturers are looking to decrease BOM costs by using in-house CAS solutions and low cost SoCs optimized with lower-powered CPUs that support HD video, but only simpler graphical user interfaces. "China has a robust ecosystem of set-top box manufacturers, coupled with CAS vendors China Digital TV and Sumavision," according to Sam Rosen. "Meanwhile, India is struggling to enable an ecosystem of local manufacturers, as well as to get an adequate supply of boxes to meet an unrealistic digitization timeframe." These findings are part of ABI Research's Set-Top Box Research Service, which includes additional competitive analyses, vendor matrices, market data and insights.



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300MHz to 4GHz, 26.8dBm IIP3 Dual Active Mixer

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V Dual Mixer Family

Part Number	Frequency Range	IIP3 (dBm)	Conv. Gain (dB)	NF/5dBm Blocking (dB)	Power (mW)	Package
LTC5569	0.3GHz to 4GHz	26.8	2	11.7/17.0	600	4mm x 4mm QFN
LTC5590	0.6GHz to 1.7GHz	26.0	8.7	9.7/15.5	1250	5mm x 5mm QFN
LTC5591	1.3GHz to 2.3GHz	26.2	8.5	9.9/15.5	1260	5mm x 5mm QFN
LTC5592	1.7GHz to 2.7GHz	26.3	8.3	9.8/16.4	1340	5mm x 5mm QFN
LTC5593	2.3GHz to 4.5GHz	26.0	8.5	9.5/15.9	1310	5mm x 5mm QFN

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INDUSTRY NEWS

Rohde & Schwarz has integrated **SwissQual**, a provider of systems for measuring and assessing the quality of service in wireless networks, into its group of companies. Effective from July 2, 2012, SwissQual – founded in 2000 and based in Zuchwil, Switzerland – became a fully independent Rohde & Schwarz subsidiary. The company head-quarters and regional presence will be retained and it will be referred to as: SwissQual AG – A Rohde & Schwarz Company, in external communications.

Agilent Technologies Inc. announced **AT4 Wireless**' Test Systems business assets are now part of Agilent. The two companies had announced an acquisition agreement on July 16. Financial details were not disclosed. The former AT4 Wireless Test Systems products are now available for sale directly from Agilent and Agilent's channel partners.

Gaas Labs LLC, a private investment fund targeting the communications semiconductor market led by industry veteran John Ocampo, announced that it has acquired privately-held **Nitronex Corp.**, a leader in the design and manufacture of gallium nitride (GaN) based RF solutions for high performance applications in the defense, communications, cable TV, industrial and scientific markets. Financial terms of the transaction were not disclosed.

Integrated Microwave Technologies LLC (IMT), a business unit within **Vitec Group**'s Videocom Division, announced the formation of a technology partnership with **Leptron**, the leader in industrial robotic helicopters. IMT's VSTx COFDM ultra-compact transmitter will be integrated into Leptron's complete product line of industrial unmanned helicopters. Leptron manufactures several different lines of small-to-medium UAV helicopters. Due to the VSTx's small form factor, weight and reliability, it is compatible with even the smallest Leptron model.

Richardson RFPD Inc. announced that it has been named one of the Top 3 Best Technical Support Distributors in China in the prestigious Electronic Components Distributor Survey, sponsored by Electronics Supply & Manufacturing-China (ESM-China). In this 12th year of the annual survey, some two thousand qualified buyers, engineers and senior managers voted on seventy-nine franchised and independent electronic components distributors, and Richardson RFPD scored in the top three for best technical support.

MITEQ has achieved AS9100 registration, expanding its scope and commitment to include the Aviation, Space and Defense Industries. MITEQ is now registered to AS9100:2009 (Rev. C) as well as ISO9001:2008 by National Quality Assurance USA (NQA), an accredited registrar of the ANSI-ASQ National Accreditation Board (ANAB). NQA performs Quality System audits at MITEQ

every six months assuring continued compliance. MITEQ attained its original ISO 9001 registration in June 1993, when fewer than 1500 companies were registered.

Aeroflex Ltd. and University College London (UCL) announced the official opening of the UCL-Aeroflex Wireless Communications Laboratory in the Department of Electronic and Electrical Engineering at the university. The new laboratory is equipped with £1.5 million worth of test equipment donated by Aeroflex, a global provider of test and measurement equipment that has a large R&D and manufacturing facility in Stevenage, UK. The Aeroflex laboratory will give UCL a major advantage in its research into technology for the next generation of wireless communication networks and user equipment, such as smartphones, tablet PCs, and future mobile devices.

CONTRACTS

L-3 Communications' L-3 GCS subsidiary has been awarded a contract by the **U.S. Special Operations Command** (USSOCOM) to develop and manufacture Very Small Aperture Terminal (VSAT) satellite systems. The program, known as Special Operations Forces Deployable Node-Family of Terminals (SDN-Lite FoT), will provide tactically deployed special operations forces users with worldwide communications connectivity. The total contract value is up to \$500 million over the next five years.

Boeing received a \$338.7 million contract modification from the U.S. Air Force to produce and launch a tenth Wideband Global SATCOM (WGS) satellite. The authorization includes production, launch site activities, initial orbital operations and checkout. Boeing is working with the Air Force on potential cost-effective upgrades that would further increase the WGS satellites' capacity and operational flexibility. In June, Boeing was contracted to implement an enhanced Wideband Digital Channelizer upgrade that provides a 90 percent improvement in satellite bandwidth – with no additional cost to the government. The new channelizer will be included on satellites WGS-8 and beyond.

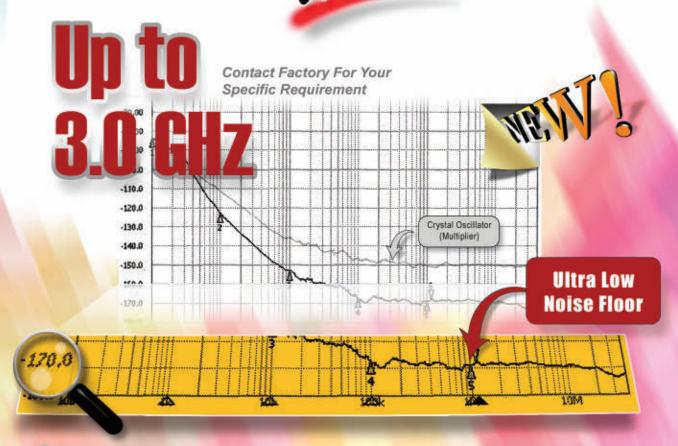
Harris Corp. received a \$10 million order to supply the Government of Canada with Falcon III® multiband manpack radios and satellite terminals. The Harris Falcon III AN/PRC-117G radios and RF-7800B Broadband Global Area Networking (BGAN) terminals will provide Canadian military forces with an integrated solution for Type-1 secure voice and data communications in both line-of-sight and beyond-line-of-sight applications. Integrated together, the radios and satellite terminals support network-enabled applications.

API Technologies Corp. received a \$2.4 million order to provide the manufacture and test of a shipboard defensive



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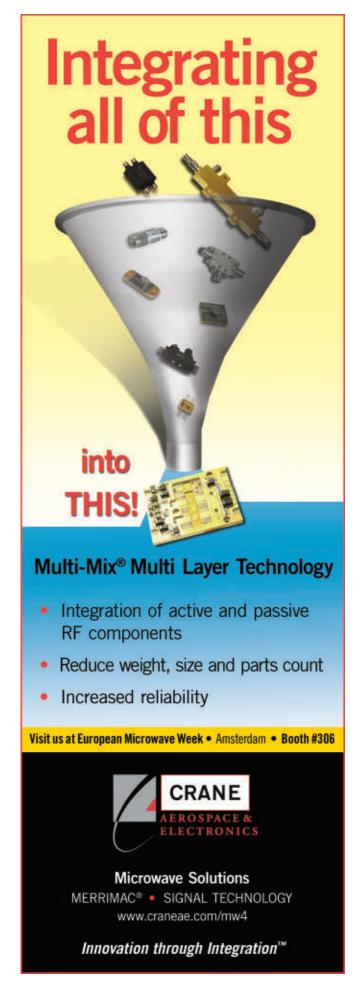
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- Eliminates Noisy Multipliers
- Patent Pending Technology

Applications

Test & Measurement Equipment High Frequency Network Clocking Scanning & Radar Systems High Performance Frequency Converters Base Station Applications Agile LO Frequency Synthesis





Around the Circuit

subsystem capable of tracking and targeting multiple low horizon threats that will support a major national defense program. No additional information is available due to the secure nature of this program.

Spectracom, a business of the **Orolia Group**, has been awarded a contract to supply the **U.S. Air Force Metrology Calibration Program** (AFMETCAL) with precision timing and frequency test equipment over the next five years. Spectracom Frequency Calibrator/Analyzers will be used across several AFMETCAL projects to test and calibrate any device or system that relies on a precisely timed signal. Typical applications include radar, radio and communications, guidance systems, and avionics. The new Frequency Calibrator/Analyzers will replace previous generation units as well as be used in a variety of new deployments.

Cassidian will supply the French Armed Forces with advanced identification systems used to prevent friendly fire. The French defense procurement agency, Direction Générale de l'Armement (DGA), awarded Cassidian a contract to supply 150 units of its newly developed Monopulse Secondary Radar (MSR) 1000 I interrogator for the shortrange friend-or-foe identification (IFF). The first units will be delivered by mid-2014. They are destined for installation on the Army's MISTRAL missile launchers and MARTHA air defense command and control stations as well as on the armored launch vehicles of the Air Force's CROTALE NG missile.

EADS and **ANSYS Inc.** have signed a master agreement to provide simulation tools to all divisions. EADS uses ANSYS technology across all its divisions for structural mechanics, fluid dynamics and electromagnetics simulation to perform, among other applications, virtual testing of composite materials, aerodynamics optimization, thermal management, and signal integrity validation on products ranging from aircraft to helicopters to space launchers to defense systems.

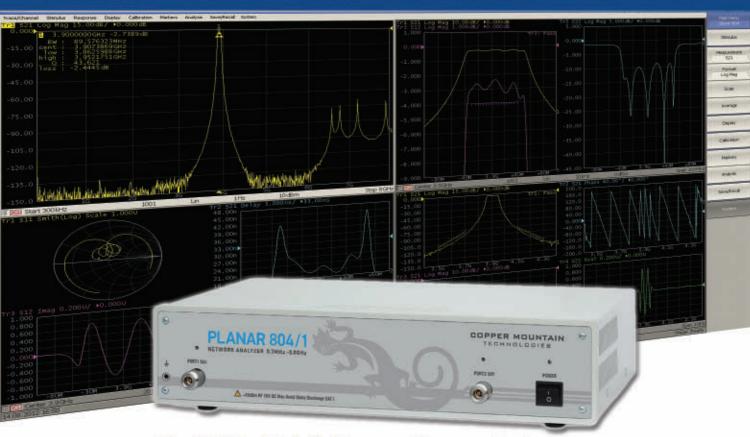
PERSONNEL

Smiths Interconnect announced the appointment of Andy Humen as president of Smiths Interconnect Microwave, one of three operational business units alongside Smiths Interconnect Connectors and Smiths Interconnect Power. Humen earned a BSEE from the University of Maryland and has extensive experience in the microwave and electronics industry from his work for Northrop Grumman, ITT, Raytheon, L-3 and, most recently, Cobham. During his decade-long tenure at Cobham, Humen held a number of leadership and technology roles, incorporating U.S. and international experience and responsibilities. Immediately prior to joining Smiths Interconnect Microwave, Humen was vice president of engineering, Cobham plc.

Hirose Electric has named **Kazunori Ishii** as president. Ishii began working at Hirose in April of 1982, and has since served as deputy chief director of engineering, deputy chief director of sales, and senior managing director. He holds a BA degree from Komazawa University.

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Planar 304/1 0.3 MHz - 3.2 GHz 2-port 2-path



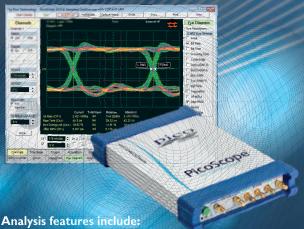
Planar R54 0.3 MHz - 5.4 GHz 1-port 1-path

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- 48 measurements for electrical signal characterization
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- Pattern mask sync trigger
- FFT analysis

PicoScope model	9201A	9211A	9221A	9231A
12 GHz Sampling Oscilloscope	•	•	•	•
8 GHz optical-electrical converter			•	•
USB port	•	•	•	•
LAN port		•		•
Mask testing	•	•	•	•
Histogram analysis	•	•	•	•
Clock recovery trigger		•	•	•
Pattern sync trigger		•		•
Dual signal generator outputs		•		•
Electrical TDR/TDT analysis		•		•

www.picotech.com/RF918





Around the Circuit



▲ Will Jensen

Times Microwave Systems named Will Jensen director of sales and OEM business reporting to Peter Page. He will be located in Wallingford, CT, with responsibility for development, implementation and execution of the growth strategy with the company's North American sales team as well as its network of manufacturer's representatives.

Jensen holds a BA from California State University, Hayward, CA and Master's in Business Administration from Arizona State University, WP Carey School of Business, Tempe, AZ.

TRAK Microwave Corp. announced the appointment of **Randy Sloan** as the director of sales for the microwave subsystems and timing group. Sloan earned a BS in Aerospace Engineering in 1989 from the University of Florida, attended the University of Central Florida in 1998 in pursuit of an MS in Computer Engineering, and received an MBA from the University of Florida in 2000. He has over 15 years of diverse experience in systems engineering, product marketing, and business development across aerospace and defense, private equity, and high technology industries.

REP APPOINTMENTS

Amphenol Industrial Global Operations now offers a variety of its products on AmazonSupply. Amphenol is the first connector company to sell its products through the online store. A variety of Amphenol Industrial products ranging from solar products to RADSOK products are available for immediate purchase on the site, including Amphenol's 97 Series, 5015, 26482 – Series 1, Amphe-Lite, Amphe-PD, Helios H4 Connectors, HelioLug, PowerLink, RPT and SurLok.

Anaren Inc. will be marketing its new family of Anaren Integrated Radio (AIR) modules with electronics distributor **RS Components**, headquartered in Oxford, UK. The initiative is Anaren's first partnering opportunity with RS and is expected to provide AIR customers with a valuable new sourcing and support option.

International Manufacturing Services Inc. announced the appointment of Microwave Marketing Ltd. as its representative to the United Kingdom and Ireland. Microwave Marketing Ltd. is headquartered in Lincoln at the heart of the RF and microwave activity in the United Kingdom.

Res-Net Microwave has appointed Cain-Forlaw Co. as its sales representative in IL, ÎN, OH, KY, Western PA, MI, WI, ND, SD, MN, NE, IA, KS, MO, OK, AK, LA and TX. Cain-Forlaw Co. maintains product excellence through its renowned customer service and state-of-the-art opportunity tracking.

Passive Plus Inc. has hired Sematron UK Ltd. to represent its passive components throughout the United Kingdom and Ireland. Sematron has built a substantial reputation as a reliable supplier of RF, microwave and digital technology, designing, supplying and implementing solutions globally.



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	Model	# Switches (SPDT)	IL (dB)	VSWR (:1)	Isolation (dB)	$\begin{array}{c} RF\;P_{MAX} \\ (W) \end{array}$	Price \$ (Qty. 1-9)	
	USB-1SPDT-A18	1	0.25	1.2	80	10	385.00	
	USB-2SPDT-A18	2	0.25	1.2	80	10	685.00	
	USB-3SPDT-A18	3	0.25	1.2	80	10	980.00	
	USB-4SPDT-A18	4	0.25	1.2	80	10	1180.00	
=۷	LISB-8SPDT-A18	8	0.25	1.2	80	10	2495 00	

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European Microwave Week

WELCOME TO EUROPEAN MICROWAVE WEEK 2012

For complete coverage of the EuMW conference, event news, exhibitor product information and special reports from the editors of *Microwave Journal*, visit our online show daily at www.mwjournal.com/eumw2012.

he global RF and microwave community is clearing its collective diary to make *Space for Microwaves* from Sunday the 28th of October to Friday the 2nd of November as the 15th European Microwave Week returns to the Amsterdam RAI Conference Centre. There will be space to accommodate a broad range of subjects, from semiconductors and nanotechnology through wireless and radar systems. Also, taking advantage of the local proximity of ESA/ESTEC, the Week will also focus on Microwaves for Space, with special emphasis being given to space applications.

It has been four years since European Microwave Week last visited the canal city of Amsterdam. A lot of water has gone under the bridge since then and the political, economic and industrial landscape has changed dramatically. However, during that time, with the support of academia and industry and through the efforts of the European Microwave Association and Horizon House publications, EuMW has endeavoured to bring the RF and microwave community together and highlight the technology and activity that is driving the sector forward.

It is this focus that has made European Microwave Week the premier microwave conference and exhibition event in Europe. The European Microwave Conference (EuMC), the

largest of the three conferences taking place, is enhanced and complemented by the European Microwave Integrated Circuits Conference (EuMIC), focusing on semiconductor device and circuit technologies, and the European Radar Conference (EuRAD), targeting the field of radar, from components to applications. Now, more than ever before, research and innovation needs to find practical commercial applications and the European Microwave Exhibition has become established as a platform where companies from across the globe showcase and demonstrate their latest products.

The exhibition halls are always a hub of activity but there is even more to see and interact with this year. Five cars will offer a practical hands-on demonstration of the latest radar sensors while the MicroApps Auditorium will house the European Microwave Week Microwave Application Seminars (MicroApps). Here, exhibitors will present technical applications-based seminars describing state-of-the-art products, design techniques and processes. The exhibition will also be the home of the coffee breaks and

BERTRAM ARBESSER-RASTBURG General Chairman, EuMW 2012 IVAR BAZZY President, Horizon House Publications

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European Microwave Week

the conference Poster Sessions, which feature a Publisher's Corner and provide that all-important Internet access via the CST sponsored Cyber Café.

Although the conference and exhibition are the mainstays of the Week, new initiatives are continually being added and developed. Special sessions focus on hot topics and expand the global reach beyond Europe to the Asia-Pacific and the wider Asian microwave community. Special events highlight the evolution of defence, security and space and the importance of supporting students and postgraduates by offering challenges and instruction that will encourage them in their careers and stimulate a bright future both for them and our industry.

To stimulate minds and interest, a number of focussed sessions target specific areas of activity and special interest. Reflecting the fact that EuMW is international, far reaching and collaborates across the globe, two sessions will centre on Asia. In the Special Session on APMC on Wednesday, three distinguished invited speakers from

Taiwan, Korea and Australia expand on the most advanced achievements in their respective fields of activity. Later on the same day, the *Microwaves Inside Asia* Session aims to provide a general overview of various microwave research strengths and system applications, as well as to identify common research topics of interest for the promotion of international collaboration.

Taking up the *Space for Microwaves* theme is the *Defence, Security and Space Forum*, which will again offer attendees the opportunity to benefit from the expertise and experience of representatives from government defence/space agencies and leading contractors. For more information see page 74.

EuMW always has its eye on the future and embraces the importance of nurturing future generations. To that end, the 5th Student Challenge at EuMW 2012, sponsored by Thales Nederland, will provide the opportunity for students from all over the world to work together on a specific topic in the microwave field. Addi-

tionally, following a pilot school held last year, EuMW 2012 will see the first course in the *Doctoral School of Microwaves*, aimed at early stage PhD students, which will focus on Microwave Fundamentals. Established initiatives continue including the *Women in Engineering* event which shows growing interest each year.

Interaction, networking and friendship are what EuMW aims to provide and that is typified by the popular Welcome Reception (including banquet), which will be held in the new Elicium building of the RAI Conference Centre on Tuesday evening. It provides the ideal opportunity to combine business with pleasure.

EuMW 2012 carries on the tradition of providing interesting and valuable content in a friendly and convivial atmosphere, which takes considerable effort. Therefore, the Local Organising Committee would like to express its gratitude to the Technical Programme Committees of the three conferences, along with the more than three hundred reviewers. A well deserved thank you goes to Dr. Matthias Rudolph for his running of the TPMS paper submission software.

We would also like to acknowledge all the organisers of workshops, special sessions and student events. Thanks also goes to the Horizon House staff assigned to EuMW whose experience and skill allowed us to obtain the best facilities and the ultimate synergy between conference and exhibition. Last but not least, we acknowledge the financial and in-kind sponsorship of many industrial enterprises and other organisations.

We are certain that you will enjoy EuMW 2012 and we are looking forward to meeting you in Amsterdam.

Welcome from Bertram Arbesser-Rastburg, General Chairman, EuMW 2012 and Ivar Bazzy, President, Horizon House Publications.

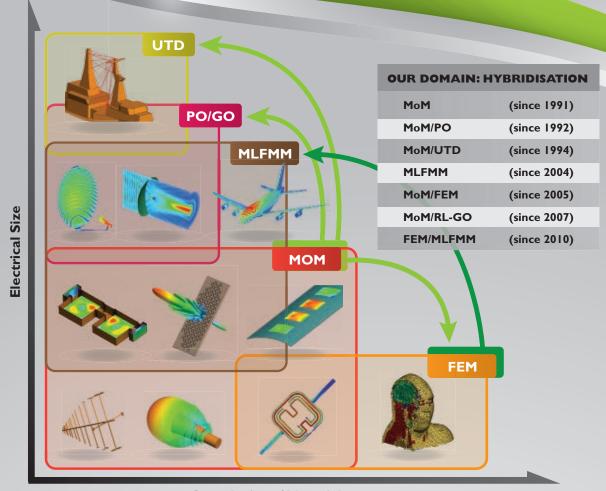


Bertram Arbesser-Rastburg



Ivar Bazzy





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European Microwave Week

ATTENDING EUROPEAN MICROWAVE WEEK 2012

hen the 15th European Microwave Week takes place at the RAI Amsterdam Conference Centre from the 28th of October to the 2nd of November, it will be dedicated to making Space for Microwaves. Every effort has been made to fill that time and conference/exhibition space with as much substance, variety and innovation as possible, while maintaining the intimacy and friendliness that EuMW is renowned for and why it is established as the premier RF and microwave event in Europe.



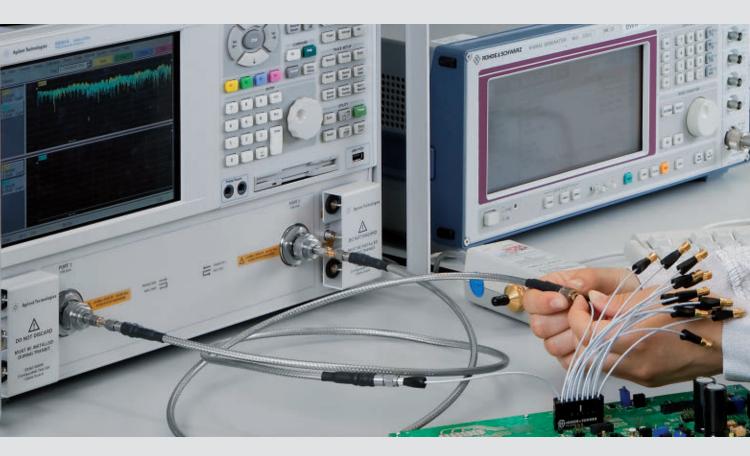
 $Courtesy\ of\ Shmuel\ Auster,\ Eu MA/Eu MW\ Steering\ Committee\ member.$

With the focus also being on Microwaves for Space EuMW 2012 will see a galaxy of familiar and new initiatives revolving around the established stars that are the three conferences: the 42nd European Microwave Conference (EuMC), the 7th European Microwave Integrated Circuits Conference (EuMIC), the 9th European Radar Conference (EuRAD); and the European Microwave Exhibition, which will feature more than 250 exhibitors spread over more than 7000 m² (gross).

Bringing industry, academia and commerce together, the Week will attract an estimated 1700 conference delegates and over 5000 visitors. With more than 830 papers submitted from around 50 countries, the conferences promise exciting presentations both in oral and poster sessions. The opening and closing plenary sessions of all three conferences will feature keynote speeches by leaders in their respective fields and a selection of workshops and short courses will be presented by interna-

RICHARD MUMFORD Microwave Journal International Editor





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European Microwave Week

tionally recognized lecturers.

On Tuesday evening, the EuMW Welcome Reception will be held in the Elicium, Amsterdam RAI. The evening will begin with a cocktail reception at 18:30 at which guests will be addressed by the 2012 EuMW chairman who will hand EuMW chairman

for Nuremburg, followed by platinum sponsor Agilent Technologies. After that, a seated buffet for 1000 people will be served.

European Microwave Week appeals to engineers and scientists from both industry and academia, working in any area related to the growing field of microwave applications. It is a platform for exchanging ideas and opinions across technology domains and offers the opportunity for students, industry and eminent experts to interact, network and establish working relationships.

The following quick reference guide gives more information on what European Microwave Week 2012 has to offer but is designed to complement the Conference Programme and Exhibition Show Guide, in which you will find more detailed information.

THE CONFERENCES

Each with their own dedicated time slots throughout the Week are the three focused conferences:

- The 42nd European Microwave Conference (EuMC) extends from Monday 29 October to Thursday 1 November
- The 7th European Microwave Integrated Circuits Conference (EuMIC) takes place on Monday 29 and Tuesday 30 October
- The 9th European Radar Conference (EuRAD) ends the Week and runs from Wednesday 31 October to Friday 2 November

The conferences focus on the needs of engineers and researchers and offer them the opportunity to discuss the latest trends and developments



over to the 2013 Courtesy of Shmuel Auster, EuMA/EuMW Steering Committee Member.

in the application of microwaves. Microwave devices, systems for tele-communications (both terrestrial and space-borne), transportation, medical, radar and new areas of application are included in the programme, with particular emphasis given to space-related technologies and applications.

sponsored Registration, Rohde & Schwarz, opened online on 12th June and remains open until 2nd November. Those who have not pre-registered can do so at the onsite registration area, which is located in the Diamond Lounge and will be available from Saturday 27th October (16:00 to 19:00) and from 7:30 each morning from Sunday 28th October to Friday 2nd November. All those who have pre-registered should bring their badge barcode and confirmation with them to the conference where they can print out their badge by scanning their barcode at the Fast Track desk onsite

Using onsite registration terminals, delegates will be able to enter their details and pay immediately by swiping their credit or debit cards through the card readers attached to the terminals. Alternatively, payment can be made at the Cashier Desk if a printed receipt is required. Delegates should register for one, two or all three of the conferences. Registration at one conference does not allow any access to other conference sessions. Those who wish to register for two or more conferences will receive a discount on these registrations. Please note that reduced (early bird) rates are available for registration in advance of 27th September. Delegate bags, sponsored by NXP and ESA, can be collected

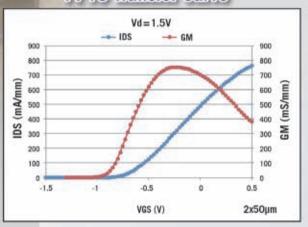




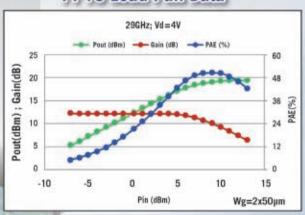
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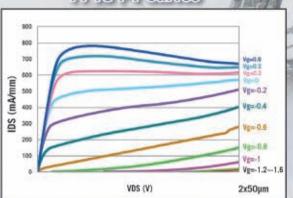
PP10 Transfer Curve



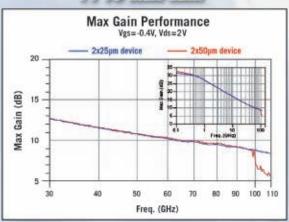
PP10 Load Pull Data



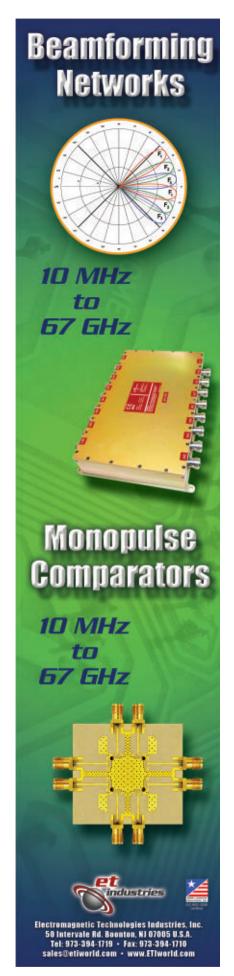
PP10 I-V Curves



PP10 Max Gain



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European Microwave Week

from collection points to the right of the registration area. The bags will include a USB stick containing the conference presentations.

THE EUROPEAN MICROWAVE CONFERENCE

As the central event of European Microwave Week EuMC exists in harmony with EuMIC and EuRAD, with which it shares several sessions. The conference offers a blend of workshops, short courses – both on Sunday and Monday – and regular and focused sessions – mainly on Tuesday, Wednesday and Thursday. The workshops cover subjects with their roots in tradition, such as filters and power amplifiers, while equally addressing subjects for the future, such as graphene nanoelectronics, biomedical applications and Terahertz technologies.

The regular (oral and poster) sessions, take a similar approach by covering a very broad range of topics, typical of the EuMC: passive components, filters, interconnects, metamaterials and EBGs, packaging, antennas, phased arrays, reconfigurable antennas, power amplifiers, field theory, EMI and biological interaction, measurements, active circuits design, THz, etc. – spiced with a bit of 'space applications.'

Both the opening and closing sessions feature an overview presentation by an expert in the field, in conjunction with a provocative reflection on the future of research by an experienced research manager with a background in industry, academia and public office. For the Opening Session, the protagonists will be Yrjö Neuvo (presently at Aalto University and the

European Institute for Innovation and Technology) and Constantine A. Balanis (Arizona State University), while the Closing Session will feature Ingo Wolff (IMST GmbH) and Jacob Fokkema (Delft University of Technology and the Netherlands Organisation for Scientific Research).

THE EUROPEAN MICROWAVE INTEGRATED CIRCUITS CONFERENCE

As part of European Microwave Week, EuMIC continues to find stability in the two organizing bodies: the European Microwave Association (EuMA) and the GAAS® Association, which has supported this conference and its predecessor since 1990. Joint sessions also run in conjunction with EuMC and EuRAD.

Always strong in microwave models, technologies, devices and applications, this year's conference particularly solicited papers in specific areas. In the microwave modelling domain, topics include complex and multidomain modelling and measurement set-ups. In the technology area, papers cover wide-bandgap devices and technologies, as well as NEMS and space-aspects of IC technologies. In the circuit design and applications track, millimetre-wave and THz devices and circuits, mixed-signal, tuneable and reconfigurable ICs, as well as integrated receivers and transmitters are featured. And, in keeping with this year's theme, EuMIC provides space for microwaves and space for microwave ICs.

As usual, there are strong plenary speakers who will address four key top-



Courtesy of Shmuel Auster, EuMA/EuMW Steering Committee member.

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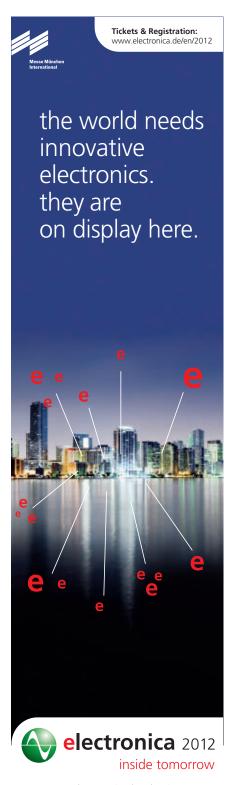
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Courtesy of Shmuel Auster, EuMA/EuMW Steering Committee member.

ics: The industrial quest for microwave technologies (Hooijmans, NXP), emerging possibilities by engineering nanomaterials for microwave applications (Blank, Twente University), the frontier of III-V THz transistors (Rodwell, UCSB) and their on-wafer measurement (Weikle, University of Virginia).

THE EUROPEAN RADAR CONFERENCE

With its very strong foothold, especially in continental Europe, this Radar Conference is the major European forum addressing the present status and future trends in the field of radar technology, system design and applications. The accepted papers are organised in 11 regular EuRAD sessions, adding up to 54 podium presentations, three focused sessions and four EuRAD/EuMC combined sessions, plus a poster session with 22 additional papers.

The conference will be held from Wednesday, when the Opening Session will be part of the Defence, Security and Space Forum for the first time, to Friday. The programme covers a very wide and interesting range of radar topics like radar architectures, radar systems, applications and processing (e.g., MISO/MIMO radar, remote sensing, high resolution techniques, automotive radar, target classification and microDoppler analysis).

In the opening and closing sessions, three internationally recognized experts will give keynote presentations illustrating the very wide range of radar applications. Holger H. Meinel (Daimler AG) will elaborate on: Automotive radar – history, state-of-theart and future trends, and Capt Rob Hendriks MA (Netherland Defense Materiel Organization) will consider: RF technology as an enabler for future above water warfare, discussing the requirement package for future surface combatants and the impact on

the radar, sensor and communication—fit of these naval platforms. During the closing session, Rene de Jongh (Thales Nederland B.V.) will speak on: Radar innovation—challenges—from technology breakthroughs—to customer added val-

ue: an industrial viewpoint.

A complimentary lunch will be offered to all attendees on Friday before the closing session. This lunch will give the opportunity for the audience to meet and exchange ideas with the worldwide radar experts attending the conference.

THE EXHIBITION

It is important to note that for the very first time the exhibition will begin on Monday (see Exhibition Opening Hours, pg. 70) and run to Wednesday in Halls 2 and 3 of the RAI. The FREE to attend European Microwave Week Exhibition has become the focus of leading companies from around the globe that want to reach the international audience that EuMW attracts. Of course, western European companies are well represented, along with the USA and Asia, with a significant increase in the number of Chinese companies making their presence felt. The French Pavilion has maintained its presence since 2006 and for the first time there will also be a Spanish Pavilion, which will bring together the country's large and small companies and distributors, all under one defined roof.

Proving that the exhibition is driving innovation, for the first time, the exhibition halls will house five vehicles that will demonstrate that automotive technology is emerging from the lab and onto the road. All of the cars will be equipped with different 24 GHz, as well as 77 GHz radar sensors. Three cars will feature radar sensors from Bosch, Conti and Valeo respectively, while two cars from Mercedes-Benz - an S-class and a brand new A-class - will demonstrate the upcoming democratization process of Advanced Driver Assistance Systems (ADAS) with sensors from Conti, Bosch and Autoliv.

Hall 3 will also feature the Micro-Apps Auditorium, where, following

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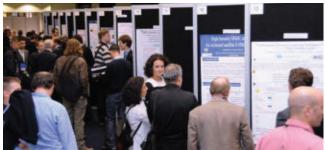
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European Microwave Week



its successful introduction in Manchester in 2011, the European Microwave Week Microwave Application Seminars (MicroApps) will be held. The AWR, Horizon House and National Instruments spon-

sored seminars will begin on Monday 29 October (first MicroApps presentation at 12:30) and continue through to Wednesday 31 October.

The established and popular exhibitor workshops offered by leaders in their respective fields will continue, offering attendees the opportunity to see live demonstrations and gain hands-on experience.

To find out which companies will be exhibiting at Amsterdam RAI, see the latest exhibitor list, starting on page 184.

Exhibition Opening Hours

- Monday 29th October: 12:00 to 18:00
- Tuesday 30th October: 9:30 to 18:00 (followed by the Welcome Reception)
- Wednesday 31st October: 9:30 to 18:00

CYBER CAFÉ AND WIFI

CST is sponsoring a Cyber Café located within the Exhibition Hall for all delegates, exhibitors and visitors to use, as well as free WiFi (4 Mb/s) access to emails for delegates in all conference areas.

POSTER SESSIONS

On Monday, Tuesday and Wednesday, the poster sessions will be located near the coffee break locations in the exhibition halls, while on Thursday they will be found in the Topaz Lounge on the 1st floor of the conference area.

GETTING TO THE AMSTERDAM RAI

From Amsterdam Schiphol Airport, the RAI Conference Centre can be reached in less than 15 minutes by car or public transport. It is situated next to the Ring A10, exit S109. There is a stop for tram 4 in front of the building and the railway station, Amsterdam RAI, is within walking distance.

By Tram and Bus

From Amsterdam Central Station (CS) take the Amstelveen express tram 51 (travelling time: 12 minutes, exit at the Amsterdam RAI station) or tram 4 (travelling time: 30 minutes, exit at the RAI Europaplein). If travelling by train to the Amstel station, take the Amstelveen express tram 51 (travelling time: 5 minutes) or the bus 62 (travelling time: 10 minutes), which goes to



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RAI Europaplein. From Amsterdam Sloterdijk station, the best way to reach the RAI is via express tram 50.

By Train

NS-station Amsterdam RAI is 300 meters from the RAI and has regular connections to all parts of the Netherlands, including Schiphol, Rotterdam, Utrecht and The Hague. It is also linked to the international train network. More information can be found on www.ns.nl.

By Car

The RAI is alongside Amsterdam's A10 orbital motorway (exit S109) and has its own underground car parks. All the main motorways can be reached easily from the orbital motorway and numerous signs indicate the way to the RAI. During large exhibitions orange signs displaying 'P RAI' direct visitors to additional parking places, where a free shuttle bus connects to the RAI.

European Microwave Week

HOTEL RESERVATIONS

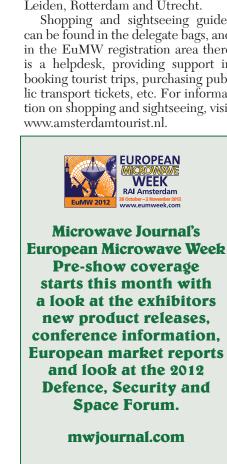
The Amsterdam RAI Hotel and Travel Service claims to be able to offer considerable savings in money, time and hassle. Make a reservation in three easy steps by visiting: www.rai. nl/hotelservice.

SHOPPING AND SIGHTSEEING

Amsterdam is one of Europe's most exciting and dynamic cities and reflects the openness and friendliness of its people. It offers the culture, entertainment and history of a big city, while also affording the charm and warmth of one much smaller.

The city boasts a fascinating and varied history and is blessed with great restaurants, hip bars and wonderful museums. The numbers speak for themselves: there are 51 museums, 141 galleries, 206 van Gogh paintings, 40 concerts a day, 755 restaurants, 1402 cafes and bars, 36 nightclubs, 600,000 bicycles, 1281 bridges, 6 windmills and 200 km of canals, not to mention the nearby fascinating cities of Den Haag, Haarlem, Delft, Leiden, Rotterdam and Utrecht.

Shopping and sightseeing guides can be found in the delegate bags, and in the EuMW registration area there is a helpdesk, providing support in booking tourist trips, purchasing public transport tickets, etc. For information on shopping and sightseeing, visit www.amsterdamtourist.nl.



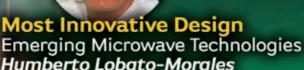


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Bruce Hoechner, President and CEO Congratulates our ROG Award Winners.



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European Microwave Week

THE 2012 EUMW DEFENCE, SECURITY AND SPACE FORUM

This is a full-day forum, focusing on space and defence issues, incorporating the EuRAD Opening Session and featuring the EuMW Defence and Security Executive Forum. Attendance is FREE and open to all EuMW 2012 conference delegates, exhibitors and visitors.

Wednesday, 31 October 2012, 08:30 to 19:00 The Auditorium, Amsterdam RAI Conference and Exhibition Centre

efence and security impacts all levels – international, cross border, regional and on individual citizens. Threats can come from land, sea or air and can be enacted by armies or a single terrorist. To combat such diverse dangers and protect lives, national and international defence and security agencies define and instigate policies, academia and research engineers strive to develop new and improved technologies and industry endeavours to efficiently and cost effectively



bring them to market. Political, budgetary and technological constraints influence decision making, timescales and final implementation.

To put these issues into perspective and analyze and discuss how they are being addressed in Europe and beyond, a full-day forum will focus on the defence and security sector. This year, special emphasis is being placed on space and defence issues, giving the event its title of the 2012 EuMW Defence, Security and Space Forum.

Following the format that attracted over 350 attendees in Manchester last year, the forum will again offer delegates the opportunity to benefit from the expertise and experience of representatives from government defence/space agencies and leading defence/space contractors, who will provide insight into how their organizations view future developments in space and defence and the role of technology in addressing these developments.

RICHARD MUMFORD Microwave Journal International Editor



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European Microwave Week

THE FORUM FORMAT

The Early Morning Session will focus on defence, security and space from an industrial perspective and consider the application of the microwave technology that is being developed to address the important issues of the day. The approach of industry to the challenges being faced will be the focus of a panel session that will

feature experts from National Instruments, Peregrine Semiconductor, RFMD, Rohde & Schwarz and TriQuint Semiconductor.

The Late Morning Session incorporates the EuRAD Opening Session into the EuMW Defence, Security and Space Forum for the first time. It will set the scene for the conference and offer an overview of



prevalent defence and security issues as well as the latest technologies deployed.

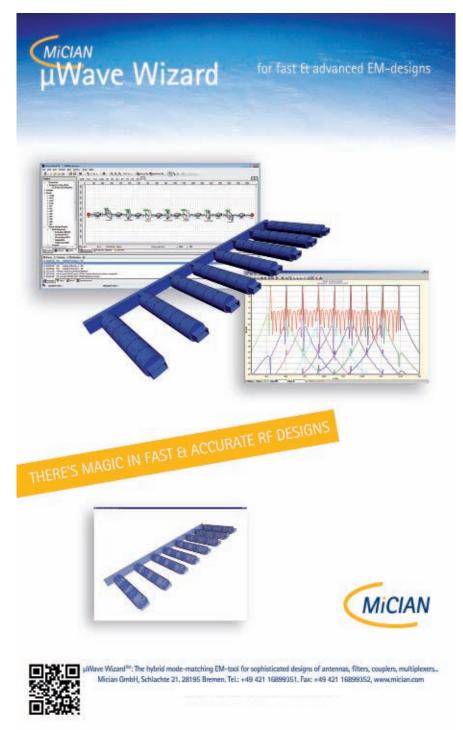
As in 2011, the Lunch and Learn Session will be given by Strategy Analytics and is titled *Military Satellite Trends and Outlook*. The session will include market analysis and industry trends for the military satellite market.

The Afternoon Session will consider how RF systems for space contribute to a safer and more secure world. Via tutorials, industry and agency experts will give an insight into the latest developments. An ESA astronaut who spent time in the International Space Station will talk about his experience in the first presentation of the session.

The Evening Executive Forum will, as usual, feature executives from space and defence agencies and leading defence/space contractors who will consider the issues that their organizations are currently addressing and the role that technology has to play. The Executive Forum will conclude with an open panel discussion with questions from the floor. The day's proceedings will conclude with a cocktail reception that will give delegates the unique opportunity to discuss the issues raised in an informal setting.

REGISTRATION AND UPDATES

Attendance is FREE and open to all EuMW 2012 conference delegates, exhibitors and visitors. However, to help with logistics and planning, those wishing to attend the 2012 EuMW Defence, Security and Space Forum are asked to pre-register. To do so, visit www.eumweek.com/2012/Special.asp and click on Register Now. As information is formalized, the Conference Special Events section of the EuMW website will give details of the speakers for all sessions and will be updated on a regular basis.





The 2012 Defence, Security and Space Forum

At European Microwave Week





Wednesday, 31 October 2012 • Auditorium 8:30 to 19:00

A full-day Forum, focusing on Space and Defence issues, incorporating the EuRAD Opening Session and featuring the EuMW Defence and Security Forum.

Schedule:

Early Morning Session: 8:30 - 10:10

Industrial Perspectives – Newly developed microwave technology for pivotal defence, security and space applications.

Late Morning Session: 10:40 – 12:20

EuRAD Opening Session – Overview of prevalent issues and synergies between industrial defence and space sectors.

Lunch and Learn: 12:30 - 13:30

Data and analysis of global defence market, presented by Strategy Analytics.

Afternoon Session: 13:50 – 15:30

Industry and agency expert panels share insights on defence and space trends and developments.

Executive Forum: 16:00 – 18:00

Executives from space and defence agencies and leading defence contractors consider the issues faced by their organizations and the role of technology.

A Q&A session will conclude the forum.

Cocktail Reception: 18:00 – 19:00

Opportunity to network and discuss issues raised throughout the forum in an informal setting.



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European Microwave Week



COMPANIES COMPETE FOR GOLD AT EUMW

hen athletes assemble at the Olympics to represent their respective countries, the world collectively celebrates individual achievement, national pride and the thrill of watching elite competition. From the Berlin games of 1936 through the Cold War and beyond, bringing home the gold has always translated into a public relations victory for governments good and bad. As a result, Cold War adversaries supported their athletic programs as surely as they invested in national defense. Since the end of the Cold War, the rivalry between east and west has diminished and the support of athletes is more likely to come from corporate sponsorships. Yet we still watch the games with a nationalistic fervor.

In the global marketplace, many companies competing on the world stage as multi-national organizations are still often identified by their country of origin. Yet, many familiar multinational companies have blurred this identity by setting up shop in select emerging markets to take advantage of being closer to potential customers in as much as they are tapping into lower labor and manufacturing costs. Other companies are distinctly regional, utilizing indigenous talent pools and servicing a localized customer base. Such companies may be well recognized within their own borders, but less so at the international level. Companies looking to expand beyond their country's borders in search of new markets have the opportunity to do so at a number of industry-based exhibitions that take place across the globe over the course of the year. As the industry descends on Amsterdam for EuMW, the Olympic spirit is alive and well as companies from around the world come to "compete" at the largest microwave exhibition in Europe.

THE GLOBAL MARKETPLACE

Recent reports on global trade indicate that a quarter of all produced goods will cross national borders and 70 percent of the goods produced in the United States will compete against products made abroad. Meanwhile, much of the global economy has shifted away from the U.S. toward China and India as these countries grow into leading economies in terms of total economic output (or GDP) and energy consumption. Estimates show that 70 percent of world growth over the next few years will come from emerging markets, with China and India accounting for 40 percent of that growth. The International Monetary Fund (IMF) forecasts that the total GDP of emerging markets could overtake that of the developed economies as early as 2014 and these emerging markets already attract almost 50 percent of foreign direct investment (FDI) global inflows and account for 25 percent of FDI outflows. This new direction in the flow of investment dollars is one reason why 7 out of 10 U.S. high technology industries have lost world market share since 1965. In today's global economy, competition is a matter of survival.

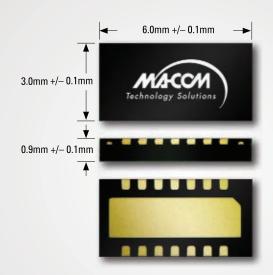
To compete in world markets, technology companies need to 1.) Create, apply, and protect their technology; 2.) Have access to capital for investment and product development; and 3.) Have access to a skilled, flexible and motivated work force. These factors are highly influenced by local business (investment) conditions and government policies (taxes, pro-business policies and support for education/training of its citizens). Given any government's impact on a business's ability to

DAVID VYE Microwave Journal Editor

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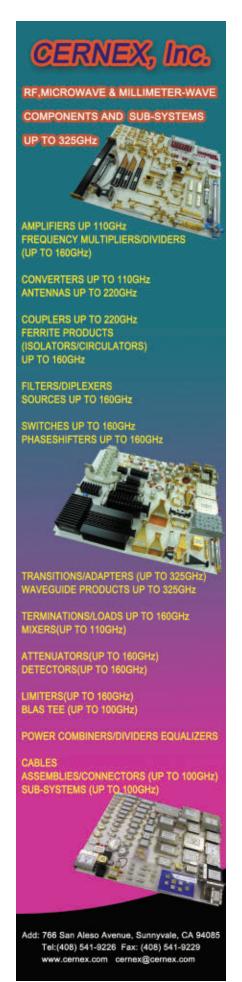
MAGX-000035-09000P THERMAL SCAN Power Dissipated vs Transient Temperature vs Pulse Duration and Duty Cycle-Tbase =85°C 190.0 Tch_max (°C) Output (W), Power Dissipated (W) & PAE ((O₀) Pout (W) Fransient Channel Temperature 170.0 90.0 Pdiss (W) PAE % 150.0 80 O 130.0 70.0 110.0 90.0 100uS 100uS 300uS 300uS 500uS 500uS 1000uS 1000uS 8000uS 10% 20% 10% 20% 10% 20% 10% 20% 9.2% 84.55 111 81 Duty Duty Duty Duty Duty Duty Duty Duty Duty Cvcle Cycle Cycle Cycle Cvcle Cycle Cvcle Cvcle Cycle Temperature (°C)



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European Microwave Week

succeed, it is understandable that we associate microwave companies with the countries where they originally flourished. Naturally, certain regions are hotbeds for particular technologies, where localized expertise has allowed one or more companies to dominate.

PASSIVE/ACTIVE HYBRID MODULES

In the RF/microwave hybrid modules category, China is represented by two companies at EuMW. Chengdu Omicron Microwave Technology Co., established in 2007, offers an array of passive RF/microwave components including power dividers, couplers, filters, attenuators, phase shifters, isolator/ circulators and terminations with SMA or N-type connectors (up to 18 GHz). The company has a limited line of active components including modularized PIN diode switches (SPST, SP2T, SP4T) and LNAs covering select narrow bands up to 6 GHz. Chengdu Omicron Microwave boosts an internal R&D department for developing new products based on customer specifications, advanced production line, and a team of technical support engineers to address both Chinese and international markets. Visit Chengdu Omicron (www. omicron-mw.com) at Booth 307.

Also from China, Chengdu Tiger Microwave Technology Co., established in 1992, hails from Chengdu, the capital of Sichuan province. Tiger possesses a production and office area of over 20,000 square meters with more than 500 employees. Tiger's main focus is in R&D, manufacturing and selling microwave components, assemblies and subsystems, offering products used in military as well as commercial applications, including power dividers, couplers, combiners, hybrids, filters & duplexers, isolators and circulators, TMA, etc. Tiger is one of the biggest microwave components manufacturers in China and has already established long-term partner relationships with Ericsson, ZTE, YAGI and others. Chengdu Tiger (www.tiger-mw.com) shows off its capabilities at Booth 107.

Representing France in this category, AA-MCS is a European leader in design, development and manufacturing of passive and active radio frequency and microwave components including

attenuators, directional couplers, filters, dividers and (PIN diode) switches for demanding applications in defense, aerospace, telecommunications, medical equipment, EMC and instrumentation. On the active side, the company designs and produces broadband solid state power amplifiers (SSPA) covering DC to 50 GHz, for power up to 500 W CW. Say 'Bon Jour' to AA-MCS (www. aa-mcs.com/en/) at Booth 507.

France's second entry in this field is Diconex, a specialist for power loads, resistors and attenuators for RF and microwaves. Founded in 1962, the company that manufactured coaxial connectors for ALCATEL back in 1988 started designing microwave components in 1996 and antenna systems in 2009. With expertise in high power, thick film technologies and antenna systems engineering, Diconex offers products from miniature surface mount components to heavy duty devices for TV transmitters, radiocom base stations, radars, synchrotrons and antennas systems. Visit Diconex (www.diconex.fr/) at Booth 201.

AFT Microwave from Germany comes to compete in Amsterdam with a product range of mainly high power components and subsystems in waveguide and coaxial line technology, including 3 dB and directional couplers, attenuators, amplitude phase (IQ) modulators and circulators/isolators. In addition to the company's expertise in integrated microwave circuits (ceramic substrates in microstrip transmission line and coplanar line technology), AFT Microwave also competes in several waveguide categories. See AFT Microwave (www.aft-microwave. com) at Booth 105.

The United States is represented in this category by powerhouse Crane Aerospace and Electronics. The Microwave Solutions division demonstrates the depth of its expertise with a wide range of product solutions from component level devices to complex, advanced integrated microwave assemblies including circulators/isolators, passive products (mixers, power dividers, couplers, hybrids, modulators, beamformers, phase shifters and antenna elements), low noise sources, frequency converters, switching and signal detection products. With over 2800 employees, this 150-plus year old company has



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products that can be found in some of the toughest environments, from aircraft engines and landing gear to space satellites and medical implants. Crane Aerospace and Electronics (www.craneae.com) is situated in Booth 306.

TEST & MEASUREMENT EQUIPMENT

This category has been dominated for years by teams such as the United States' perennial favorite, Agilent (www. Agilent.com) at Booth 114, Germany's precision expert Rohde & Schwarz (www.rohde-schwarz.com) at Booth 115 and the measurement gurus at Anritsu (www.anritsu.com) from Japan (with U.S. headquarters in Morgan Hill, CA) at Booth 316. Aeroflex Test Solutions (www.aeroflex.com/ ats) with divisions in the U.S. and UK has made an impact in this category as well by offering stand-alone boxes and modular components such as the S-series digital signal generators and vector signal analyzers. The company, which will be located at Booth 523, has been scoring points with highly reliable, customized, innovative and cost effective tools. Meanwhile, relative newcomer to the RF/microwave market, National Instruments from Austin, TX is becoming a major player in high frequency measurement instruments. The company's graphical programming software, LabVIEW, and modular, open hardware delivers flexible solutions for a wide variety of applications ranging from simple data logging to high-performance automated test, industrial control, and advanced embedded control and monitoring. Check out NI (www.ni.com) at Booth 317. NI will be debuting their

European Microwave Week

new software-defined instrument, the vector signal transceiver, to a general microwave audience.

China Qingdao Xingyl Electronic Equipment, otherwise known as The 41st Institute of CETC (China Electronics Technology Group Corp.) is the only such institute in China developing and manufacturing electronic measurement instruments and automatic testing systems. The company has over 920 employees with more than 350 technical personnel with mid to high level engineering degrees. The company's long term objective aims quite high, "To be a best in Instrument industry in China; To be a world-known brand; To be a first-class Institute." To realize such an ambitious goal, the Institute is calling on its teams of researchers "to acquire knowledge and develop its own intellectual property based on self-development and selfdesign." With an eye on the advanced technologies throughout the world, CETC 41 management is committed "to the longterm principle of independence gained through complete selfowned knowledge property rights." Currently the company offers a portfolio of portable and bench top test equipment including transmission line/antenna analyzers, spectrum analyzers, signal generators, power meters and integrated VNAs. To learn more about the company's product lines and their quest to be a major test & measurement player, visit CETC 41 (www. ei41.com) at Booth 206.

The test and measurement field also includes specialized test solutions from across the globe including competitors in sub-categories such as load pull - Maury Microwave (U.S., Booth 314A) and Focus Microwave (Canada, Booth 510),

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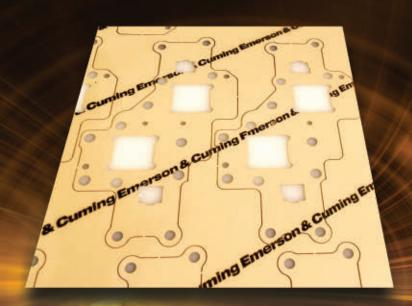
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nonlinear device characterization – Auriga Measurement Systems (U.S., Booth 314E), AMCAD (France, Booth 413), NMDG (Belgium), and Mesuro Ltd. (UK, Booth 226), and VNA addons such as wafer probes from Cascade (U.S., Booth 314F) and millimeterwave extensions from OML (U.S., Booth 310).

CABLES/CONNECTORS

There are a lot of global competitors in the cable and connector categories, especially in Switzerland and Germany, where the precision machining found in high-performance interconnects is considered an art form. *Microwave Journal* readers are well-acquainted with the likes of HUBER+SUHNER (Switzerland, Booth 517), Rosenberg-

er Hochfrequenztechnik (Germany, Booth 325), Spinner GmbH (Germany, Booth 613), and Ingun GmBH (Germany, Booth 517). Also from Europe, ATEM Holding offers cable assemblies and coax links designed and manufactured in France. Look for coaxial links, flexible cords (RG, MIL-17, low loss, stable phase), and semi-rigid cables from ATEM Holding (www.atem.com) at Booth 326.

While the American cable/connector companies mostly opted out of the EuMW exhibition, several new competitors from Asia will be at the exhibition looking to establish some penetration into European markets.

From Taiwan, HUANG LIANG designs and manufactures high performance RF and microwave connectors, cable assemblies, adaptors and specialty OEM matching parts. Operating from Taiwan since 1986, HUÂNG LIANG (www.thlp.com.tw) is in Booth 323. And from China, Xi'an Gold Wave is located in the ancient city of Xi'an. Established in 2002, the company specializes in high precision RF coaxial connectors, low-loss stable cable assemblies R&D and production, the series covers the products that are widely used in the domestic aerospace, aviation, navigation, telemetry, remote control, radar, electronic warfare and other military equipment, military industrial machine systems supporting key units. The company is fully qualified and has passed Chinese military standard of GJB, quality system certification GB/ T19001-2009/ISO9001: 2008 confidential certification and weaponry research and production license book, one of the 100 competitive enterprises in Shaanxi Province. Visit Xi'an Gold Wave (www. xiangoldwave.com) in Booth 108.

In our highly specialized field, where performance is paramount to survival, the industry as a whole can take pride in the technological achievements of our fellow microwave practitioners and the companies (and countries) they represent on the field of competition at any of the major trade exhibitions.

Reference

 Six Global Trends Shaping the Business World: Emerging Markets Increase Their Global Power Report from Ernst & Young, www.ey.com.







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Microwaves in Europe: Winning Ways?

Faced with unpredictable market conditions, the European RF and microwave industry must play to its strengths, stay focused and keep in the (Euro) zone. This Report considers the support the industry is getting and the tactics it is employing to remain competitive and lead the way in technological innovation.

It has always been a competitive world with the survival of the fittest being the law of the jungle. And there is no doubt that it has been a jungle out there in recent years. In Europe, the economic slowdown has meant that the realities of depressed markets, currencies under pressure and a tougher credit environment have hit hard. Supersized companies, institutions and economies have been forced to slim down and shed a few pounds (or Euros). Difficult decisions have had to be made in order to negotiate the organisational, structural and financial hurdles necessary to remain competitive.

The slowdown is global and all regions and individual nations are approaching the problem from their own perspective. Europe in particular has its own issues – it is a conglomeration of individual countries, each with their own priorities, trading partners, research and educational systems and indigenous industry. Importantly too, it is a global exporter of products and expertise, and a marketplace for goods and services.

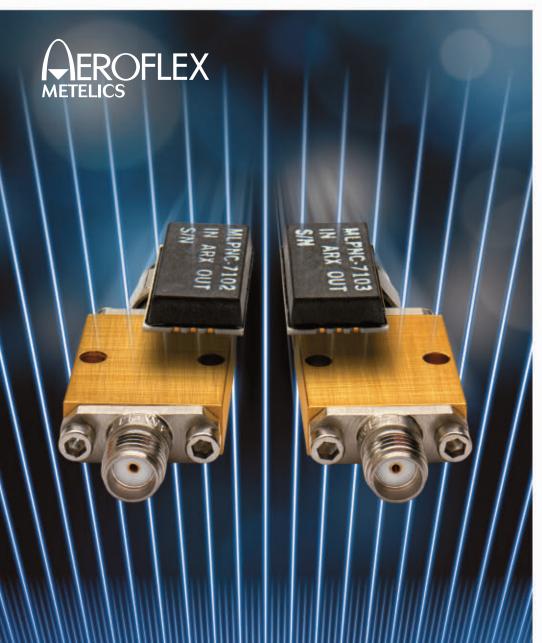
It is also, predominantly, a European Union and that unity has the capacity, if channelled effectively, to break down trade barriers, establish mechanisms to achieve realistic and common goals and build a framework for development and innovation. As will be outlined in the European Initiatives section of this Special Report, comprehensive mechanisms have been put in place to support, encourage, facilitate and fund development.

The realisation in Europe and beyond is that there will be no solution to the 'crisis' without growth and that investments in education, research and technological development focused on addressing practical/commercial requirements increase the chances to minimise the impact of the slowdown while building a platform from which to bounce back quickly when recovery deigns to make an appearance.

Like all sectors, the European RF and microwave industry must invest. As well as the preoccupation with smartphones, there must also be 'smart' thinking, as spending time and money makes no sense unless it is spent wisely. At any time, but especially in times of austerity, results must be achieved and a return on investment accrued. To do so our industry needs to take advantage of key initiatives that have been instigated at the EU and national level, to increase both the efficiency and the economic impact of research and innovation.

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MLPNC-7103-SMA800	21 @ 800 MHz	23 @ 1300 MHz	>-5 @ 6 GHz	> -1 5 @ 18 GHz	>-20 @ 30 GHz	
MLPNC-7103-SMT680	21 @ 800 MHz	23 @ 1300 MHz	>-5 @ 6 GHz	> -1 5 @ 18 GHz	>-20 @ 30 GHz	

* Contact the factory for additional information or for products not covered in the table.







Special Report

The RF and microwave industry has always been one of innovation; research and development are the best tools at our disposal to renew and strengthen business. Teamwork, at all levels, is particularly important as good partnerships have the potential to attract the best talents, with different skills and experience, to tackle the prevailing challenges.

"...There will be no solution to the 'crisis' without growth..."

The challenges that our industry is faced with also offer opportunities. For instance, the smartphone/tablet generation's voracious appetite for data, social media, entertainment on the move, etc., caught many operators in Europe by surprise, resulting in 'network capacity crunch' and the call for more spectrum (read our cover feature in this issue for more on that subject, page 24). The result has been the World Radio Congress ruling that the 700 MHz band be a cellular allocation throughout Europe. The RF and microwave industry is in a position to find innovative ways to address the problem.

Although core competencies, strengths and experience have to be maintained and built-on, the world is changing, offering the prospect of addressing new sectors such as health or getting on the environmental bandwagon with green radios and green communications.

Developments continue in the semiconductor/IC sector with greater integration being a major focus, together with the development of metamaterials. The expansion in the development in GaN has seen the first commercial GaN products introduced and mobile handsets with RF MEMS reconfiguration capability are set to enter the market.

Defence and security have long been fertile areas of development in Europe. Over recent years, the landscape has changed with traditionally robust defence budgets directly in the firing line when austerity measures are taken. Now, the focus is on improving the cost/performance ratio of components, subsystems and systems and finding different applications to exploit, such as in the security, space and civil sectors.

There is no doubt that Europe has individual companies, conglomerates, research institutes and academic institutions with the expertise, experience and enthusiasm to develop new products and processes and expand horizons. However, they can be helped by being able to easily partner, share and discuss technological innovation and have access to funding. Following is an overview of the initiatives that the EU has put in place over recent years, highlighting the new and long term programmes.

EUROPEAN INITIATIVES

In 2010, when the extent and severity of the impact of the economic and industrial downturn was being fully realised and impacting across the globe, the Europe 2020 Strategy was launched. Its aim is to help overcome the slowdown, stimulate growth and create more and better jobs in the EU.

The strategy identifies the drivers of EU growth for the decade, focusing on new solutions and structural reforms. Based on the principles of smart, sustainable and inclusive growth, Europe 2020 sets out five key targets in the areas of research and innovation, education, employment, poverty reduction and climate/energy.

Although all are relevant, research and innovation and education are areas where the European RF and microwave industry can both benefit and contribute. As this annual European Special Report has highlighted in previous years, a key driver to collaboration, development and innovation is the Seventh Framework Programme for Research (FP7) worth €55 billion overall and with a mandate to run from 2007 to 2013.

By removing obstacles to the free flow of scientific/engineering knowledge, data and researchers, in Europe, FP7 encourages, supports and funds networking between research centres, commercial enterprises, universities and regional authorities. Its aim is to stimulate knowledge transfer from academia to business and take research through to commercialisation. Having achieved tangible breakthroughs in research and product development with positive consequences for our industry, those goals have been achieved to some degree.



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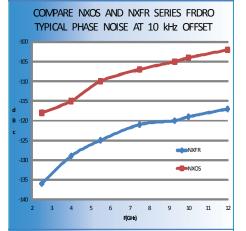
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Special Report

On 9 July 2012, the European Commission announced the final and largest set of calls for proposals for research under FP7. In total, ϵ 8.1 billion – the lion's share of the EU's proposed ϵ 10.8 billion research budget for 2013 – will support projects and ideas aimed at boosting Europe's competitiveness.

According to the European Commission, EU research funding generates considerable added value, with €1 of EU Framework Programme funding leading to an increase in industry added value of between €7 and €14. The expected long-term macro-economic impact of the current Seventh Framework Programme amounts to 900,000 jobs, of which 300,000 in research, and an extra 0.96 percent of GDP.

"...FP7 encourages, supports and funds networking..."

In its final call, FP7 continues to support sectors where the RF and microwave industry contributes. For instance, approximately €1.5 billion has been earmarked to support information and communication technologies related projects in 2013. The aim is to stimulate product, service and process creativity and innovation through ICT use to benefit Europe's industry, businesses, governments and citizens.

By early 2013, two Future Emerging Technologies (FET) flagship initiatives, which go beyond traditional ICT research and link up with specialists in other fields, will be selected. Funding will also support the European Cloud Partnership (ECP) being launched later in 2012. The ECP is designed to solve the challenges caused by fragmented markets and legislation for cloud computing, so that providers can start building trustworthy clouds, fit for Europe.

Smart Systems, which are increasingly impacting on daily life in the form of communications (smart-phones), aeronautics, automotive, medical applications, etc., are also being addressed. In particular, EURIPIDES is the EUREKA R&D programme dedicated to Smart Systems, packaging and systems integration. Led by industry, it motivates and supports innovative projects aimed at

the development of new products and services. These projects involve large companies and a growing number of SMEs and academia, from at least two EUREKA countries.

As European Microwave Week 2012 demonstrates, defence, security and space are significant drivers in our industry at present. And, by the end of the FP7 in 2013, the EC will have financed over 250 security research projects, with more than 1500 participants, from 45 countries. Significantly too, with over 21 percent participation by SMEs, the security programme greatly exceeds the target for SME participation in the whole of FP7.

Maintaining a competitive space industry is paramount for Europe and providing appropriate infrastructure and services requires sustained research into new technologies and their transferral to commercial exploitation. The Space Theme of the Seventh Framework Programme aims to support the European Space Policy and focuses on applications such as Global Monitoring for Environment and Security (GMES) and broader fields such as space technologies, space science and space transportation.

As an illustration of current programmes, specific examples of FP7 projects, which have been announced in the last 12 months that address the RF and microwave, semiconductor/IC and radar sectors of our industry, are highlighted in Sector Overviews & Initiatives later in this report.

Small and medium-sized enterprises play a significant role in the RF and microwave industry and can actively benefit from a package worth up to €1.2 billion outlined in the 2012 FP7 call. This includes financing for SMEs to around €970 million out of the €4.8 billion call budget for the Cooperation Programme, which covers ten thematic research priorities. Ring-fenced budgets for SMEs, in some calls covering up to 75 percent of available funding, will exist in nine of the ten themes. There will be €250 million for the dedicated research for the benefit of SMEs Programme, including demonstration actions for FP7 research results.

By the completion of FP7 it is estimated that around 4000 SMEs will have benefited from this dedicated programme that aims to strengthen the innovation capacity of SMEs

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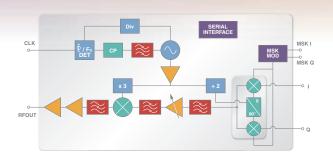
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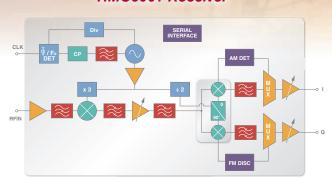


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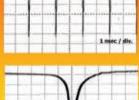
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GIM200A	200	-18	90
GIM250A	250	-18	80
GIM500A	500	-15	60
GIM1000A	1000	-10	50
GIM1500A	1500	-8	45
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Special Report

and help them acquire technological know-how for the development of new products and markets. Approximately 20,000 SMEs are expected to have benefitted from FP7 before the end of the Programme.

Also aimed at SMEs is the Eurostars Programme co-funded by the European Communities and 33 EUREKA member countries. It aims to stimulate SMEs to lead international collaborative research and innovation projects by easing access to support and funding. Taking a bottom-up approach, the programme is dedicated to the needs of SMEs, and specifically targets the development of new products, processes and services and the access to transnational and international markets. With the Seventh Framework Programme having been perceived to be a success and the final FP7 call for 2013 having been announced, future initiatives will come under close scrutiny.

Horizon 2020 is the proposed £80 billion investment programme for research and innovation for 2014 through 2020. It will bring together all European-level support for research and innovation under one umbrella to aid progress from idea to market, through streamlined funding, simpler programme architecture and rules for participation.

"...Maintaining a competitive space industry is paramount for Europe..."

The programme's architecture is composed of three distinct priorities, or pillars. One of particular interest, with an investment of almost €18 billion, aims to boost industrial leadership, with actions to make Europe a more attractive place for businesses to invest in R&D and innovation. €13.7 billion will be targeted at supporting key enabling and industrial technologies that underpin innovation across different industries and sectors. These include nanotechnologies, advanced materials, ICT, advanced manufacturing processes, space and biotechnology. Its structure will enable it to support research and innovation from the laboratory to exploitation including testing, prototyping and early demonstration; allied to new measures for risk and equity funding of innovative companies.

Horizon 2020 has the capability of offering a structure that will help foster collaboration between R&D and industry. The next section of this report elaborates on how this relationship is developing and the technological issues it is addressing and identifies specific areas of activity and growth.

SECTOR OVERVIEWS & INITIATIVES

The chairmen of the three 2012 European Microwave Week conferences – the European Microwave Conference (EuMC), the European Microwave Integrated Circuits (EuMIC) Conference and the European Radar Conference (EuRAD) – offer insight into key areas of development and identify future trends. To illustrate specific European activity in these sectors, examples of recent FP7 initiatives are highlighted.

RF AND MICROWAVES

Sector Overview by Bart Nauwelaers, EuMC 2012 Conference Chair



With European Microwave Week, and especially the European Microwave Conference imminent, it is a good time to

lean back and think about the field of microwaves, millimetre-waves and beyond. For instance, in what environment is our community developing its activities? Currently we are operating in a world that is warming up, where people want to live longer and desire consumer goods that are cheaper and have been produced in an environmentally friendly way. Does this have anything to do with our research and development? The answer is: yes, indeed.

To get an interesting and indicative insight into European microwave research, consider some of the subjects that the European Commission has put forward and published in its calls for the current FP7. In FP7, you will find titles such as Smart Cities and Communities, Factories of the Future, ICT for Green Cars, Future Internet, Energy Efficient Buildings, Brain Research, Smart Factories... All these subjects reflect the societal

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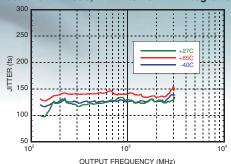


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NEW	HMC1031MS8E	500	Integer Mode PLL (x1, x5, x10)	Defined by VCXO	Defined by VCXO	140	0.005	-208
NEW	HMC1033LP6GE	500	3.3V Only, High Performance, Frac-N Clock Generator	120	-155	350	0.68	-226 / -229
NEW	HMC1035LP6GE	2500	3.3V Only, High Performance, Frac-N Clock Generator	120	-155	350	0.68	-226 / -229
	HMC1034LP6GE	3000	High Performance Fractional-N Clock Generator	78	-165	350	0.86	-227 / -230

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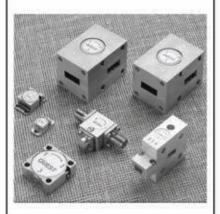


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concerns evident at present and several of them lend themselves to microwave and millimetre-wave investigations and applications.

The European Commission is spending roughly €10 billion per year on FP7. This is subdivided into themes, of which Information and Communication Technologies takes roughly one third. Health accounts for one fifth, while Nanosciences, Nanotechnologies, Materials and Production Technologies of the order of one tenth of the budget. Space and Security together are also worth one tenth and Energy a bit less. It is in relation to these themes that microwaves and millimetre-waves must find their research resources but always as a supporting technology.

European funding correlates very well with what is going on in our research community. We continue to work to develop radios and are aiming for all-wireless communications, MMICs are prominent with silicon becoming more significant, together with frequencies ranging from microwave to millimetre-wave. Health and biological subjects are coming to the fore: we are paying much more attention to positive applications with sensors and curative applications. Green radios and green communication is a driver for (reduced) power applications: this is our contribution to the energy theme. And we are talking again about power transmission with microwave beams and the good old rectennas.

Space and security are the two themes in which our field of activity has the greatest prominence, while metamaterials may well be seen as a microwave answer to the nanomaterial question. The trend towards ever higher frequencies however, is as a law unto itself: it seems to be independent of anything else. The terahertz range is also taking on increased significance.

With regards to how we tend to work, research is mostly done in relatively small teams, in universities, research centres and companies. Even larger teams are usually not composed of more than tens of staff members. In fact, some of the most important recent innovations have emanated from teams of less than ten – think of the

nonlinear network analyser.

So microwaves and millimetre-wave engineering are subjects with very dedicated, skillful and innovative people, but they are dispersed over many organisations and thus have difficulty to speak with one voice. Conversely, space and security are the two truly microwave related themes in the European Framework Programmes that have visibility. So, with ESA-ESTEC's backing it is no coincidence that the theme of EuMW is Space for Microwaves, and that the Defence, Security and Space Forum is a full-day focused event.

FP7 PROJECTS

With just under €1.85 million of EU funding, the multi-Reconfigurable Antenna SoluTions based on REflectarray technOlogy (RAS-TREO) project will investigate the development of multi-reconfigurable antennas, which has numerous potential applications including satellite communication and cognitive radio. The project proposes, for the first time, an efficient solution to large directive antennas able to simultaneously achieve spatial, frequential and polarization dynamicreconfiguration. Microfabrication technologies for RF reconfiguration will be employed to implement the proposed concepts, in order to achieve higher frequency operation, enhanced performance, integration and low power consumption.

As its title suggests, the results of the Active and Passive MIcrowaves for Security and Subsurface imaging (AMISS) project will be two-fold ground penetrating radar for subsurface sensing and critical infrastructure diagnostics and passive and active microwave imaging systems for security applications. The proposal is for two lines of research. The first is concerned with the development, characterization and performance evaluation of new systems, sensors and configurations able to mitigate the clutter. and increase information content and redundancy, for both passive and active microwave imaging, while the second considers the development, implementation and performance evaluation of processing tools.



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ICS & SEMICONDUCTORS

Sector Overview by Frank van Vliet, EuMIC 2012 Chair (In Collaboration with John Long, Vice-Chair and Arttu Luukanen, TPC chair)



The 7th European Microwave Integrated Circuits Conference captures a snapshot of a dynamic field of research and in-

dustrial exploitation in integrated cir-

cuits covering frequencies from microwaves to the submillimetre-wave region. The underlying trends for microwave ICs seen this year include: higher levels of system integration, adaptivity, improved RF performance and especially cost. Scaling of CMOS has pushed the technology into the mm-wave region, whilst simultaneously enabling integration of an RF system from antenna through to A/D conversion and digital peripheral

communications blocks onto a single chip. The high integration level, including built-in-test capability, is ushering in an era of highly adaptive radio systems at a fraction of the cost of previous generations.

"...MMICs are prominent with silicon becoming more significant..."

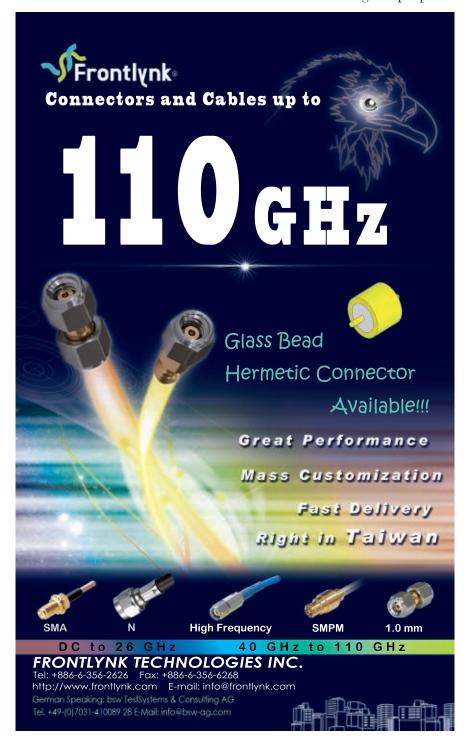
For compound semiconductor technologies, heterogenous integration of III-V technologies on silicon is opening another avenue for the realization of high-performance systems. This, coupled together with exciting new developments in passive device integration, is driving further reductions in the size and cost of higher performance systems.

In the millimetre-wave region, communication applications at 60 and 80 GHz together with the broader commercialization of 77 GHz automotive radar are motivating low-cost and adaptive radio systems. These applications have also provided a consistent pull for improvements in broadband power amplifiers. The initial commercial product implementations in GaN technologies are demonstrating excellent performance in terms of efficiency, output power, bandwidth and linearity, and at costs competitive with more mature technologies.

"...exciting new developments in passive device integration..."

Long associated with the desire for greater agility, efficiency and integration, RF MEMS integrated on-chip are finding application in reconfigurable RF and mm-wave ICs. Mobile handsets with RF MEMS reconfiguration capability are vying to enter the market in the near future.

Rapid development is also seen at sub-millimetre-wave frequencies, primarily driven by imaging applications. Active devices are now pushing the 1 THz mark, and the traditional paradigm of high cost is being erased by sub-millimetre-wave devices and circuits implemented in SiGe BiCMOS technologies. Furthermore, the barrier to entry associated with



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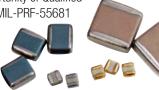


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the availability of test systems is being alleviated by the introduction of 1 THz VNAs. Packaging of THz circuits is another challenge that is addressed by increasing levels of on-chip integration and the development of micromachined waveguide blocks, as we are now seeing in III-V technologies, for example.

Last but not least, the advances in RFICs pay homage to better theoretical understanding as well as to the ever cheaper and easier-to-use simulation and test capabilities available. The diversification of applications and mobile LTE, together with broader spectrum coverage of adaptive radio systems, ensure that microwave ICs face an exciting future.

FP7 Projects

The Nanostructured materials and RF MEMS RFIC/MMIC technologies for highly adaptive and reliable RF systems (NANOTEC) project has attracted total funding of nearly €10 million. Its aim is to generate innovative approaches towards novel RF/mm-wave systems with increased functionality and potentially lower cost addressing future needs of European industry.

NANOTEC will develop four demonstrators: 10 to 24 GHz reflect arrays for aerospace, 71 to 86 GHz frequency-agile LNA/PA for E-Band point to point communication, 94 GHz high-sensitivity front-ends for passive imaging and 140 GHz radar front-ends for active imaging – with advanced functionalities based on enabling technologies and via monolithic integration of high-performance RF MEMS switches in GaN/GaAs/SiGe IC foundry processes. The project will aim to improve reliability of RF MEMS by using nanostructured materials and demonstrate added-value by employing the proposed GaN/ GaAs/SiGe MEMS-ICs for 10 to 140 GHz applications. The emergence of European sources (SiGe/GaAs/GaN MEMS-IC foundries) will play a key role towards increasing the availability of RF MEMS technology and related

Other FP7 projects of note include the GaN Quantum Devices for T-Ray Sources (TERAGAN) project, which will receive around €1.6 million of EU funding, while the LAyer Transfer for Integration of Compound sEmiconductors (LATICE) project will benefit from funding of just over €1.9 million.



Sector Overview by Willem Hol, EuRAD 2012 Chair (In Collaboration with Albert Huizing, Vice-Chair and Francois Le Chevalier, TPC-Chair)

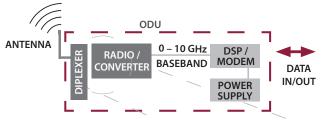


The ninth European radar conference will offer an academic/industry perspective of the rapidly changing landscape of ra-

dar research and development. These changes are not only driven by the advances in microwave and electronics technology but also by changing user requirements. Traditional radar applications such as defence continue to demand improvements in radar performance to counter the danger of diverse threats such as improvised



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explosive devices, small slow unmanned aerial vehicles, and long range ballistic missiles. At the same time, budgets for the procurement and maintenance of military radar systems are dwindling and this drives the need for an improved cost/performance ratio of military radar systems as well as the search for new radar applications in the security, space and civil domain.

"...new radar applications in the security, space and civial domain."

Active phased array radars with multifunction and multimission capabilities are rapidly becoming operational because of their greater flexibility when compared with traditional single function/single mission radar systems. To optimise the performance of a multifunction radar for a specific mission, new waveforms, scheduling techniques and processing algorithms need to be developed. MIMO radars that simultaneously transmit and receive orthogonal waveforms provide extra degrees of freedom for the radar designer to optimise the cost/performance ratio of radars.

The developments in semiconductor and digital processing technology enable new radar architectures and algorithms that previously were not viable. Phased array radars with digitization on receive at the element level and digital beamforming not only support adaptive techniques for suppression of jamming and interference signals, but also enable the use of micro-Doppler features to discriminate targets of interest, and man-made objects, from the clutter background.

A recent challenge for radar systems to address is the increased use of the electromagnetic spectrum by mobile communications systems which limits the spectrum that is available for active radar systems. Potential solutions to this challenge are distributed radars that employ narrowband waveforms to detect and track targets and passive radar systems that rely on transmitters of opportunity such as analogue and digital radio and television emitters, base stations and hot spots for mobile communications.

Compressive sensing is a new paradigm in data acquisition and signal processing that allows sparse signals to be sampled at a much lower frequency than the Nyquist rate. In radar systems that use wide bandwidths and/or many receiver channels for automatic target recognition, compressive sensing can provide a significant reduction in acquisition time, pulse repetition rate, or hardware.

"...compressive sensing can provide a significant reduction in acquisition time..."

The advances of radar technology in new application domains provide a fertile breeding ground for innovative ideas that will challenge conventional solutions in traditional radar applications such as defence, and will invigorate the radar community well into its second century.



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FP7 Projects

The Advanced Radar Tracking and Classification for Enhanced Road Safety (ARTRAC) project aims to develop an active safety system to protect vulnerable road users (VRU) from vehicles in motion that is economically viable in the volume vehicle market. The environmental sensing is to be based on a single automotive 24 GHz narrowband radar sensor, which

offers the potential to overcome the hitherto price barrier that has prevented VRU protection systems from entering widespread use.

To meet the challenging technical requirements for extremely short measurement time, reliable target detection, ego motion and road condition estimation that have to be met, a new transmit/receive antenna and multi-channel receiver will be developed. Existing microwave

technology in the 24 GHz band will be utilised as much as possible to facilitate low-cost mass production applications.

Having attracted around €1.12 million of EU funding, the intention of the International automotive 79 GHz frequency harmonization initiative and worldwide operating vehicular radar frequency standardization platform is to establish and speed up the worldwide harmonized frequency allocation for automotive radar systems in the 77 GHz to 81 GHz (79 GHz) frequency range. This 79 GHz international frequency harmonization and standardization platform will bring all the interested parties together and promote and accelerate the rulemaking process for 79 GHz on an international level.

CONCLUSION

This annual report has put the spotlight on the European RF and microwave industry, both as an individual entity and in the context of how it functions within, is supported by, and contributes to the wider European community.

It is clear that the European Union is striving to live up to its title and provide a union that smoothes, facilitates and augments the transition from research and development to implementation and commercialisation. Mechanisms have been established that remove barriers, provide funding and nurture partnerships. FP7 in particular has proved a focus and a catalyst for innovative collaborations and targeted research with applications in the real world. Funding has been simplified and forthcoming, and it can only be hoped that Horizon 2020 can build on FP7's achievements in the

This report has accentuated the positives, but we are far from over the finishing line and we cannot underestimate the challenges that lie ahead. Europe still has to face up to the demons of economic instability and political division if it is to successfully beat the recession. Stimulating growth through innovation and endeavour is the baton that we cling on to and need to pass to the next generation but realistically, it will be a marathon, not a sprint.





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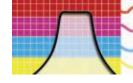


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Harmonic Suppression of Edge Coupled Filters Using Composite Substrates

Bandpass filters are employed in numerous microwave applications such as communication systems, radar and test equipment. Microstrip edge coupled structures are often used for bandpass filters because they are relatively easy to implement in printed circuit board (PCB) technology. These filters have many advantages, however, they suffer from an inherent issue with harmonic spurious responses. There are many techniques to address the suppression of these responses, however, each have their own concerns. The harmonic suppression procedure outlined in this article has minimal impact on design complexity and has some additional benefits for the microstrip PCB features, which are often in addition to the filter pattern on some designs. The design process will be outlined, models defined and circuit performance will verify the procedure.

The center bandpass frequency (f_0) of a microstrip edge coupled filter will have spurious responses at even harmonic frequencies, that is unwanted filter responses at $2f_0$, $4f_0$, $6f_0$, etc. Specifically, the band at $2f_0$ has a detrimental effect on symmetry of the intended passband and can impact the bandwidth. The spurious responses occur because the phase velocities of the even and odd mode for each filter element are different.

There are many methods to suppress the $2f_0$ mode and most of these methods attempt to equalize the phase velocity of the even and odd modes. The use of over-coupling^{1,2} is done to extend the phase length of the odd mode to equal the even mode phase velocity. Another method^{3,4} uses capacitors to extend the travel path of the odd mode. A sawtooth pattern or wiggly coupled⁵ segment is used to lengthen

the odd mode path, while maintaining a relatively unchanged even mode path and equalizing the phase velocities. Additionally, suspended microstrip configurations have been employed to equalize the modal phase velocities. All of these methods introduce their own set of capabilities and limits, however, in general, increase the design cycle difficulty. In the case of the suspended microstrip, shown in *Figure 1*, the design cycle is less impacted, but achieving proper dimensional control in the circuitry with effective multilayer via hole interconnections can be extremely challenging.

The current work offers a variation on suspended microstrip and utilizes a composite substrate copper clad laminate. The laminate

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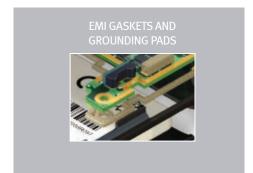




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Technical Feature



▲ Fig. 1 Cross-sectional views of a suspended coupled microstrip (a), and a composite laminate coupled microstrip (b).

uses two dielectric layers, which have significantly different relative permittivity (ϵ_r) . As opposed to the suspended microstrip, this composite laminate concept can be processed through normal PCB fabrication processes, have plated through hole vias and are assembled like most other PCBs.

COMPOSITE LAMINATE DEFINITION

The copper clad laminate used to fabricate the microstrip circuitry should ideally be the same type of substrate, however, with very different $\varepsilon_{\rm r}$. Several variations have been evaluated, but only a composite laminate substrate, using layers of RO3010™ and RO3003TM materials, will be discussed here. The choice of these materials is due to their proven ability to be used in a variety of high volume and multifaceted PCB configurations. Additionally, these materials are from the same substrate family, so there are no concerns for material compatibility issues. The RO3010 material has a suggested Design Dk (ε_r) of 11.2 and the RO3003 substrate has a suggested Design Dk of 3.0. This difference in ε_r is enough to alter the odd mode phase velocity to approach an equalization of the even mode.

The composite laminate uses the dielectric layer with the high ε_r adjacent to the signal plane and the low ε_r material next to the ground plane as shown in the figure. There is a ratio consideration for the thickness of the different ε_r materials to be used in the composite laminate. A comprehensive study for even-odd mode equalization regarding edge coupled microstrip structures τ suggests some general design rules for frequencies below 20 GHz. When using layered dielectrics with ε_r ratio of 3.5:1 to 4.5:1, the thickness ratio should be

2:1, with the thicker substrate being the high ϵ_r material and placed against the signal plane. Recent experiments have shown that the high ϵ_r material can be thinner than the low ϵ_r material and still have benefits regarding altering the odd mode phase velocity. Even though this configuration is not optimum for a near perfect equalization of the odd and even mode phase velocities, it does have enough effect on the odd mode velocity to help minimize the $2f_0$ response.

Having the composite laminate with a thin layer of the high ε_r material and a larger thickness of the low $\varepsilon_{\rm r}$ material is beneficial for achieving a composite z-axis (thickness) ε_r value that is closer to the low ε_r material value. For microwave features that predominately use the z-axis ε_r properties of this laminate, such as transmission lines, this enables wider conductor widths for less conductor losses. Essentially a composite laminate can be constructed, which will give a nearly equal even-odd mode phase velocity for suppressing the 2f₀ mode, have a high ε_r value near the signal layer to give improved bandpass performance of coupled features and have a lower z-axis ε_r in order to maintain wider conductor widths which will yield less conductor loss.

EVEN AND ODD MODE OPERATION FOR EDGE COUPLED MICROSTRIP FEATURES

For a microstrip edge coupled feature, the even and odd mode phase velocity can be approximated by:⁸

$$V_{P,even} = \frac{c}{\sqrt{\epsilon_{eff,even}}}$$
 (1)

$$V_{P,\text{odd}} = \frac{c}{\sqrt{\epsilon_{\text{eff,odd}}}}$$
 (2)

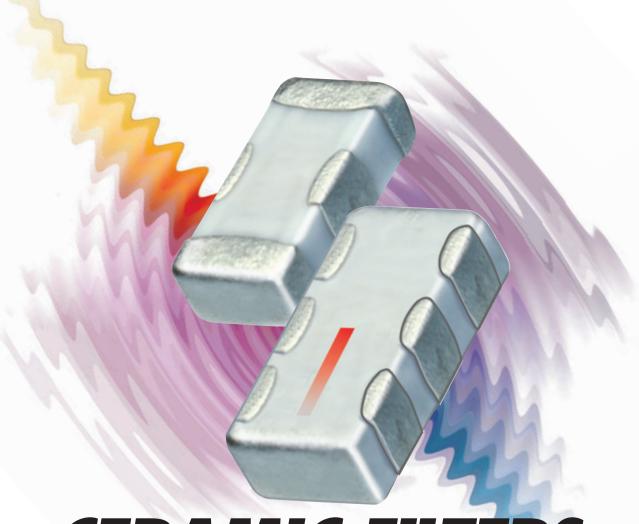
$$\epsilon_{eff,even} = \frac{C_{even}}{C_{even,air}}$$

$$\epsilon_{\rm eff,odd} = \frac{C_{odd}}{C_{odd,air}}$$

$$C_{\text{even}} = C_{\text{p}} + C_{\text{f}} + C_{\text{f'}}$$

$$\mathbf{C}_{\mathrm{odd}} = \mathbf{C}_{\mathrm{p}} + \mathbf{C}_{\mathrm{f}} + \mathbf{C}_{\mathrm{ga}} + \mathbf{C}_{\mathrm{gd}}$$

where V_P is the phase velocity for either even or odd mode, ϵ_{eff} is the effective dielectric constant for even or odd mode and C is the various capacitances. $C_{even,\,air}$ is the capacitance



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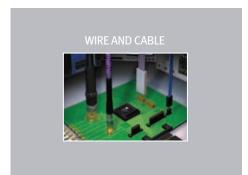




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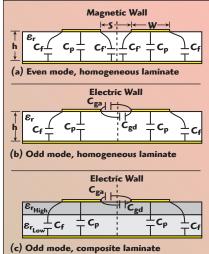


Fig. 2 Cross-sectional view of a microstrip edge-coupled filter element.

of the microstrip structure when air is used as the substrate for the even mode and the same nomenclature applies to the odd mode. C_p is the parallel plate capacitance, C_f is the fringing capacitance, Cf' is the fringing capacitance in the even mode only at the magnetic wall, C_{ga} is the gap capacitance due to coupling in air, C_{gd} is the gap capacitance in the dielectric and c is the speed of light in free space. Figure 2 gives a visual depiction of the even-odd mode operation of coupled microstrip features.

When considering the even mode operation, it can be seen that the phase velocity will be affected by the dielectric properties of the laminate only. The odd mode phase velocity associated with the quasi TEM wave propagation is affected by the laminate as well as the capacitive gap coupling in the air (C_{ga}) . The odd mode phase velocity will be faster than the even mode just by the nature of using air in the gap coupling. The composite laminate can slow the odd mode phase velocity by the use of a thin layer of high ε_r substrate. The capacitive gap coupling (C_{gd}) using the high ε_r material, in combination with the capacitance gap coupling (C_{ga}) in the air can be made to approximate the phase velocity of the even mode.

OUTLINE OF FILTER DESIGN PROCEDURE

Several different edge coupled filters were designed in order to evaluate different composite laminate configurations. Furthermore, filters were designed at different frequencies and

bandwidths to evaluate the effects of coupling as well as E field depth penetration into the higher ε_r material.

The filter design, which will be discussed in more detail, is a 5 element (n = 5), Chebychev filter with a passband ripple of less than 0.5 dB, a fractional bandwidth of 0.07 and designed for a center frequency of 2 GHz. The procedure for defining the circuit features is a common ladder circuit, lowpass prototype method defined in many microwave texts.^{9,10} The n = 5 prototype parameters for this filter are:

$$\begin{array}{l} g_0 = g_6 = 1.0 \\ g_1 = g_5 = 1.7058 \\ g_2 = g_4 = 1.2296 \\ g_3 = 2.5408 \end{array}$$
 The design equations are given by:

$$\begin{split} \frac{J_{01}}{Y_0} &= \sqrt{\frac{\pi}{2}} \left(\frac{FBW}{g_0 g_1} \right) \\ \frac{J_{01}}{Y_0} &= \frac{\pi FBW}{2} \frac{1}{\sqrt{g_n g_{n+1}}} \\ \frac{J_{n,n+1}}{Y_0} &= \sqrt{\frac{\pi FBW}{2g_n g_{n+1}}} \end{split} \tag{3}$$

 $g_0, g_1...g_n$ are the elements of the ladder-type low pass prototype with a normalized center frequency equal to 1. FBW is the fractional bandwidth of the filter. $J_{n,\,n+1}$ are admittances for the J-inverters and Y_0 is the characteristic admittance of the terminating lines.

The desired even and odd mode impedances of each element of the filter are determined by:

$$\left(Z_{0e}\right)_{n,n+1} = \frac{1}{Y_0} \left[1 + \frac{J_{n,n+1}}{Y_0} + \left(\frac{J_{n,n+1}}{Y_0}\right)^2 \right]$$

$$\left(Z_{0o}\right)_{n,n+1} = \frac{1}{Y_0} \left[1 - \frac{J_{n,n+1}}{Y_0} + \left(\frac{J_{n,n+1}}{Y_0}\right)^2 \right]$$

$$(4)$$

Once the even and odd mode impedances for each element are defined, the circuit pattern dimensions are determined by the use of a free software from Rogers Corp., MWI-2010. This software¹¹ uses closed form equations to determine the even and odd mode impedance with a given circuit geometry and material properties. The software will also give



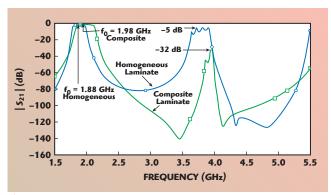


Fig. 3 Comparison of simulated S₂₁, using the same geometry with different substrates.

the wavelength and for each element, the length of the element will be ½ the wavelength, minus the extension due to fringing. Another method for determining the length of each element is given by: 12

$$l_{n} = \frac{\lambda_{0}}{4\left(\sqrt{\left(\varepsilon_{re}\right)_{n}\left(\varepsilon_{ro}\right)_{n}}\right)^{1/2}} - \Delta l_{n} \qquad (5)$$

where ϵ_{re} is the even mode effective dielectric constant, ϵ_{ro} is odd mode and Δl_n is the length extension due to field fringing. The MWI-2010 software can also calculate the length extension, using the well known closed form equations for microstrip configurations. 13

After the circuit dimensions are defined, a more thorough model is done, using the electromagnetic modeling (EM) software from Sonnet Software Inc. to fine tune the filter performance. Once the filter model is adequately defined on the composite laminate mi-

crostrip design, the model is repeated with a homogeneous laminate of the same composite ε_r . The results from these models are shown in **Figure 3**. The filter performance for the composite laminate is using a 0.127 mm (5 mil) layer of RO3010 substrate and 0.635 mm (25 mil) layer of RO3003 substrate, with the

signal plane next to the RO3010 material. The homogeneous laminate is using a single substrate with a $\varepsilon_r = 4.13$.

It can be seen that the range of frequencies in the $2f_0$ response region for the microstrip filter using the homogeneous substrate has an insertion loss of approximately -5 dB and the filter using a composite substrate has an insertion loss of -32 dB. Therefore, the spurious $2f_0$ response is significantly reduced with the use of the composite laminate. Furthermore, it can be seen that the bandwidth of the filter using the composite laminate is wider and the $2f_0$ response has a much narrower bandwidth, compared to the filter using the homogeneous laminate.

MEASURED RESULTS

The composite laminate was made with the two substrates previously described, RO3010 and RO3003 materials. The homogeneous laminate used a TMM®4 copper clad laminate of the same thickness as the composite

laminate. The choice of that material is based on the ε_r being near the desired value and the material being readily available.

The information in **Table 1** was found by using the MWI-2010 software for a microstrip edge coupled model, with an enhancement to include composite substrates. The phase velocity of the different segments of the filter was found and averaged. The physical PCB conductor layout for the filter is shown in *Figure 4*. The circuits were fabricated, assembled, tested and the measured results are shown in *Figure* **5**. Tr2 is the S_{21} curve for the filter using a homogenous laminate and Tr4 is the S_{21} curve for the filter using the composite laminate. The markers were placed at two frequencies for each S_{21} curve. Marker 1 is the center frequency and marker 2 is the peak of the $2f_0$ response for the filter using the homogeneous laminate. Marker 2 has a $|S_{21}|$ peak of -7.3 dB. Marker 3 is the center frequency and marker 4 is the peak of the $2f_0$ response for the filter using the composite laminate, the peak of this $2f_0$ response is -31.3 dB. Although there are some differences from the measured results as compared to the model shown in Figure 3, the significant reduction of the spurious $2f_0$ response is verified.

The main difference of the measured results, as compared to the model, is a frequency shift. The composite laminate uses two substrates and the high ε_r substrate has a wider ε_r tolerance, which is typical of dielectric material with high ε_r values. The high ε_r material was within the manufacturers specification, however it had a slightly higher ε_r value than the nominal 11.2 given as the Design Dk. This accounted for the center frequency shift. The other frequency shift associated with the filter using the homogeneous material is a natural response of using the available TMM4 material, which had a slightly higher ε_r than the desired composite ε_r of 4.13.

TABLE I						
PHASE VELOCITY DATA FOR FILTERS USING HOMOGENEOUS AND COMPOSITE SUBSTRATES						
	Phase V	Difference				
Laminate	Odd Mode	Even Mode	Odd/Even			
Homogenous	1.75	1.59	1.10			
Composite	1.68	1.65	1.02			

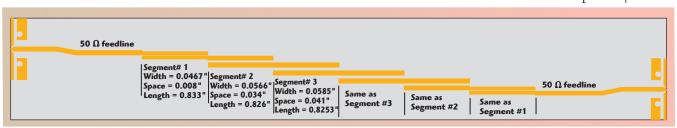


Fig. 4 Physical PCB conductor layout of the microstrip filter.

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SPECIFICATIONS

Freq Range	Freq Range	Gain	P _{SAT}	Drain Efficiency	V _D	I _D		Part
(Min) (MHz)	(Max) (MHz)	(dB)	(dBm)	(%)	(V)	(mA)	Package	Number
0000	2400	400	E4.E	F0	F0	4.40	DEECE O	DECOOL
2800	3400	12.0	54.5	52	50	440	RF565-2	RF3928
2800	3400	13.0	55.8	50	65	440	RF565-2	RF3928B
1200	1400	15.0	54.5	55	50	440	RF565-2	RFHA1020
1200	1400	15.0	53.5	58	36	440	RF565-2	RFHA1023
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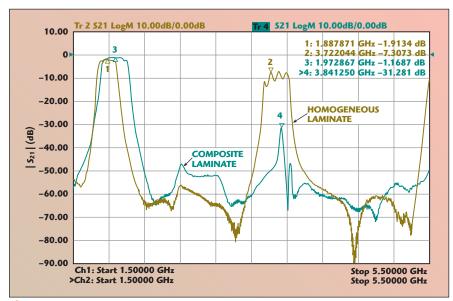


Fig. 5 PNA test results for the same circuit pattern using composite and homogeneous laminates.

The TMM4 material has a Design Dk (ε_r) of 4.5 and this too accounts for the frequency shift.

Other differences between the measured results and the model are attributed to the PCB manufacturing effects and tolerances regarding the circuit conductor patterns. These differences are likely the cause for the peaks of the $2f_0$ responses to be slightly different on the measured circuits as compared to the EM model.

BRIEF OVERVIEW OF EXTENDED EVALUATIONS

Other circuits were modeled and evaluated with regards to the same

material considerations. Some of the other issues evaluated were 3 element and 7 element filters, as compared to the 5 element filter shown previously. Intuitive assumptions were verified where less filter elements (3 element) had less benefit of the composite material for the $2f_0$ suppression. More filter elements (7 element) had a slight improvement over the 5 element results shown.

Additionally, there were alterations of the 5 element filter with changes in coupling, bandwidth and center frequency. Experiments were also performed using thinner composite materials, using a larger range of ε_r .

These materials used the same high ϵ_r material ($\epsilon_r = 11.2$) and the low ϵ_r material had an $\epsilon_r = 2.2$. Due to the wide range of circuit patterns involved with the different filter elements and the material considerations, only general observations can be given here for the composite laminate:

- Tightly coupled elements will have more benefit than loosely coupled.
- 2. Higher frequency filters can use a composite laminate with a thinner layer of the high ϵ_r material.
- 3. Wider bandwidth can be achieved when using a larger ratio of ϵ_r values.
- 4. As the laminate gets thinner, firm definition on the ratio of the high/low ε_r material becomes more critical.

The composite laminate procedure shown here can be very successful to minimize the spurious 2f₀ responses, however thorough EM modeling is highly recommended. The filter models shown here demonstrated the concepts, but they were not optimized.

CONCLUSION

It has been shown that a composite laminate using the proper ratio of high/low ε_r material can significantly reduce the spurious $2f_0$ harmonic response of a microstrip edge coupled bandpass filter. It was also illustrated that the composite laminate can achieve wider bandwidth. In compari-

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son to the many other techniques for reducing the $2f_0$ harmonic response, the composite laminate does not increase the design complexity and is capable of most common PCB configurations.

Additionally, there are other benefits to this technology, since many microwave PCB designs with filter features also have many other microwave structures. The added benefit of the composite laminate shown here

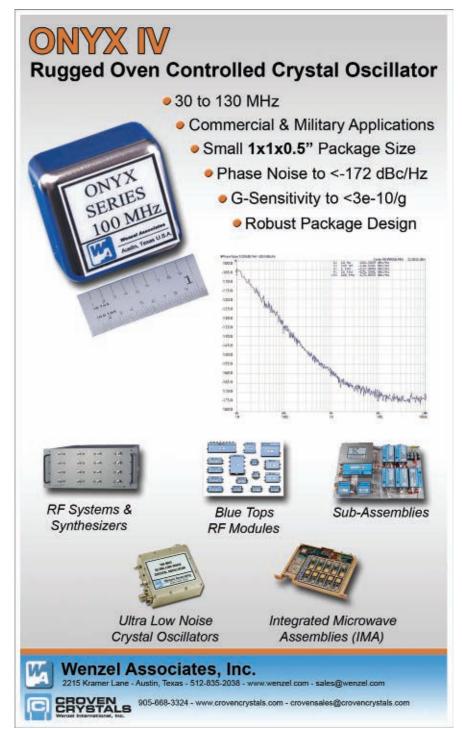
is when the thinnest effective high ϵ_r material is used to reduce the $2f_0$ response, the overall z-axis ϵ_r value remains relatively low and this allows the other PCB features to have wider conductors. The wider conductors will allow other microwave features to have less conductor loss as well as improved PCB fabrication yields.

The composite laminate allows the designers to easily and significantly reduce the $2f_0$ harmonic response, in-

crease the bandwidth and still maintain a lower z-axis ε_r value to allow other features on the microwave PCB to have lower losses.

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An Input Matching Network Without Gain Trade-Off for a CMOS LNA

A capacitive feedback circuit along with a π -matching network is proposed to achieve the input matching condition without gain trade-off for the commonsource low noise amplifier (CSLNA). The π -matching network introduces an additional degree of design freedom and allows the LNA to achieve high gain. Designed for the 2.4 GHz ISM band, the proposed LNA achieves a measured gain of 21.5 dB with an S_{11} of -12 dB while consuming only 0.6 mW. The NF is 4.9 dB and the IIP3 is -12 dBm.

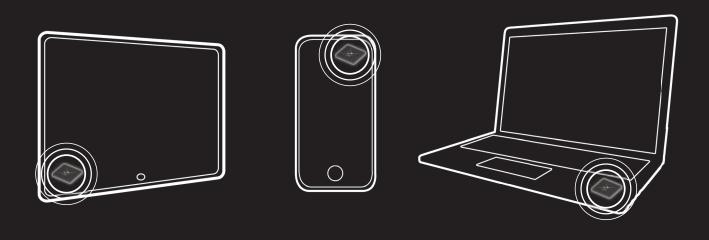
owadays, it is normally desirable to have a high gain LNA in most wireless receivers. Serving as the first active block in the receiver chain, an LNA should provide enough gain to overcome the noise contribution of the subsequent stages and add as little noise as possible. However, in some wireless standards such as the IEEE 802.15.4, the LNA's noise figure (NF) is not a critical performance parameter. ^{1,2} The NF requirement can be relaxed to allow optimization on other design parameters such as gain, power consumption and chip area. The LNA presented in this article is designed for the IEEE 802.15.4 standard.

Popular LNA topologies are the inductive source-degeneration common-source LNA (L-CSLNA), the common-gate LNA (CGLNA) and the resistive feedback LNA (RFLNA). The L-CSLNA is generally preferred for ultra-low power narrow-band applications due to its ease of input matching, high gain and low noise. However, its gain performance is limited by the input matching condition. There exists a trade-off between high gain and good input matching in the L-CSLNA.

In this article, an LNA, where the input matching is realized by a capacitive feedback scheme and a π -matching network, is pro-

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posed. The capacitive feedback helps to reduce the number of inductors needed for input matching, when compared to the L-CSLNA. Moreover, higher gain and more degrees of design freedom are achieved with the use of the $\pi\text{-matching}$ network. The concept of utilizing capacitive feedback for input matching has been implemented by Chung and Shahroury. However, the LNA used has a non-cascode structure. In order to have high reverse isolation, it makes use of a multi-stage structure, which results in very high power consumption. The proposed LNA has a single stage cascode structure. The detailed analysis on input matching, gain and NF are presented. The LNA was implemented using the IBM 0.13 μm RF CMOS technology.

INDUCTIVE SOURCE-DEGENERATION COMMON-SOURCE LNA

The schematic of the L-CSLNA and its equivalent small signal circuit for input impedance analysis are shown in **Figure 1**. C_Y includes all parasitic capacitances at node Y and can be approximated as:

$$C_{Y} \approx C_{gs2} + C_{sb2} + C_{db1} \tag{1}$$

 R_{Y} is the total impedance looking into the source of M_{2} from node Y. In this circuit, R_{Y} can be approximated to be $1/g_{\rm m2}$ where $g_{\rm m2}$ is the transconductance of transistor $M_{2}.$ The L-CSLNA's input impedance is derived to be:

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$$\begin{split} Z_{\rm in_L} &= j \, \omega L_{\rm g} \, + \\ &\frac{1 \! + \! \left(g_{\rm m1} \! + \! j \, \omega C_{\rm gs1}\right) j \, \omega L_{\rm s}}{j \, \omega C_{\rm gs1} \! + \! j \, \omega C_{\rm gd1}} \frac{1 \! + \! \left(g_{\rm m1} \! + \! j \, \omega C_{\rm gs1}\right) j \, \omega L_{\rm s} + g_{\rm m1} Z_{\rm Y}}{1 \! + \! j \, \omega C_{\rm gd1} Z_{\rm Y}} \end{split} \tag{2}$$

where ω is the operating frequency, C_{gs1} and C_{gd1} are the parasitic gate-source and gate-drain capacitance and g_{m1} is the transconductance of transistor $M_1.$ When $C_{gd1} \rightarrow 0,$ $Z_{in\ L}$ can be simplified to:

$$Z_{\text{in_L}} \approx j \left(\omega L_g + \omega L_s - \frac{1}{\omega C_{gs1}} \right) + \frac{g_{m1} L_s}{C_{gs1}}$$
(3)

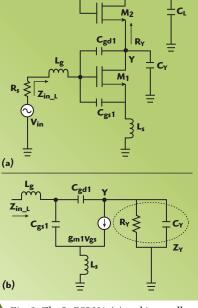
which is consistent with the classical result. At the resonant frequency, the input impedance, R_{in_L} , equals to $g_{m1}L_s/C_{gs1}$ and the transistor's transconductance, g_{m1} , is effectively boosted to $G_{\rm eff}$ $_Lg_{m1}$ where $G_{\rm eff}$ $_L$ is:

$$G_{\text{eff}_{L}} = \frac{1}{\omega_{0} C_{gs1} (g_{m1} L_{s} / C_{gs1})} = \frac{1}{\omega_{0} C_{gs1} R_{s}}$$
(4)

and ω_0 is the resonance frequency. The noise factor of this LNA at the input matching condition is:

$$F_{CS_{-L}} = 1 + \frac{R_{Lg}}{R_s} + \frac{R_g}{R_s} + \frac{\overline{\iota_{d1}^2}}{\overline{\nu_{in}^2}} \frac{1}{\left(g_{m1}G_{eff_{-L}}\right)^2} + \frac{\overline{\iota_{d2}^2}}{\overline{\nu_s^2}} \left(\frac{2\omega_0 C_Y}{g_{m1}g_{m2}G_{eff_{-L}}}\right)^2$$
(5)

In Equation 5, R_{Lg} is the parasitic series resistance of inductor L_g , R_g is the gate resistance of transistor $M_1, \overline{\iota_{d1}^2}$ and $\overline{\iota_{d2}^2}$ are the drain current noise of transistor M₁ and M_2 , respectively, and $\overline{\upsilon_{in}^2}$ is the input source voltage noise. A large g_{m1} and small C_{gs1} are desired to achieve high gain and low noise.4,5 Due to the input matching condition, the value of L_s is normally quite small. The requirement of small L_s some-



▲ Fig. 1 The L-CSLNA (a) and its small signal circuit (b).

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Multiplication Factors	4	6	12	12	12	18	36	54	81
Input Frequencies (GHz)	12.5-18.8	12.5 - 18.3	7.5 - 11.7	9.2 - 14.2	11.7 - 18.3	12.2 - 18.3	9.0 - 13.9	9.3 - 13.9	9.3 - 13.6
Alternate Multiplicat Factors	ion 2	3	6	8 or 4	6	9	24 or 12	36 or 18	54 or 27
Typical Output Powe (dBm)	r 20	14	9	8	4	-2	-10	-21	-25/-35
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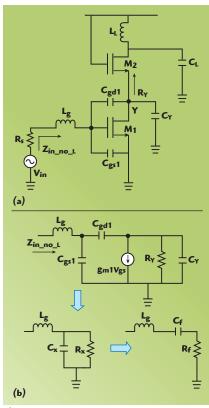


Fig. 2 The L-CSLNA (a) and its equivalent small signal (b).

times becomes a nuisance for the LNA design, because not all the inductor values are available in the Process Design Kit (PDK).

THE PROPOSED CAPACITIVE FEEDBACK CSLNA WITH II -MATCHING NETWORK

The LNA introduced Cheng⁷ uses the parasitic gatedrain capacitance of the input device and the output capacitance, ${
m C_L}$, to form the capacitive feedback matching Only network. one inductor

was used to realize the input matching. However, the analysis is only applicable for the non-cascode structure. For the CS topology, in order to have high reverse isolation and good stability, a cascode structure is preferred. Here, the analysis for the cascode structure is presented. Its schematic is shown in $\it Figure~2$. Based on the small signal circuit (b), the input network of the cascode capacitive feedback LNA can be converted to a series RLC matching network including of $L_g,\, C_f$ and $R_f.$ The value of C_f and R_f can be derived as:

$$C_{f} = C_{X} \left[1 + \left(\omega C_{X} R_{X} \right)^{2} \right] / \left(\omega C_{X} R_{X} \right)^{2}$$
 (6)

and

$$R_{f} = R_{X} / \left[1 + \left(\omega C_{X} R_{X} \right)^{2} \right]$$
 (7)

C_x and R_x can be calculated as follows:

$$C_{X} = C_{gs1} + C_{gd1} \frac{\left[\left(g_{m2} + g_{m1} \right) g_{m2} + \omega^{2} C_{Y} \left(C_{gd1} + C_{Y} \right) \right]}{g_{m2}^{2} + \omega^{2} \left(C_{gd1} + C_{Y} \right)^{2}}$$
(8)

$$R_{X} = \frac{g_{m2}^{2} + \omega^{2} \left(C_{gd1} + C_{Y}\right)^{2}}{\omega^{2} C_{gd1} \left[g_{m2} C_{gd1} + g_{m1} \left(C_{gd1} + C_{Y}\right)\right]}$$
(9)

To achieve the input matching, R_f is designed to be equal to R_s . The effective gain of this input matching network is:

$$G_{\text{eff_no_L}} = \sqrt{1 + \frac{1}{(\omega_0 C_f R_f)^2}} = \sqrt{1 + \frac{1}{(\omega_0 C_f R_s)^2}}$$
 (10)

The noise factor at the input matching condition of this LNA can be derived as:

$$F_{CS_{-no_{-}L}} = 1 + \frac{R_{Lg}}{R_s} + \frac{R_g}{R_s} + \frac{\overline{\iota_{d1}^2}}{\overline{\nu_{in}^2}} \frac{4}{\left(g_{m1}G_{eff_{-no_{-}L}}\right)^2} + \frac{\overline{\iota_{d2}^2}}{\overline{\nu_{in}^2}} \left(\frac{2\omega_0 C_Y}{g_{m1}g_{m2}G_{eff_{-no_{-}L}}}\right)^2$$
(11)

When compared to the L-CSLNA, the capacitive feedback LNA requires a lesser number of inductors for input matching. But this benefit comes with a trade-off of higher NF, which can be observed from Equations 5 and 11. As seen from Equations 4 and 10, the input network's effective gain of the two LNAs discussed above are limited by the 50 Ω matching condition. To achieve a good input matching, R_f and $(g_{m1}L_s/C_{gs1})$ must be matched to 50 Ω . This will restrict the selection of G_{eff_L} and $G_{eff_no_L}$, therefore limiting the achievable gains of these two LNAs. There exists a trade-off between high gain and good input matching in these two LNAs.

The proposed LNA adds a parallel capacitor, C_g , preceding the gate inductor as seen in **Figure 3** to create a π -matching network. It shows the small signal circuit for input impedance calculation of the proposed LNA (b). R_f and C_f are formed by the capacitive feedback mechanism as described above. Inductor L_g can be divided into two smaller parts: L_1 and L_f . These two inductors will resonate







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with C_{σ} and C_{f} , respectively. The input impedance at the resonance frequency is:

$$R_{\text{in}_{-}\pi} = \frac{1}{\omega_0^2 C_\sigma^2 R_f} = \frac{\omega_0^2 L_1^2}{R_f}$$
 (12)

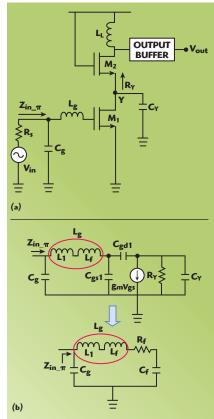
The effective gain of the proposed input matching network is:

$$G_{\text{eff}_{-\pi}} = \sqrt{\frac{1 + \left(\frac{1}{\omega_{0}C_{f}R_{f}}\right)^{2}}{1 + \left(\frac{\omega_{0}L_{1}}{R_{f}}\right)^{2}}} = \sqrt{\frac{1 + \left(\frac{1}{\omega_{0}C_{f}R_{f}}\right)^{2}}{1 + \frac{R_{s}}{R_{f}}}}$$
(13)

Equation 13 shows that the effective gain of the proposed LNA can be increased by reducing the value of R_f, unlike in the capacitive feedback LNA and the L-CSL-NA, where the effective gains are limited by the 50 Ω matching condition. When reducing R_f, the input impedance of the LNA can be matched to 50 Ω by decreasing L_1 according to Equation 12. Capacitor C_g and inductor L_1 add an additional degree of freedom to the LNA design. The effective gain is no longer limited by the input matching condition. Therefore, the proposed LNA will be able to achieve much higher gain when compared to the L-CSLNA and the capacitive feedback LNA. Figure $\boldsymbol{4}$ shows the S_{21} and S_{11} responses of the proposed LNA

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and the L-CSL-NA at the same power consumption level and output load condition. The LNAs designed to have the same input matching at the frequency of interest. The proposed LNA shows a much better gain performance. The gain of the LNA is 3 dB higher than that of the L-CSLNA. The bandwidth (BW) decreases as the effective of the matching network is increased. However, as shown, the BW of the LNA in this simulation quired standard.



is still sufficiently Fig. 3 The proposed LNA (a) and its large for the re- equivalent small signal circuit (b).

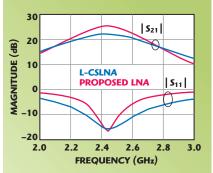
The noise factor of the proposed LNA is:

$$\begin{split} F_{CS_{-\pi}} &= 1 + \frac{R_{Lg}}{R_s} \frac{4 \left[1 + \left(\omega_0 L_1 / R_f \right)^2 \right]^2}{1 + 4 \left(\omega_0 L_1 / R_f \right)^2} + \\ \frac{R_g}{R_s} &+ \frac{\overline{t_{d1}}^2}{v_{\rm in}^2} \frac{4}{\left(g_{\rm mI} G_{\rm eff_{-\pi}} \right)^2} + \frac{\overline{t_{d2}}^2}{v_{\rm in}^2} \left(\frac{2 \omega_0 C_Y}{g_{\rm mI} g_{\rm m2} G_{\rm eff_{-\pi}}} \right)^2 \end{split} \tag{14}$$

Compared to Equation 11, the noise contribution of R_{Lg} has been increased due to the π -network. However, when the LNA is designed such that G_{eff_n} is higher than G_{eff_n} , the noise contribution from $\overline{\iota}_{\text{d}_1}^2$ can be reduced. Therefore it can compensate for the loss caused by R_{Lg} . Moreover, the noise contribution of the cascode stage is

also reduced when $G_{eff_{-\pi}}$ is increased. For a narrow band LNA at frequency f_0 , the design steps are summarized as follows:

- Employ the smallest channel length for the best transistor performance.
- 2.) To achieve high



 \blacktriangle Fig. 4 S_{21} and S_{11} responses of the progain and low noise, posed LNA and L-CSLNA.

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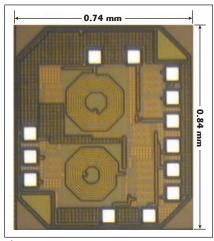


Fig. 5 Micrograph of the proposed LNA chip.

the value of R_f is designed to be as small as possible. However, the BW must be kept sufficient for required application as discussed. In addition, when R_f decreases, the required L₁ is reduced, but the required C_g increases. As the negative plate of C_g is connected directly to ground, its value should not be too

3.) Derive the value of $C_{\rm g}$ and $L_{\rm 1}$ from Equation 12.

4.) Determine the value of L_f according to the desired gain and the available chip area. The larger L_f is, the higher the gain gets. C_f resonates with L_f at f_0 .

5.) Given a specific drain current and the desired $R_{\rm f}$ and $C_{\rm f}$ value, design the transistor size and biasing according to Equations 6-9.

To verify the theory, an LNA was designed and fabricated using the IBM 0.13 µm RF CMOS technology.

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Its schematic is shown in Figure 3(a). All inductors are on chip. Inductor L_L will resonate with the total capacitance at the drain node of transistor M₂ at the frequency of interest. Inductors L_g and capacitor C_g° are designed to satisfy the matchcondition. The second stage of this LNA is an output buffer. The output buffer was designed to match the output port to the 50Ω load of the measuring equipment. The loading effect of the buffer is about the same as the mixer loading effect on the LNA stage.

Simulated gain of the proposed LNA Measured gain of the proposed LNA Measured gain of the L-CSLNA Simulated S₁₁ of the proposed LNA Measured | S₁₁ | of the proposed LNA of the proposed LNA Measured | S₂₂ | of the proposed LNA 30 25 20 (gp) 15 MAGNITUDE (-15 -20 2.0 2.6 FREQUENCY (GHz)

Fig. 6 Simulated and measured voltage gain, S_{11} and S_{22} .

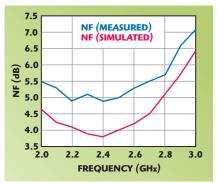


Fig. 7 Simulated and measured NF of the A micrograph proposed LNA.

MEASUREMENT RESULTS

of the LNA's chip is shown in *Figure 5*. The total area including the output buffer and pads is 0.74×0.84 mm. Figure 6 shows the voltage gains, S₁₁ and S₂₂, of the proposed LNA. An L-CSLNA, with the same power consumption level and output load condition than the proposed LNA, was also fabricated. The LNA's voltage gain at 2.4 GHz is 21.5 dB, while the L-CSLNA's voltage gain is 18.8 dB. The measured gain of the LNA is 2.7 dB higher than that of the L-CSLNA. The proposed LNA has good input and output matching. The S_{11} value is -12 dB and the S_{22} value is -16 dB at 2.4 GHz. The corresponding NF is 4.9 dB as shown in *Figure* **7**. The measured NF exceeded the simulated NF by 1 dB. This large difference is attributed to the poor noise modeling and process variation. An IEEE.802.15.4 receiver can tolerate a noise factor of the LNA and the mixer of 11.2 or 10.5 dB.¹ This requires a mixer of NF less than 19.8 dB if our LNA is used in the receiver front end. Such a relaxed NF requirement is not difficult to achieve in present CMOS mixer designs. The IIP3 of the LNA is -12 dBm. The core LNA draws 0.6 mA from a 1 V voltage supply. The total power consumption is only 0.6 mW.

The comparisons of this LNA with results published in the literature are summarized in *Table 1*. A few LNAs¹¹⁻¹⁴ have better NF but consume much more power than the proposed one. Moreover, such low NF is not necessary for the application,¹ and the performance is quite comparable with the proposed one. However, this LNA

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TABLE I PERFORMANCE COMPARISONS FOM2 Gain (dB) IIP3 FOM1 NF (dB) S₁₁ (dB) Vdd (V) Topology (mW) Capacitive feedback 0.18 12.8 10 13.2 4 57 -11 -1 1 4.97 3 97 **CSLNA** [8] 0.13 3.0 0.4 9.1 4.7 -17 -11 0.6 10.4 -0.6 Sub-threshold L-CSLNA L-CSLNA with current-[9] 0.18 5.0 0.9 9.2 4.5 -12 -15 0.6 9.45 -5.5 reuse L-CSLNA with forward [10] 0.13 5.1 1.03 10.3 5.3 -17.7 0.4 8.32 n/a n/a body biasing [1] 0.18 1.13 214 52 -19 -11 1.8 10.33 -0.67Sub-threshold CSLNA [11] 0.18 8 12.5 2.72 -19 -5 1.5 1.62 -3.37 L-CSLNA Parallel LC input [12] 0.18 15 24 to 25 2.62 to 2.8 -14 n/a 1.5 4.97 n/a matching CSLNA [13]° 0.18 12.2 14.6 3.7 -24.1 2.6 1.8 -1.05 1.43 L-CSLNA 2.4 [14] 0.18 11.7 10.1 2.9 -10.1 4 1.8 -1.61 2.34 L-CSLNA CGLNA with series input [15] 0.18 0.98 1 -11 15.5 5.2 -11 -19 8.0 resonance This 0.13 0.6 21.5 4.9 -12 -12 1 13.57 1.57 Proposed work

*pre-layout simulation results

$$**FOM1 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} \right) \\ ***FOM2 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM2 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM2 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mag)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mw)}}{(F-1)_{mag} P_{DC(mw)}} IIP3_{(mw)} \right) \\ ***FOM3 = 10 log_{10} \left(\frac{Freq_{(GHz)} Gain_{(mw)}}{(F-1)_{mag} Freq_{(mw)}} IIP3_{(mw)} \right) \\ **FOM3 = 10 log_{10} \left(\frac{Freq_{(mw)} Gain_{(mw)}}{(F-1)_{mw}}$$



used a large resistive load to achieve high gain. Therefore, it cannot operate at a low supply voltage such as 1 V. Some of the LNAs^{13,14} show a trade-off between gain and linearity. Their IIP3 is higher, but the power consumption is much higher and the gain is much lower than the proposed LNA. Based on the FOMs calculated in Table 1, this LNA has the best FOM1 and an acceptable FOM2.

CONCLUSION

A new input matching topology, without gain trade-off for the CSLNA, was presented. The input network is realized using a capacitive feedback and a π -network. Based on this method, the CSLNA is able to achieve higher gain, while maintaining good input matching and low power consumption. The design method was explained and the LNA was designed and fabricated. The need of source inductor L_s is eliminated and higher gain was achieved when compared to the L-CSLNA. The proposed LNA consumes only 0.6 mW, while providing very high gain, good input matching and moderate NF. ■

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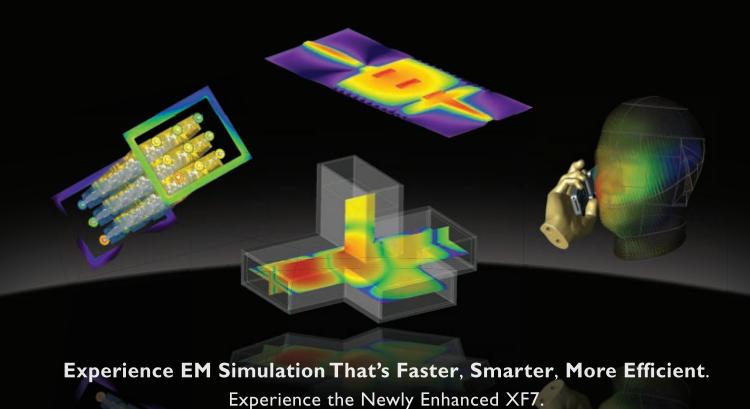
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he power handling capability for microwave filters has always been an important issue, and with the introduction of new spectrum efficient wireless systems, with large crest factors and stringent filtering demands, the ability to accurately predict the power handling capacity of a filter is as relevant as ever. When breakdown occurs in a filter, the surface is damaged and the interior gets contaminated with impurities, which often has the effect of decreasing the power handling capability of the filter as well as increasing the losses. Breakdown is therefore most often a destructive event, which leads to replacement of the filter.

Some simple waveguide filters may be analyzed for power handling using simple mathematical expressions, but generally this is not the case and 3D EM simulators therefore often have to be used for that purpose. For example, in order to power analyze a coaxial cavity filter with a 3D simulator, all couplings and tuning screw positions have to be optimized until the right filter characteristic is achieved. If the filter has more than just a few resonators, the task of obtaining a 'nice' filter characteristic will most often be an extremely time consuming matter – if possible at all.

In this article, a detailed step by step approach is presented for accurate power handling analysis of microwave filters – based on 3D EM analysis (HFSS in this case) on a single cavity plus knowledge about the filter obtained through circuit analysis (CMS). This approach leads to accurate results, even for complex filters, using a fraction of the time needed for a full 3D simulation on the actual filter itself. The analysis follows the methods outlined by other authors. ^{1,2}

PROCEDURE FOR THE ANALYSIS

When a filter is designed and analyzed for power handling, the procedure can be broken down in the following eight steps:

- Synthesis of filter characteristic and coupling matrix based on simple lumped circuit models or equivalent.
- **2** Calculation of stored energies based on simple model.

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- The scale factor is applied via the "Edit Sources" functionality in HFSS and a Field Plot is generated. The peak E-field value is noted.
- The relation between stored energy and E-field is now established for the cavity in question. This relation is used together with the stored energy previously calculated for each resonator in the filter (step 2) to get the maximum E-field strength, which can occur in the filter.
- **3** This E-field value is compared to the breakdown threshold for air in order to validate the power handling capability of the filter.

All the above points will be dealt with, in detail, in the following.

POWER HANDLING ANALYSIS

To demonstrate the different steps outlined above, a coaxial cavity filter, for which a design already exists,³ will be used. A HFSS model of the filter is shown in *Figure 1*.

Example Filter (Steps 1 & 2)

The filter has been synthesized using the Filter and Coupling Matrix Synthesis tool (CMS) from Guided Wave Technology.⁴ This tool uses coupling matrix synthesis techniques,^{5,6} for deriving a suitable topology and corresponding coupling matrix. The transformation of the coupling matrix into a physical filter may follow different paths, some of which have been described,^{3,7} but here, this subject will not be dealt with further.

The main parameters of the example filter are:

- Center frequency: 1915 MHz
- Ripple bandwidth: 20 MHz
- Return loss: 18 dB
- Transmission zero 1: 1932 MHz (x-coupling between resonator 3 & 5)
- Transmission zero 2: 1942 MHz (x-coupling between resonator 1 & 3)
 The CMS synthesized filter char-

acteristic and resulting coupling matrix are shown in Figure 2. The filter has been designed using the technique outlined by one of the authors.³ Therefore, all main- and x-coupling apertures have dimensions, which implement the coupling matrix also shown. The filter characteristics obtained through CMS are equivalent to the results one would get with a circuit simulator on lumped element models. The results are therefore most accurate for narrow band filters with relative bandwidths less than 10 percent.

Since the topic of this article is to investigate how accurate power handling can be predicted through simple analysis, the CMS model has been adjusted slightly to fit with the HFSS model. It is seen from *Figure 3* that

it is possible to get an almost 100 percent match between the two models.

In order to calculate the power handling of the final filter, one needs to know the stored energy level of each individual resonator. In CMS, this information is available in the QL (Loaded Q) pane, whose content is shown in *Figure 4*. It is seen here that the highest stored energy level (72)

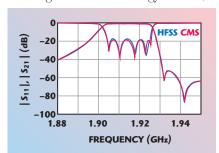
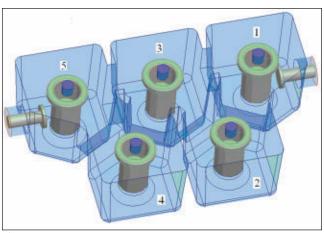


Fig. 3 CMS and HFSS characteristics.



▲ Fig. 1 HFSS model of filter to be analyzed for power handling capability.

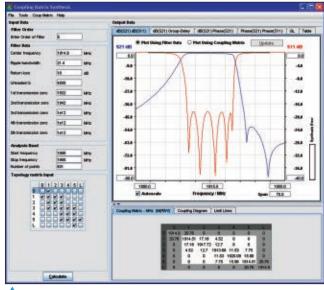


Fig. 2 CMS synthesized filter characteristics.

nJ/W) is found at resonator 2, just outside the passband (1926.2 MHz). At other frequencies, the situation may be very different as seen from the figure. Across the passband, resonators 2, 3 and 4 have, in turn, the highest stored energy levels. Loaded Q is an equivalent way of describing the same as stored energy.

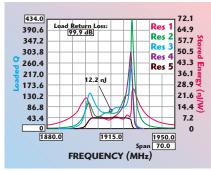


Fig. 4 Stored energy levels for each resonator in the example filter.



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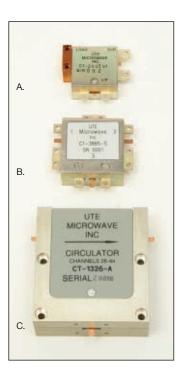
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The power handling capability of the filter will be analyzed at the center frequency (1915 MHz). The highest stored energy level at this frequency, 12.2 nJ/W, is found in resonator 3. It will be assumed for a start that a perfect match exists between the filter and the load (for example an antenna). This is obtained by entering a high dB value in the return loss field in the plot. In reality, a perfect match is not possible and a more realistic val-

ue would be 15 to 20 dB, but this will be dealt with later. In the following, a perfect match is assumed. Steps 1 and 2 of the procedure outlined previously have now been completed.

Single Cavity HFSS Simulation (Step 3)

In order to find the relationship between stored energy and peak E-field in the filter, a simple HFSS model of a single resonator is made. The model should contain all relevant details of the resonator – especially near the top where the E-field is strongest. The model is shown in *Figure 5*.

The single resonator model has the same height and layout as the resonators in the example filter. The cavity is a simple square cavity with a base area tuned to give an overall resonance frequency close to $f_{\rm c}$ (1915 MHz – this is done fast in a few trials with the Eigen mode solver). The height of the cavity is identical to the example filter cavity height.

Calculating Stored Energy (Step 4)

A HFSS Eigen mode simulation is now performed on this resonator. Since the highest field strength is restricted to a small area around the edge of the tuning screw, it is important that the mesh is fine enough for accurate results. To ensure accuracy, the calculated stored energy can be

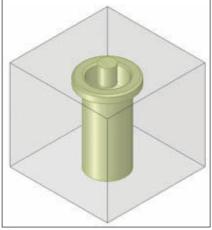


Fig. 5 Single resonator HFSS model.

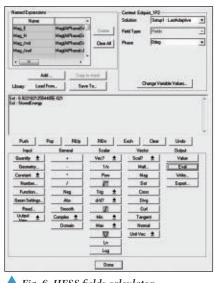


Fig. 6 HFSS fields calculator.



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used as convergence criteria in the adaptive mesh refinement.

When the simulation is done, post processing must be performed, using the Fields Calculator in HFSS to find the stored energy. Ansoft has made a collection of recipes,⁸ in which one can find instructions about how to calculate the peak electrical energy in a volume. In *Appendix A*, the script necessary for calculating the stored energy is listed. These few lines may

be written and stored in a text file of type ".clc" and loaded into the field calculator. The "clc" file may also be downloaded from www.gwtsoft.com/Misc/StoredEnergy.zip.

When the fields calculator is started (in HFSS project 'tree': Right click on 'Field Overlays' and chose 'Calculator') the window shown in *Figure 6* appears. Use the 'Load From' button to load the 'StoredEnergy.cle' script into the calculator – or write your own

script using the built-in calculator functions.

Important: If you use the downloaded StoredEnergy scrip, it is important to note that this script assumes that the model consists of one single vacuum object with the name: Cavity. The resonator and tuning screw have been subtracted from the square cavity. The name of this vacuum object must match the name used in the script (that is 'Cavity'). When the StoredEnergy script is successfully loaded into the calculator, it must be selected and made active by using the "Copy to stack" button. The stored energy can now be calculated by selecting the "Eval" button. In the present case one gets: WHFSS = 6.922E-21 J.

Normalization (Steps 5 & 6)

The next step is to use the just found stored energy to adjust the source excitation so that the stored energy in the cavity becomes 1 nJ. The reason for this is that the CMS generated stored energies use 1 nJ as reference (See Figure 4).

The following normalization/scaling constant is defined:

norm = sqrt(1 nJ/WHFSS) (1)

WHFSS is the stored energy just found by the fields calculator in HFSS.

gets: norm sgrt(1E-9/6.92E-21) = 380080. This voltage is inserted in the Magnitude field in the 'Edit Sources' menu (in HFSS project 'tree': Right click on 'Field Overlays' and choose 'Edit Sources') as shown in **Figure 7**. When the normalization is done, it can be verified that it has been done correctly by using the fields calculator again to find the stored energy, which should now give 1 nJ. With the excitation voltage properly scaled it is now time to plot the Efields in the cavity. This is shown in Figure 8. The E-field strengths in



Fig. 7 Insertion of normalized excitation in "Edit Sources" menu.





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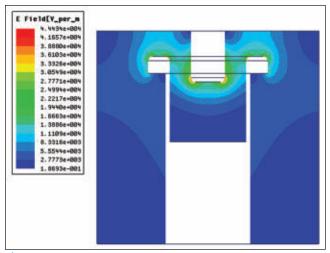
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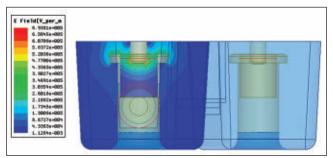
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▲ Fig. 8 E-field plot in the cavity corresponding to a stored energy level of 1 nJ.



▲ Fig. 9 E-field strength in a plane through resonators for 20 W input power.

the cavity can be read from the legend scale to the left in the figure.

Hint: Use the 'ComplexMag_E' function when plotting the E-field. This function displays the E-field at its maximum. A maximum E-field of 4.44E4 V/m is read. This value is obtained at the lower edge of the tuning screw. This E-field is what results from 1 nJ stored energy in this cavity.

 $E_{\text{norm,max}} = 4.44E4 \text{ V/m/V}(\text{nJ})$

All information necessary for calculating the power handling capability of the final filter is now available.

Hint: In Figure 8, the E-field has been plotted in a plane through the center of the resonator. This is a better approach than plotting the E-field in the whole cavity volume. Numerical 'fluctuations' may locally (that is in a single mesh cell) give E-field strengths above the 'true' max level. By mapping E-field in planes instead of volumes, the probability of hitting such a cell is very low. To validate the result, one can rotate the plane 90° to see that approximately the same max E-field is obtained.

Power Handling Capability of Example Filter (Steps 7 & 8)

With the maximum normalized E-field in a single cavity now determined, the simple equation below (Eq. 2) is used to find the actual maximum E-fields in resonator 'i' of the example filter¹:

$$E_{max,i} = E_{norm,max} \, sqrt(P*WCMS,i)$$
 (2)

 $\boldsymbol{E}_{\text{max},i}$ is the maximum E-field strength at the i^{th} resonator.

 $E_{\text{norm},\text{max}}$ is the maximum normalized E-field found by a single cavity HFSS simulation.

P is the input power to the filter in Watt.

WCMS,i is the stored energy of the ith resonator found from the CMS model.

Please note that there is a typing error in the expression given in Ref. 1, which has been corrected in Equation 2.

From the CMS stored-energy simulation in Figure 4, it was found that the maximum stored energy at 1915 MHz was in resonator 3.

 $WCMS_{2} = 12.2 \text{ nJ/W}$

It was also previously found that

 $E_{\text{norm,max}} = 4.44E4 \text{ V/m}$

Assuming an input power P = 20 W, one then gets

 $E_{max} = 4.44E4 \ sqrt(20*12.2) = 0.69 \ MV/m$ which is the maximum E-field strength in the filter at 1915 MHz for 20 W input.

As a rule of thumb, the breakdown field-strength at 1 atmosphere for microwave signals is 2.3 MV/m.¹

For 20 W input to the filter, a comfortable margin exists to the breakdown limit in resonator 3 at 1915 MHz. Normally it is good practice to have a factor two safety margin to the breakdown limit. Rewriting Eq. 2 gives:

$$P = (E_{\text{max},i} / E_{\text{norm,max}})2 / WCMS,i$$
 (3)

If $E_{max,i}$ is replaced in Equation 3 by the breakdown field strength at normal pressure (2.3 MV/m), the following expression for the breakdown input power appears:

$$PBD = (2.3E6 / E_{norm,max})2 / WCMS,i$$
 (4)

If the above used values for $\mathbf{E}_{\text{norm},\text{max}}$ and WCMS,i $% \mathbf{E}_{\text{norm},\text{max}}$ are inserted one gets:

PBD = (2.3E6/4.44E4)2/12.2 = 220W

which is the threshold input power for breakdown in this filter at $1915~\mathrm{MHz}$

At other frequencies, the situation may be quite different. At a little above the passband (1926.2 MHz), it is seen that resonator 2 is the limiting resonator with a stored energy level equal to 72.1 nJ/W. The breakdown power is PBD = (2.3E6/4.44E4)2/72.1 = 37 W, which is six times lower power-handling capacity compared to the center frequency.

Comparison with a Full HFSS Filter Simulation

To validate the above results, a breakdown analysis has been conducted on the complete filter whose filter characteristic has been optimized in HFSS to give the result shown in Figure 3. From Figure 4, it is known that at the center frequency the highest stored energy for the complete filter is found in resonator 3. The field strengths are therefore plotted in a plane through the center of this resonator, as shown in Figure 9, with the power at the input port set at 20 W. It is seen that the field analysis of the complete filter gives a max E field equal to 0.69 MV/m. From the simple analysis conducted previously, the max E field was found to be 0.69 MV/m. Identical results have therefore been obtained - but with the simple method, the time and computer resources used for the job, have been at least an order of magnitude lower compared to the HFSS treatment of the full problem.



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OTHER FACTORS WITH INFLUENCE ON POWER HANDLING

Load Mismatch

It was mentioned in the example filter section that the load return loss has also an influence on the power handling capacity of a filter. If power is reflected at the load, this leads to standing waves in the filter, which may severely decrease the power capacity of the filter. If the reflection coefficient at the load is p, the worst case level of stored energy in the filter increases by a factor $(1+\rho)^2$.

In $\dot{\text{CMS}}$, it is possible to enter the actual load reflection coefficient when calculating stored energies in a filter (see Figure 4). In the previous sections, it was assumed that a perfect match existed between filter and load. If instead a 15 dB return loss is assumed, the breakdown power will

decrease from 220 W to 149 W at the center frequency. Compared to a reflection free connection - the 15 dB load return loss will, in the worst case, reduce the power handling capability of the filter by a third. Whether or not a worst case situation appears is dependent on the actual phase condition of the connection between filter and load. Often this connection is difficult to control and one should therefore assure that the filter is capable of handling the worst case situation.

Pressure, Temperature and Moisture

Low pressure, high temperature and humidity will also decrease the power handling capacity of a filter. Of these, especially pressure and temperature may give rise to problems under certain conditions. Here, these issues will not be dealt with, but it shall only be mentioned that pressure must be considered for equipment intended for high altitudes, aeronautical applications or space: The power handling capability may well be reduced by a factor of 100 when subjected to the low pressure environment at for example 10 km altitude. An overview of these factors can be found in the literature.9

CONCLUSION

In this article, a step-by-step approach has been described, which allows filter engineers to make accurate power handling analysis of microwave filters with minimum use of computer resources and time. To demonstrate the method, a circuit model has been combined with 3D electromagnetic simulations on a single resonator, whereby the power handling capacity has been determined for a five pole coaxial cavity filter with two cross couplings. The method determines the peak electrical field strength in the filter – and the breakdown power.

To verify the results, full 3D simulations on the complete filter have also been carried out. It has here been demonstrated that the simple method gives near identical results to full 3D simulations - but with a time consumption which may well be an order of magnitude lower than 3D simulations on the complete filter.

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APPENDIX A STORED-ENERGY SCRIPT FOR HFSS FIELDS CALCULATOR

\$begin 'Named_Expression'

Name('StoredEnergy')

Expression('Integrate(Volume(Cavity),*(*(Real(Dot(Conj(<Ex,Ey,Ez>),< Ex,Ey,Ez>)), 8.854187817E-012), 0.5))')

Fundamental_Quantity('E')

Operation('Conj')

Fundamental_Quantity('E')

Operation('Dot')

Operation('Real')

Scalar_Constant(8.85419e-012)

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Ultra-Wideband Nonlinear Modeling of W-Band Schottky Diodes

An ultra-wideband (DC to 125 GHz) nonlinear model for a W-Band Schottky diode is presented in this article. The model is validated against multiple measurement datasets, including IV and S-parameters at different bias and temperature conditions. Its large signal performance is studied against large signal harmonic power measurements to illustrate its capability to accurately predict the device's nonlinearities, such as harmonic levels.

Schottky diodes are widely used as detectors or mixers in transceiver modules due to the low forward voltage drop and very fast switching speed. This is the result of the device structure – a metal layer deposited on semiconductor material such as GaAs and SiC, forming the "Schottky barrier." In this work, an advanced ultra-wideband nonlinear diode model that covers the DC to 125 GHz frequency range for a W-Band Schott-

ky single anode diode from Virginia Diodes Inc. is described. Although there have been models of sub-mm wave and THz Schottky diodes in the literature in the past, this is the first known model that is based on and validated against such broadband data and implemented in multiple commercial simulation platforms.

To develop and fit appropriate package parasitic and nonlinear modeling elements, custom fixturing was developed. The fixturing used 10 mil quartz coplanar-waveguide lines, along with custom calibration standards that enabled reliable ultra-broadband bias dependent data for the Schottky to be obtained. *Figure 1* shows the top view of the diode as well as the

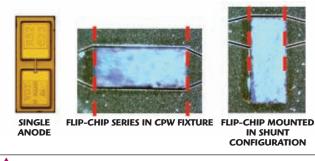


Fig. 1 A single anode Schottky diode along with two test fixtures setups.

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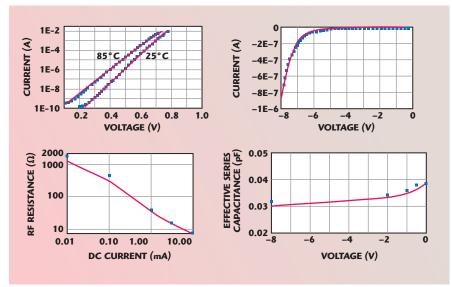
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series and shunt "flip-chip" configurations used. The red lines illustrate the reference planes of the measurement. Measurement-related specifics of this work are described elsewhere.³ The model was developed based on series measurement datasets, including DC I-V, C-V, R-I and S-parameter

measurements over temperature (25° and 85°C). Anritsu's Vector Star ME7838A mm-wave VNA was used to obtain the broadband S-parameters, ranging between 70 KHz and 125 GHz. While the internal details of the model are proprietary, encoded models fully compatible with popu-



▲ Fig. 2 DC I-V, R-I and C-V measurements (markers) and simulations (solid lines).



lar microwave circuit simulators are now commercially available for both a single-anode and a zero-bias detector diode. A review of example model performance for the single-anode W-Band Schottky diode is outlined briefly in the following sections.

STUDY OF MODEL PERFORMANCE

Figure 2 shows the measured DC I-V, R-I and C-V data, compared with the model. As can be seen, the model predicts all these measurements well and shows good temperature scalability. The R-I curve shows that the junction resistance decreases exponentially as the diode becomes more conductive. Cj increases gradually with the decrement in the reversed bias voltage (up to 0 V). The RF resistance and effective capacitance versus bias data, for model extraction, was obtained from the measured S-parameters. An accurate low frequency core model was achieved by fitting to the R-I and C-V data at 1 GHz. As illustrated, the developed model captures the nonlinearities in Rj and Cj very well. This sets the stage for a robust broadband model after carefully applying a high frequency parasitic treatment.

Figure 3 shows the S-parameters comparison between the measurements and simulated results at multiple bias conditions. The transition in the diode conduction can be seen in the magnitude in S_{21} . The model accurately predicts the S-parameters (magnitude and phase) from DC up to 125 GHz. The resonance in the S_{11} around 100 GHz for 0.1 mA bias condition is correctly captured, a result of careful package/parasitic effect modeling.

Large signal power sweep measurements were taken on the Schottky diode at 10 GHz. The model is simulated to compare to the nonlinear datasets. Figure 4 shows the gain compression (that is S_{21}) comparison for the series case at different bias conditions in the two setups (red = 0 V, blue = 0.1 mA, pink = 10 mA). As expected, in series configuration, when the diode conducts (1 mA), the insertion loss (S_{21}) is low, meaning the power going to the output load; whereas for shunt configuration, most of the signal power goes through the diode to ground, leading to higher loss in S_{21} .



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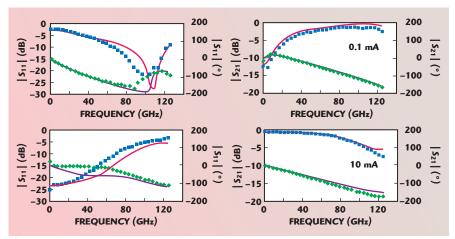
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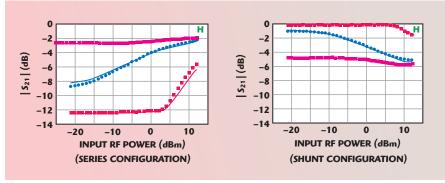


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▲ Fig. 3 Multi-bias broadband S-parameters comparison between measurements (markers) and simulations (solid lines).



▲ Fig. 4 S₂₁ comparison between measurements (markers) and simulation (solid lines).

The model predicts the trend of the S_{21} versus input power very well for all conditions. Harmonic power data comparisons, not included here due to space limitations, also show excellent agreement.

CONCLUSION

An ultra-wideband nonlinear diode model, for a W-Band Schottky diode, has been developed, that demonstrates excellent performance in predicting both the small signal and large signal behavior of the diode under test. The excellent large signal performance that the model illustrates is the result of careful treatment of the IV. R-I and C-V nonlinearities of the diode. A separate model was developed for a W-Band zero-bias detector (ZBD) diode, for which comparable performance was achieved in accurately predicting the measurement results of the actual device. This study results from a practical modeling approach, based on measurements and the equivalent circuit model for W-Band Schottky diodes. ■

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- 1. See the single anode datasheet at http://vdi.bz/diodes.
- B.L. Gelmont, D.L. Woolard, J.L. Hesler and T.W. Crowe, "A Degenerately-doped GaAs Schottky Diode Model Applicable for Terahertz Frequency Regime Operation," *IEEE Transactions on Electron Devices*, Vol. 45, No. 12, December 1998, pp. 2521-2527.
- 3. H. Morales, S. Skidmore and L. Dunleavy, "Ultra-Broadband Characterization of Schottky Diodes," appeared in the June 2012 Automatic RF Techniques Group Conference Digest.
- Model downloads can be requested at www.modelithics.com/mvp/VDI/.

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Compact UWB Antennas with Dual Band-Notched Characteristics

A novel dual band-notched ultra-wideband (UWB) printed monopole antenna with simple structure and small size is presented. The antenna, with the size of $25 \times 25 \times 0.8$ mm, provides an impedance bandwidth (VSWR < 2) of 38.4 GHz (2.7 to 41.1 GHz), except the bandwidth of 3.2 to 3.9 GHz for WiMAX applications and 4.8 to 5.9 GHz for WLAN applications, while that of the modified structure of the antenna is from 2.7 to 36.8 GHz, except the bandwidth of 3.2 to 3.9 GHz for WiMAX applications and 5.14 to 5.94 GHz for WLAN applications. The bandwidths of the antennas are approximately 512 and 455 percent broader than for conventional band-notched UWB antennas. For validation purposes, two antenna prototypes were fabricated and tested. The simulated and measured results show relatively good agreement and confirm good impedance matching, stable gain and near omnidirectional radiation patterns.

There has been more and more attention given to UWB antennas ever since the Federal Communications Commission's (FCC) allocation of the frequency band 3.1 to 10.6 GHz for commercial use. However, there are some other existing narrowband services that already occupy frequencies in the UWB band, such as wireless local-area network (WLAN) operating in the 5.15 to 5.875 GHz band and World Interoperability for microwave access (WiMAX) service from 3.3 to 3.6 GHz. The use of filters increases the complexity and cost. It is desirable to design the UWB antenna with dual band notches. The printed planar monopole antenna is a good candidate for a band-notched UWB system because of its low cost, low profile, light weight, omni-directional radiation patterns and easy realization and convenience for integrating with microwave monolithic integrated circuit (MMIC) technologies. Various kinds of printed monopole antennas with notched band have been reported in the literature. Some band-notched UWB antennas are not able to satisfy the compact property, 2-5 some antennas have high profile, 5-7 other antennas have only single band-notches. 4-8 The challenge is to realize a feasible dual-notched UWB antenna design, containing proper notched bandwidths as well as the above advantages which belong to printed planar monopole antennas.

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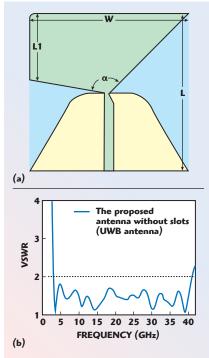
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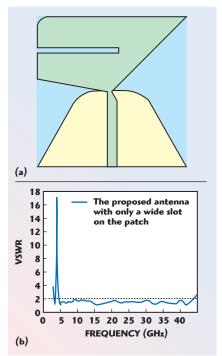


▲ Fig. 1 Geometry (a) and simulated VSWR results (b) of the proposed UWB antenna without slots.

Based on previously reported research, a simple and compact ultrawideband printed monopole antenna with dual band-notched characteristics is proposed in this article. By cutting a wide slot on the patch and a narrow slot on the ground plane, dual frequency band notches can be obtained. The desired notched band frequencies can be easily achieved by adjusting the total lengths of the slots. Moreover, by changing the widths and locations of the slots, the notched bandwidths can be efficiently controlled. The bandwidth of the proposed antenna is from 2.7 to 41.1 GHz, except the bandwidth of 3.2 to 3.9 GHz for WiMAX applications and 4.8 to 5.9 GHz for WLAN applications. The size of this antenna is only $25 \times 25 \times 0.8$ mm. The modified structure of the antenna is also discussed in this article.

THE PROPOSED ANTENNA STRUCTURE AND DESIGN UWB Antenna Design

Figure 1 shows the geometry and configuration of the proposed antenna without slots, which is a UWB antenna fed by a 50 Ω microstrip feed line. The length L (25 mm) and the width W (25 mm) are the dimensions of the dielectric substrate. L1 is the length of the patch, which is 10.4 mm. The most im-



▲ Fig. 2 Geometry (a) and simulated VSWR results (b) for the proposed antenna with only a wide slot.

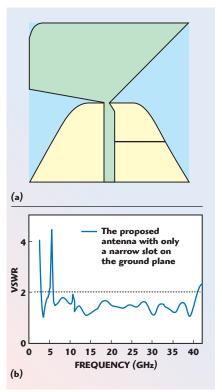
portant parameter affecting the performance of the proposed antenna is the apex angle α , which is given by:

$$\alpha = \frac{3}{4}\pi - \arctan\left(\frac{L - 2L1}{W}\right) \tag{1}$$

The tapered microstrip line at the connection between the feed line and the patch is used for broadband matching of the antenna to the 50 Ω microstrip line. The width and length of the 50 Ω microstrip line are 1.5 and 10.9 mm, respectively. The arcs at the edges of the patch and the ground plane are used for reducing the radiation loss and the difficulties of fabrication. The proposed antenna is printed on a FR4 substrate with a thickness of 0.8 mm, a relative permittivity of 4.4 and a loss tangent tan δ = 0.02. The simulated VSWR results of the proposed UWB antenna show that the impedance bandwidth (VSWR < 2) is from 2.9 to 41 GHz.

Single Band-Notched UWB Antenna Design

To reduce the interference from WiMAX or WLAN applications, the band-notched function is desirable in the UWB system. *Figures 2*, 3 and 4 show the geometry and configuration of the proposed antennas, with a filtering property operating in the 3.2 to 3.9 GHz, 5.2 to 5.9 GHz and 5.14 to



▲ Fig. 3 Geometry (a) and simulated VSWR results (b) of the proposed antenna with only a narrow slot in the ground plane.

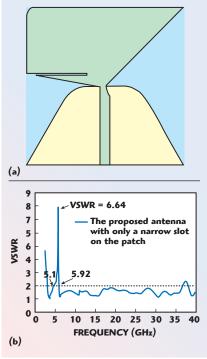


Fig. 4 Geometry (a) and simulated VSWR results (b) of the proposed antenna with only a narrow slot on the patch.

5.94 GHz bands, respectively.

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antenna, a frequency band notch is created. Note that when the band-notched design is applied to the UWB antenna, there is no retuning work required for the previously determined dimensions. Generally speaking, the design concept of the notch function is to adjust the total length of the straight slot in accordance with Equation 2. The wide slot etched in the patch shown in Figure 2, whose length and width are 13.8 and 0.8 mm respectively, is used to

obtain the desired notched band from 3.2 to 3.9 GHz so that the proposed antenna cannot interfere with WiMAX applications. The narrow slot etched in the ground plane, shown in Figure 3, whose length and width are 8.4 and 0.2 mm, respectively, is used to obtain the desired notched band from 5.2 to 5.9 GHz and the narrow slot etched in the patch shown in Figure 4, whose length and width are 9.6 and 0.25 mm, respectively, is used to obtain the desired

notched band from 5.14 to 5.94 GHz, so that the proposed antenna cannot interfere with WLAN applications. Note that the bandwidth is smaller when

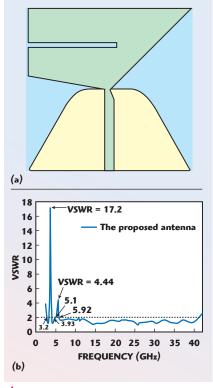
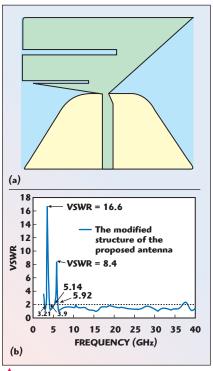


Fig. 5 Geometry (a) and simulated VSWR results (b) of the proposed antenna.



▲ Fig. 6 Geometry (a) and simulated VSWR results (b) of the modified structure of the proposed antenna.



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adding a narrow slot on the patch; the reason is that the narrow slot and the wide slot are so close that they interfere with each other. The notched frequency, given the dimensions of the bandnotched feature, can be postulated as:

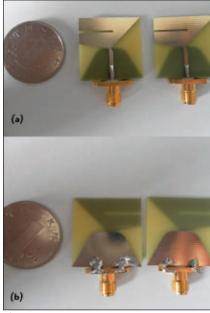
$$f_{\text{notch}} = \frac{c}{4L\sqrt{(\epsilon_r + 1)/2}}$$
 (2)

Dual Band-Notched Antenna Design

To further the study of bandnotched antennas and to reduce the interference from the existing bands, a dual band-notched function is desirable in a UWB system. Figures 5 and 6 show the geometry and configuration of the proposed dual bandnotched antenna and the modified structure of the proposed antenna, respectively. From the VSWR results, it can be seen that the bandwidth of the UWB system is hardly affected by the slots and the bandwidth of the low frequency band-notched antenna formed by only a wide slot and the bandwidth of the high frequency band-notched antenna formed by only a narrow slot do not interfere with each other.

RESULTS AND ANALYSIS

The dual band-notched UWB antenna was simulated and optimized using CST software. Shown in *Figure 7* are prototypes of the



▲ Fig. 7 Photographs of the proposed and modified structure of the proposed antennas: front side (a) and back side (b).

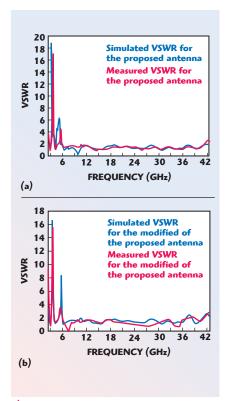
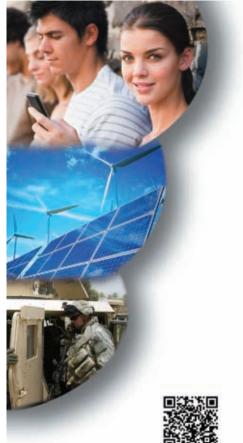


Fig. 8 Simulated and measured VSWR results of the proposed antenna (a) and the modified structure of the proposed antenna (b).



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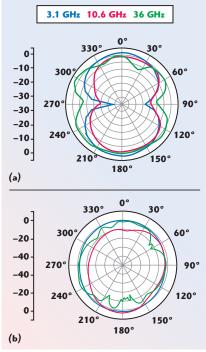
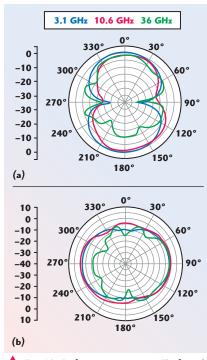


Fig. 9 Radiation patterns on E-plane (a) and H-plane (b) for the proposed antenna.



▲ Fig. 10 Radiation patterns on E-plane (a) and H-plane (b) for the modified structure of the proposed antenna.

antenna and the modified structure of the proposed antenna. As shown in Figure 8, the simulated measured results show relatively good agreement. The measurement shows that WiMAX the band (3.2 to 3.9 GHz), the VSWR is greater than 2 and the center frequency of the notched band is approximately 3.55 GHz, while the WLAN band (4.8 to 5.9 GHz), the VSWR is greater than 2 and the center frequency is approximately 5.35 GHz and in the 5.14 to 5.94 GHz band, the VSWR is greater than 2 and the center frequency is approximately 5.54 GHz for WLAN applications. The simulated radiation patterns at 3.1, 10.6 and 36 GHz are shown in Figures 9 and 10. The antennas give a nearly omnidirectional diation pattern in the H-plane. The antennas' simulated gains in the entire operating band are shown in **Figure 11**. As desired, two sharp decrease, gains are in the vicinity

of 3.55 and 5.6 GHz, and the gains are stable in the entire operating band.

CONCLUSION

A simple and compact ultra-wideband printed monopole antenna with dual band-notches and the modified structure of the antenna are proposed in this article. Using a monopole configuration, the antenna dimensions were

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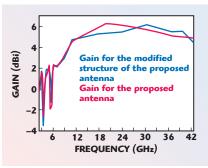


Fig. 11 Gains of the proposed and modified structure of the proposed antennas.

optimized to gain the best VSWR response throughout the UWB frequency band. By embedding two slots in the antennas, dual band-notches are created, which avoid interference with existing WiMAX and WLAN operating bands and meas-

urement results show that the designed antennas satisfy the UWB design goals very well. \blacksquare

ACKNOWLEDGMENTS

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2-WAY	0				71			
CSBK260S	20 - 600	0.28 / 0.4	0.05 / 0.4	0.8/3	25 / 20	1.15:1	50	377
DSK-729S	800 - 2200	0.5 / 0.8	0.05 / 0.4	1/2	25 / 20	1.3:1	10	215
DSK-H3N	800 - 2400	0.5 / 0.8	0.25 / 0.5	1/4	23 / 18	1.5:1	30	220
P2D100800	1000 - 8000	0.6 / 1,1	0.05/0.2	1/2	28 / 22	1.2:1	5	329
DSK100800	1000 - 8000	0.6 / 1.1	0.05/0.2	1/2	28 / 22	1.21	20	330
DHK-H1N	1700 - 2200	0.3 / 0.4	0.1 / 0.3	1/3	20 / 18	1.3:1	100	220
P2D180900L	1800 - 9000	0.4 / 0.8	0.05 / 0.2	1/2	27 / 23	1.2:1	5	331
DSK180900	1800 - 9000	0.4/0.8	0.05 / 0.2	1/2	27 / 23	1.21	20	330
3-WAY			THE STREET	1 1111		74224		3970
S3D1723	1700 - 2300	0.2/0.35	0.3/0.6	2/3	22/16	1.3:1	5	316
O In excess of theor	etical split loss of 3.0	dB						

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Model #	Frequency (MHz)	Insertion Loss (dB) [Typ:/Max.] 0	Amplitude Unbalance (dB) [Typ./Max.]	Phase Unbalance (Deg.) [Typ.Max.]	(dB) [Typ.Min.]	VSWR (Typ)	Input Power (Watts) [Max.)	Package
90°			- Harana					
DQS-30-90	30 - 90	0.3 / 0.6	0.8 / 1.2	1/3	23 / 18	1.35:1	25	102SLF
DQS-3-11-10	30 - 110	0.5 / 0.8	0.6/0.9	1/3	30 / 20	1.30:1	10	102SLF
DQS-30-450	30 - 450	1.2 / 1.7	1/1.5	4/6	23 / 18	1.40:1	5	102SLF
CSDK3100S	30 - 1000	0.8 / 1.2	0.05/0.2	0.2/3	25 / 18	1.15:1	50	378
DQS-118-174	118 - 174	0.3 / 0.6	0.4/1	1/3	23 / 18	1.35:1	25	102SLF
DQK80300	800 - 3000	0.2 / 0.4	0.5 / 0.8	2/5	20 / 18	1.30:1	40	113LF
MSQ80300	800 - 3000	0.2/0.4	0.5 / 0.8	2/5	20 / 18	1.30:1	40	325
DQK100800	1000 - 8000	0.8 / 1.6	1/1.6	1/4	22/20	1.20:1	40	326
MSQ100800	1000 - 8000	0.871.6	1/1.6	174	22 / 20	1.20:1	40	346
MSQ-8012	800 - 1200	0.2/0.3	0.2/0.4	2/3	22 / 18	1.20:1	50	226
180° (4-POR	rs)		11 0050000	1000				
DJS-345	30 - 450	0.75 / 1.2	0.3/0.8	2.5/4	23 / 18	1.25:1	5	301LF-1
0 in excess of theor	etical coupling loss of	3.0 dB						

COUPLERS

						The second secon	
Model #	Frequency (MHz)	Coupling (dE) [Nom]	Coupling Flatness (dB)	Mainline Loss (dB) [Typ.Max.]	Directivity (dB) [Typ./Min.]	Input Power (Wats) [Max.] -	Package
KDS-30-30	30 - 512	27.5 ±0.8	±0.75	0.2 / 0.28	23 / 15	50	255 *
KFK-10-1200	10 - 1200	40 ±0.75	±1.0	0.4 / 0.5	22 / 15	150	376
KBS-10-225	225 - 400	10.5 ±1.0	±0.5	0.6 / 0.7	25 / 18	50	255 *
KDS-20-225	225 - 400	20 ±1.0	±0.5	0.2/0.4	25 / 18	50	255 °
KBK-10-225N	225 - 400	10.5 ±1.0	±0.5	0.6 / 0.7	25 / 18	50	110N *
KDK-20-225N	225 - 400	20 ±1.0	±0.5	0.2/0.4	25 / 18	50	110N *
KEK-704H	850 - 960	30 ±0.75	±0.25	0.08 / 0.2	38/30	500	207
SCS100800-10	1000 - 8000	10.5 ±1.5	±2.0	1.2 / 1.8	8/5	25	361
KBK100800-10	1000 - 8000	10.5 ±1.5	±2.0	1.2 / 1.8	8/5	25	322
SCS100800-16	1000 - 7800	16.8 ±1.5	±2.8	0.7/1	14/5	25	321
KDK100800-16	1000 - 7800	16.8 ±1.5	±2.8	0.7/1	14/5	25	322
SCS100800-20	1000 - 7800	20.5 ±2.0	±2.0	0.45 / 0.75	12/5	25	321
KDK100800-20	1000 - 7800	20.5 ±2.0	±2.0	0.45 / 0.75	14/5	25	322

^{*} Add suffix - LF to the part number for RoHS compliant version.

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▲ Fig. 1 Agilent's FieldFox handheld analyzers provide precise microwave measurements in harsh conditions.

ments in much harsher conditions: in a base transceiver station (BTS) during a snowstorm, aboard a ship in rough seas, at a satellite trailer in a sandstorm, and elsewhere (see *Figure 1*). In such scenarios, only the best gear — rugged, dependable and flexible — makes it into the "field kit." Measuring up and earning a spot is the driving idea behind Agilent's FieldFox handheld analyzers.

MEETING THE FAMILY

Inside and out, FieldFox handheld analyzers were designed with on-the-go applications — and end users — firmly in mind. Within its compact, 6.6 lb (3.0 kg) package, a FieldFox analyzer can be configured as a cable and antenna analyzer, spectrum analyzer and vector network analyzer (VNA). Additional capabilities include a power meter, vector voltmeter, an independent signal source, a variable DC supply, a frequency counter, an interference

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analyzer, and built-in GPS receiver. The FieldFox family now consists of sixteen models, with top-end frequencies of 4 and 6.5 GHz in the RF models and 9, 14, 18 and 26.5 GHz in the microwave models.

This level of flexibility can replace a variety of instruments (see *Figure 2*). It also enables a user to define a "just right" initial configuration and, later on, easily amend it with additional capabilities as needs change and budgets allow. Because those capabilities are inclusive, a CAT version can be enhanced with any of the other capabilities: spectrum analysis, network analysis, and so on.

DESIGNING FROM THE GROUND UP

It is one thing to assemble a luggable analyzer that includes multiple functions. It is quite another to create a handheld instrument designed for the day-to-day workflows of technicians and engineers in the field. It is still another to provide handheld microwave measurements that agree with those made using a benchtop analyzer.

Rather than repurposing an existing benchtop instrument, the industrial and electronic design of FieldFox started with a clean sheet of paper. Defining and developing a suitable analyzer meant getting out of the design lab and tagging along with techs and engineers in the field. As they performed their daily work — from maintenance to troubleshooting — members of the FieldFox team were there, observing, asking questions and listening.

CREATING A FIELD-WORTHY INDUSTRIAL DESIGN

The team traveled to a variety of sites in vans, pickups and trucks. In most cases, the "good" instruments rode up front with the crew while the rest of the gear was tossed — literally — into the cargo area of a van or the bed of a pickup truck. In all cases, the people, vehicles, and instruments had to be equipped for a wide range of conditions — above ground or underground, day or night, rain or shine.

In FieldFox, these experiences translated into attributes that make it ready for the toughest conditions. To ensure durability in harsh environments, the completely sealed enclo-

PUTTING IT TO THE TEST

During development, the FieldFox handheld analyzers underwent rigorous environmental testing. This included water, electrostatic discharge (ESD), vibration and shock. However, the toughest challenge was drop testing from three feet onto a concrete floor. During this process individual tests were performed on all six faces and every corner of the instrument.

Two key design attributes enable the instrument to survive these tests. One is the shape of the case. The shape was designed to disperse impact and increase the structural resistance to shock and impact from all angles. Additionally, the specially designed recessed RF connector bay protects this area from direct drops. The other attribute is the special polymer blend used in the case. In addition to its innate durability, the polymer is formulated to resist shattering at the low end of the specified operating temperature range.

sure is compliant with US MIL-PRF-28800F Class 2 requirements. This spec covers the general requirements for test equipment used in the testing and calibrating of electrical and electronic equipment. Equipment designated as Class 2 is capable of operating in rugged operational environments that include unprotected, uncontrolled climatic conditions.

Consistent with the specification, FieldFox has a water-resistant chassis, keypad and case that can withstand salty, humid environments and operating temperatures of -10° to $+55^{\circ}$ C (14° to 131° F). Gasket-sealed doors protect the instrument interfaces from moisture, and the dust-free design — with no vents or fans — helps extend instrument reliability. The case can also withstand shock and vibration. Finally, a specially designed connector bay protects the RF connectors from damage due to drops or other external impacts.

DEFINING FIELD-READY ERGONOMICS

First-hand observations made indelible impressions that led to practical, meaningful decisions about ergonomics. For example, a nonslip rubber grip built into the case not only fits securely into the user's hands, it also prevents the analyzer from sliding off the hood of a vehicle. The frontpanel buttons are large enough to easily operate while wearing gloves (see **Figure 3**).

The vertical or "portrait" orientation and 7.4 inch (188 mm) width makes FieldFox easy to hold. Coupling that with a carefully designed keypad layout makes it easy for users to operate the instrument with their thumbs. Also, a weight of just 6.6 pounds (3.0 kg) makes FieldFox



▲ Fig. 2 FieldFox helps reduce equipment costs by replacing a truck full of equipment with one compact instrument.

easier to carry than similar analyzers.

Because FieldFox may be used day or night, inside or outside, it includes a bright, low-reflective display and five display modes that optimize viewing under a wide range of lighting conditions. The keys are also backlit to enable operation in darkness.

REDUCING POWER CONSUMPTION

The electronic design of FieldFox is a natural extension of Agilent's technological heritage. FieldFox integrates Agilent proprietary designs to deliver superior performance with smart power management technologies. For FieldFox, Agilent's best measurement scientists enhanced those technologies to provide high performance with low power consumption. The result: FieldFox consumes less than 15 W and lasts 3.5 hours on a single charge. And because it consumes just 15 W of power, the enclosure can be completely sealed.

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In network analysis, built-in calibration engines leverage extremely accurate algorithms from

high-end VNAs which enable precise and repeatable measurements. Agilent's approach to calibration is leveraged from benchtop VNAs. With an emphasis on portability, Agilent simplified calibration by adding built-in calibration standards, so measurements can be made in the field without carrying additional accessories. With any other instrument, when additional devices to the test port are added, such as jumper cables, recalibration is required using an external calibration kit. CalReady is another unique feature that saves time in the field — turn it on and it is already calibrated to the end of the cable. This means it is immediately ready to make accurate measurements such as S₁₁, S₂₂ and VSWR.

To enhance spectrum analysis, the design team leveraged the power measurements used in Agilent spectrum and signal analyzers to the FieldFox spectrum analyzers. This enables users to make fast, accurate one-button power measurements of channelized communication systems easily and with confidence. FieldFox microwave spectrum analyzers save time by improving accuracy with InstAlign, an internal amplitude alignment that occurs automatically as the environmental conditions change, without any user intervention. This provides an industry-leading ampli-



tion engines lever- A Fig. 3 FieldFox handheld analyzers are designed for the day-to-age extremely accu- day workflows of technicians and engineers in the field.

tude accuracy of ± 0.5 dB at power-up, with no warm up required. FieldFox is the only 26.5 GHz handheld spectrum analyzer with a built-in full-band tracking generator.

Measuring up and earning a spot in the field kit is the driving idea behind the Agilent FieldFox handheld analyzers. With a unique combination of advanced measurement capabilities in an extremely rugged package, they are equipped to handle all field measurements — routine maintenance, in-depth troubleshooting, and more — everywhere technicians and engineers need to go.

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Compact Radio Channel Emulator for MIMO Verification

transition is underway in the wireless communications industry as wireless cellular devices migrate from 3G to 4G. technologies such as LTE. For 4G products it is necessary to upgrade existing SISO test systems to MIMO capable test systems. This does not just mean multiplying the test hardware, but updating the test system capability to address the MIMO radio channel characteristics such as spatial correlations, power polarizations and antenna radiation patterns, too. To address this issue EB (Elektrobit) has introduced a new, compact EB Propsim® FS8 radio channel emulator to meet the demanding design and verification challenges of 4G products cost effectively.

The EB Propsim FS8 radio channel emulator is designed for testing MIMO performance scenarios according to 3GPP standard and is also compliant with operator defined performance testing requirements. Operators are often held responsible for the quality of service despite the possible underlying performance issue in the actual device and carry the risk of

diminishing revenues due to possible increased operating and support costs caused by poor performance. Leading operators recognize the risk and are demanding thorough acceptance test criteria in order to mitigate the risk of poor performance.

4G MIMO RADIO CHANNEL EMULATION

The EB Propsim FS8 emulates the typical radio channel characteristics like path loss, multipath fading, delay spread, Doppler spread, polarization and spatial parameters such as Angle of Arrival (AoA) and Angular Spreads (AS), which are critical for MIMO product performance. It is designed for LTE testing, supporting carrier bandwidth up to 40 MHz and frequency bands up to 2700 MHz, and features a very compact and highly integrated design.

In order to get reliable results from MIMO product testing, the radio channel emulator has

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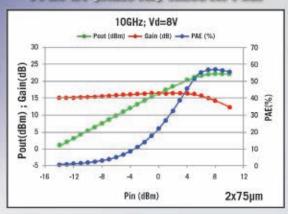




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- Power performance at 8V and 10GHz: >1W/mm, PAE 56%, 14dB Gain

PP25-21 (Class-AB) Tuned for Pout



Gain	P1dB	P1dB	Psat	Psat	PAE
(dB)	(dBm)	(mW/mm)	(dBm)	(mW/mm)	Max(%)
15.0	22.1	1086	22.2	1114	56.8

2x75µm device @8V, 10GHz, 150 mA/mm

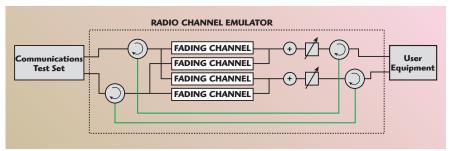


Summary of WIN mmWave pHEMT portfolio

	PP25-21	PP15-50/51	PL15-12	PP10±10/11
Gate length	0.25 µm	0.15 μm	0.15 µm	0.1 µm
Max Drain Bias	8 V	6 V	4 V	4 V
Idmax (Vg=0.5V)	490 mA/mm	620 mA/mm	525 mA/mm	760 mA/mm
Peak Gm	410 mS/mm	460 mS/mm	580 mS/mm	725 mS/mm
Vto	-1.15 V	-1.3 V	-0.7 V	-0.95 V
BVGD	20V(18V min)	16V(14V min)	9V(8V min)	10V (8V min
fr	65 GHz	90 GHz	100 GHz	130 GHz
f _{max}	190 GHz	185 GHz	150 GHz	180 GHz
Power Density (2x75µm)	1100 mW/mm @ 8V, 10GHz	870 mW/mm @ 6V, 29GHz	580 mW/mm @ 4V, 29GHz	860 mW/mm @ 4V, 29GHz (2x50μm)

WIN SEMICONDUCTORS CORP. Tel:+886-3-397-5999 Fax:+886-3-397-5069 http://www.winfoundry.com

Product Feature



▲ Fig. 1 A typical test setup for a 4G MIMO device (2×2 MIMO downlink) shows four fading channels.

to have excellent RF performance. Error Vector Magnitude (EVM) and internal noise level must be very low to minimize errors impacting the measurement results.

Also, the fading process has to be repeatable in order to have consistent test results across different test rounds. This is very important when benchmarking the performance of different 4G products. The EB Propsim FS8 minimizes these risks by exhibiting excellent RF performance and the use of EB's patented emulation technology, with excellent channel condition repeatability.

The emulator addresses RF, data, mobility and voice performance evaluation under realistic propagation conditions. In addition, Over-The-Air (OTA) testing in an anechoic chamber is supported, providing the capability to measure realistic mobile terminal performance without using artificial cabling in the test setup. With EB Propsim FS8, the bottlenecks in 4G product performance can be identified early in the product development cycle enabling savings in costly redesign and verification later in the development stages.

4G DEVICE PERFORMANCE

To test the performance of a 4G LTE handset or chipset, developers can measure bit-error rate (BER), block-error rate (BLER), and frameerror rate (FER) as a function of the signal-to-noise ratio. All of these measurements count the number of errors in a predefined amount of data. High error values mean that the device does not adequately mitigate fading effects in the radio channel. Another typical performance measure is the data throughput versus the signal-to-noiseratio. This is typically measured in megabits per second and defines how much data the system is able to correctly transmit in 1 second.

Performance tests require a communications tester and a radio channel emulator for the device under test (DUT). A communications tester establishes a link to a cellular device by emulating a base station, but featuring only a small subset of functionality of a real base station. For a throughput measurement, the communications tester sends a known data pattern to the DUT. With a direct cable connection from the tester to the device, the test setup can achieve its highest possible throughput. When placed between the tester and the DUT, the EB Propsim FS8 radio channel emulator will distort the signal as it occurs in real wireless communications correspondingly changing the data throughput. Figure I shows a typical test setup for a 4G MIMO device.

Typically, the main purpose of testing is to verify a product's compliance to a standard. Standard channel models are defined by the 3GPP LTE standard. The standard also sets performance limits with a given model, ensuring a certain minimum performance for all 4G LTE devices on the market. Most tests against the standard requirements are simply pass/fail measurements, so they do not measure the performance limits of the device.

COMPATIBILITY WITH PERFORMANCE TEST SYSTEMS

MIMO product performance testing solutions depend on the desired coverage of different layers from RF and protocol levels to network radio resource management. EB Propsim FS8 is designed and verified to be compatible with used key components in the performance test systems from vendors like Rohde & Schwarz, Agilent, Anritsu and Aeroflex. This

compatibility, coupled with the ability to cost-effectively replace existing CDMA or GSM/UMTS tests systems to add LTE testing capability, ensures that the investment in the test equipment continues to pay back throughout the product lifecycle.

The emulator brings additional value to 4G product performance test systems with realistic propagation scenarios, provided by cutting edge channel modelling applications. EB's Virtual Drive Testing (VDT) application with the EB Propsim FS8 enables the verification of challenging propagation scenarios with full repeatability. VDT utilizes the field measurement data from real live networks captured by drive test tools or a channel sounder in order to bring repeatable real-world conditions to laboratory testing. All the elements of the real environment: fast fading, Doppler, signal level variations, interference and antenna parameter effects can be replicated, making it possible to isolate performance issues early in the development and design verification phase.

ACCELERATED DEVELOPMENT CYCLE

Realistic field scenarios in laboratory testing at the early development stages provide immediate feedback and facilitate the improvement of product maturity before field trials and operator acceptance testing, thus accelerating the product development cycles and yielding better product quality and acceptance. EB Propsim FS8 4G performance test capabilities enable quantification of the device performance in the most critical areas. Beyond testing for conformance to industry specifications, the emulator is indispensable in comparing device performance, gathering data for operational and support cost projections, or to identify issues that are not caught by basic conformance testing. Testing with the new radio channel emulator guarantees high quality user experience of devices and hastens the time to market of new wireless 4G products and systems.

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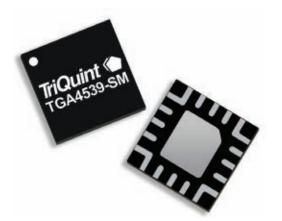






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Ka-Band VSAT Chipset Family

pplications for communications systems using very small aperture terminals (VSAT) have grown from their initial operation at C-Band in the 1980s to become a large and diverse market. Satellite service and companion ground terminals are arguably the most central element that made modernized point-of-sale transaction processing possible, along with supervisory control and data acquisition (SCADA) remote monitoring systems, not to mention fixed and portable wideband systems for military and maritime communications

What began as "not very small" aperture terminals that relied on backyard-filling, three-meter parabolic antennas is now dominated by more than 370 VSAT operators throughout the world that rely on rooftop antennas that capture Ku- and Ka-Band signals. Commercial data transmission dominates Ku-Band services along with home/consumer programming. Despite the advantages of non-tethered access

that satellite service provides, bandwidth limitations and cost have meant that most North American consumers seeking high definition programming and broadband Internet access have remained cable TV subscribers or patrons of emerging fiber to the home (FTTH) services. Broadband consumers by the millions are the prize sought after by satellite service providers – a market that is now more within reach thanks to additional Ka-Band services coming online in the near future.

The latest major Ka-Band event for North America was the successful launch and deployment of the Hughes EchoStar XVII satellite in July. The Jupiter satellite, built for Hughes Network Systems by Space Systems/Loral, has 60 Ka-Band transponders designed to provide HughesNet broadband services to consumers,

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Product Feature

businesses and governmental customers throughout North America. It uses a bent-pipe Ka-Band architecture delivering spot beams with a total of 360 Gb/s of data throughput.

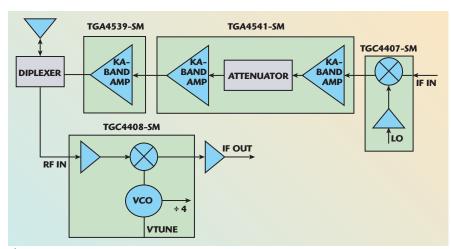
The benefits of increased bandwidth and the potential for lower ground terminal costs are driving significant interest in Ka-Band (28 to 31 GHz) frequencies for broadband Internet access, digital telephony, high-definition video and other 'Triple Play' services.

A new family of GaAs MMICs from TriQuint Semiconductor is designed to help Ka-Band ground terminal manufacturers support this emerging market. TriQuint's high-performance, functionally-integrated products offer easy-to-assemble, cost-effective packaged solutions for VSAT RF requirements.

TriQuint Semiconductor has long supported satellite communications with GaAs solutions, including amplifiers and control products for orbital payloads as well as VSAT devices in commercial and defense programs. TriQuint leads the orbital payload market with more GaAs devices aloft than any other provider. Long known for its amplifier solutions, TriQuint has introduced a complete RF chipset for Ka-Band applications including a variable-gain driver amplifier, 1 W MMIC amplifier, sub-harmonic upconverter and a block downconverter. All four VSAT Ka-Band products use TriQuint's GaAs PHEMT process and are housed in standard QFN packages. A typical lineup is shown in the Figure 1 block diagram.

Amplification stages are provided by two components: TGA4541-SM and TGA4539-SM. The TGA4541-SM variable gain amplifier is designed to be used as a highly linear driver amplifier over a 28 to 31 GHz frequency range, and provides P1dB RF output power of +23 dBm, gain of 33 dB and a third-order intercept point (OIP3) of +31 dBm. Output of the amplifier can be varied over a wide 30 dB range. The amplifier draws 330 mA from its +5 V DC supply. The TGA4539-SM GaAs MMIC amplifier delivers P1dB RF output power of 1 W (+30 dBm), gain of 20 dB from 28 to 30 GHz, and has an OIP3 of 33 dBm. It draws 420 mA from a +6 V DC supply.

The TGC4408-SM block downconverter includes dual-band switch-



▲ Fig. 1 Complete chipset solution for Ka-Band VSAT ground terminal.

TABLE I									
KEY VSAT DEVICE SPECIFICATIONS									
	TGA4539-SM	TGA4541-SM	TGC4407-SM	TGC4408-SM					
Frequency Range (GHz)	28 to 30	28 to 31	Input: 21.5 to 32.5 LO: 11 to 16 IF: DC to 7	Input: 18.3 to 20.2 IF: 0.950 to 1950					
P1dB RF Power Output (dBm)	30	23							
Gain (dB)	20	33	-9 (conversion gain)	8.5 dB (conversion)					
IP3 (dBm)	33 (output)	31 (output)	13 (input)	–6 (input)					
Gain Attenuation Range (dB)	-	30	-	-					
Noise Figure (dB)	ı	-	-	6.5					
Power Supply (VDC at mA)	6 at 420	5 at 330	+5 at 65	+5 at 305					
Phase Noise (dBc/Hz)	-	-	-	10 kHz offset: -73 1 MHz offset: -126					
Package	20-lead 5×5 mm QFN	40-lead 6×6 mm QFN	16-lead 3×3-mm QFN	32-lead 5×6-mm QFN					

able VCOs, a subharmonic mixer with LNA and LO buffer amplifiers in a 32-pin 5×6 mm QFN package. It has an input frequency of 18.3 to 20.2 GHz and IF frequency of 950 to 1950 MHz. Conversion gain is 8.5 dB, noise figure is 6.5 dB, and phase noise is –73 dBc/Hz at a 10 kHz offset and -126 dBc/Hz at a 1 MHz offset. The downconverter also has a differential signal at one quarter of the VCO frequency that can be used in a phase-locked loop. TGC4408-SM utilizes TriQuint's PHEMT process and HBT processes, and draws 305 mA from a +5 V DC supply.

The TGC4407-SM is a sub-harmonic upconverter with an integrated

local oscillator buffer amplifier that has an input frequency range of 21.5 to 32.5 GHz, wide IF range of DC to 7 GHz, a sub-harmonic LO frequency of 11 to 16 GHz, and accepts an LO input power of 0 to +7.5 dBm. It has conversion gain of –9 dB and draws 65 mA from a +5 V DC supply. Full details of all four devices are shown in *Table 1*. All of the devices are in production and supporting evaluation boards are available.

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Precision and Lab Adapters

aury Microwave has released its new Test Essentials™ line of precision and lab adapters. The Test Essentials line expands Maury's portfolio of RF/microwave adapters by adding two new lines alongside its existing Calibration (Metrology) family: Test Essentials Lab Adapters and ColorConnect™ Precision Adapters.

Test Essentials Lab Adapters have been designed for daily use in RF/microwave labs and

production facilities and offer one of the industry's best price/performance ratios. Test Essentials Lab Adapters feature excellent electrical performance, rugged construction for durability, repeatable mating and high reliability. Test Essentials Lab Adapters are available in SMA, N Type, 3.5mm, 2.92mm, 2.4mm and 1.85mm in-series and between-series.

ColorConnect Precision Adapters have been designed for lab and field use where quality, performance, ease-of-identification and ease-ofuse are critical. New manufacturing techniques have given ColorConnect Precision Adapters improved VSWR specifications bridging the gap between calibration-grade metrology adapters and daily-use lab adapters (see Figure 1). Following the proposed IEEE high-frequency connector/adapter color convention, ColorConnect Precision Adapters are the first commercially available products to offer clear indications of compatibility and intermatability. ColorConnect makes it a simple matter to avoid and eliminate damaged equipment, degraded equipment reliability, degraded performance and lengthy maintenance times due to improper mating (and attempted mating) of incompatible adapters. ColorConnect Precision Adapters are available in N Type, 3.5mm, 2.92mm, 2.4mm and 1.85mm in-series and between series.

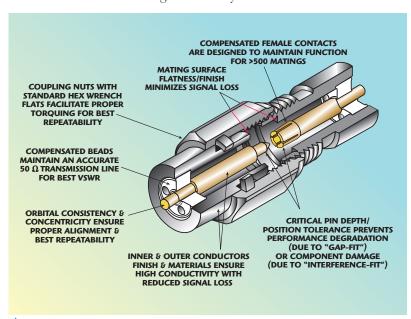


Fig. 1 Construction features of Test Essentials Adapters.

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Tech Brief



he new Open, Short, Load, Through (OSLT) calibration kits from SPINNER are configured for an extended frequency range and expand the company's test and measurement portfolio.

These 4-in-1 kits are developed for frequency ranges from DC to 18 GHz (BN 533879, BN 533880) and DC to 26.5 GHz (BN 533881, BN 533882). This upgrade guarantees optimized calibration accuracy of vector network analyzers (VNA) and enables the product range to address the emerging trend for handheld devices that can be used at higher frequencies.

The product line of compact calibration kits combines all standards

OSLT Calibration Kits with Extended Frequency Range

needed in one cleverly designed body. This means that Open and Short circuits, a Load and a Through can achieve complete calibration of a VNA with two or more ports utilising the OSLT method. The attractive and handy design and the ergonomic arrangement of the standards as well as its size and light weight makes the OSLT calibration kits suitable for applications in the area of production or in laboratories and science facilities. As opposed to single calibration standards in suitcases, the standards in the fixed central housing are captive, which is particularly of interest when using the kits in the field.

The new highly precise compact kits are available as OSLT versions with gold-plated male or female connections for N and 3.5 mm plug connectors. Both frequency ranges have a 50 Ω impedance and the loads have a maximum power rating of 0.5 W. These 4-in-1 versions are delivered with global calibration coefficients. The names of the standards are engraved on the central housing so that they can be identified easily.

SPINNER can also modify the design to particular customer specifications.

SPINNER GmbH, Munich, Germany, Europe: +49 89 12601-0, USA: (770) 263-6326, email: info@spinner-group.com, www.spinner-group.com.



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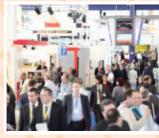
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Tech Brief



USB Style RF/Microwave Components

lanar Monolithics Industries (PMI) has developed a family of USB controlled RF and microwave components including amplifiers, switches and attenuators. Two amplifiers are available operating from 0.05 to 18 GHz and 0.05 to 40 GHz with 12 dB gain, ±2.5 dB gain flatness, 4.5 dB typical noise figure to 20 GHz, OP1dB of +10 dBm typical and VSWR of 2.3:1. Two absorptive switch models are

available operating from 0.5 to 18 GHz and 0.5 to 40 GHz with insertion loss of 5 dB (18 GHz model) and 6 dB (40 GHz model), 60 dB isolation and operating input power of 20 dBm. Two attenuator models are available operating from 0.1 to 18 GHz and 0.1 to 40 GHz with 30 dB attenuation range in 1 dB steps, ±2.5 dB attenuation accuracy, 5 dB insertion loss to 20 GHz and VSWR of 2.5:1.

All components are controlled and powered via USB 2.0 interface using a custom PMI graphic user interface for control using a PC. Other models and custom components are also available.

VENDORVIEW

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





High Power IC Package

tratEdge has developed the LL family of leaded laminate copper-moly-copper (CMC) base packages that dissipates heat from high power compound semiconductor devices, such as gallium nitride (GaN), gallium arsenide (GaAs) and silicon carbide (SiC). These packages handle applications through 6 GHz for use in RF radios for communications, radar and high power millimeter-wave signals.

The series includes two laminate power packages, both with a ratio of 1:3:1 CMC, which provides

a good thermal match for alumina-based materials and a GaN chip. The LL802302 is 0.8" (20.32 mm) long × 0.23" (5.84 mm) wide with two leads and a raised lid with an epoxy seal. This is a flange package with a bolt hole on each end so the package can be bolted to the printed circuit board. The LL362302 is a flangeless, fully hermetic version of the LL802302 package, and has a flat ceramic lid. StratEdge offers both flange and flangeless styles to accommodate manufacturing processes to either bolt down or

solder the package. Hermeticity is especially critical in aerospace and defense applications.

StratEdge's new laminate power packages solve thermal problems encountered when using GaN devices. The excellent thermal conductivity of the CMC base enables use of GaN devices in high power applications, and the flange package facilitates manufacturing.

StratEdge Corp., San Diego, CA (866) 424-4962, www.stratedge.com.



Web Update

Web-Based Tool

Amphenol Industrial Global Operations now offers a web-based tool that simplifies online part selection and configuration of its most popular connectors. It allows users to download 3D CAD models or PDFs of the connectors that they have created using this new system. Found under the 'Design Online' section of the Amphenol Industrial website, this new intuitive interface provides on-demand plug and play models to customers during any phase of the design process and features

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Anteral 303
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Germania Elektronik
Globes Elektronik GmbH 328
HBH Microwave GmbH 328
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Technologies Co. Ltd 323
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LeCroy Europe GmbH 120
Link Microtek
Linwave Technology
LPKF Laser & Electronics AG 425
Lynx
3,
Solutions Inc
Solutions Inc
Solutions Inc
Solutions Inc.421Marki Microwave.310Maury Microwave.314AMerrimac Industries306
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries 306 Mesuro Ltd. 226
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries 306 Mesuro Ltd. 226 Mician GmbH 321
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries 306 Mesuro Ltd. 226 Mician GmbH 321 Micro Systems Engineering
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries. 306 Mesuro Ltd. 226 Mician GmbH. 321 Micro Systems Engineering GmbH & Co. 104
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries. 306 Mesuro Ltd. 226 Mician GmbH. 321 Micro Systems Engineering 321 GmbH & Co. 104 Micross Components 327
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries. 306 Mesuro Ltd. 226 Mician GmbH. 321 Micro Systems Engineering 320 GmbH & Co. 104 Micross Components 327 Microwave Journal. 630
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries. 306 Mesuro Ltd. 226 Mician GmbH. 321 Micro Systems Engineering 320 GmbH & Co. 104 Micross Components. 327 Microwave Journal. 630 Microwave Marketing Ltd.
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries. 306 Mesuro Ltd. 226 Mician GmbH. 321 Micro Systems Engineering 320 GmbH & Co. 104 Micross Components. 327 Microwave Journal. 630 Microwave Marketing Ltd. (Linwave)
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries 306 Mesuro Ltd. 226 Mician GmbH 321 Micro Systems Engineering 320 GmbH & Co. 104 Micross Components 327 Microwave Journal. 630 Microwave Marketing Ltd. (Linwave) Mitsubishi Electric Europe BV 509
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries. 306 Mesuro Ltd. 226 Mician GmbH. 321 Micro Systems Engineering 320 GmbH & Co. 104 Micross Components. 327 Microwave Journal. 630 Microwave Marketing Ltd. (Linwave)
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries. 306 Mesuro Ltd. 226 Mician GmbH. 321 Micro Systems Engineering 320 GmbH & Co. 104 Micross Components. 327 Microwave Journal. 630 Microwave Marketing Ltd. (Linwave). Mitsubishi Electric Europe BV. 509 National Instruments. 317
Solutions Inc. 421 Marki Microwave. 310 Maury Microwave. 314A Merrimac Industries 306 Mesuro Ltd. 226 Mician GmbH 321 Micro Systems Engineering 327 GmbH & Co. 104 Micross Components 327 Microwave Journal. 630 Microwave Marketing Ltd. (Linwave) Mitsubishi Electric Europe BV 509 National Instruments 317 Newfasant 404

NXP Semiconductors 515
OML310
OMMIC 616
Ophir Microwave 513
Pascall Electronics Ltd
Pickering Interfaces Ltd 224
PICO Technology 610
Pole Zero
Presto Engineering Europe 212
Qingdao Xingyl Electronic
Equipment Co. Ltd
Q-Par Angus Ltd
Radar Systems Technology Inc 310
Radiall 502
RF Microtech407
RFHIC 409
Rogers Corp 525
Rohde & Schwarz 115
Rosenberger
Hochfrequenztechnik
S3 Group
Schmid & Partner
Engineering AG
Schott Electronic
Packaging GmbH611
SELEX Galileo
SIAE Microelettronica
Sonnet Software Inc
Southwest Microwave Inc 406
Spinner GmbH 613
SSBV Space and Ground Systems Ltd
Systems Lia419
Sumitomo Electric Europe Ltd 128
Sumitomo Electric Europe Ltd 128 Swisstronics AG 100
Sumitomo Electric Europe Ltd 128 Swisstronics AG 100 Syfer 113
Sumitomo Electric Europe Ltd 128 Swisstronics AG
Sumitomo Electric Europe Ltd 128 Swisstronics AG
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc. 230
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc. 230 Teledyne Labtech Ltd. 503 Thales Microelectronics 205 The IET. 624 TNO 614 Trackwise Designs Ltd. 428 Transcom Inc. 622 TriQuint Semiconductor 311
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc. 230 Teledyne Labtech Ltd. 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd. 428 Transcom Inc. 622 TriQuint Semiconductor 311 TTI. 403 UMS SAS. 514
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 Vaunix 129
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 Vaunix 129 VIA electronic GmbH 611
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 Vaunix 129
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 Vaunix 129 VIA electronic GmbH 611 Voltronics Corp 113 Weinschel Associates 513
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc 230 Teledyne Labtech Ltd 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd 428 Transcom Inc 622 TriQuint Semiconductor 311 TTI 403 UMS SAS 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 Vaunix 129 VIA electronic GmbH 611 Voltronics Corp 113
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc. 230 Teledyne Labtech Ltd. 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd. 428 Transcom Inc. 622 TriQuint Semiconductor 311 TTI. 403 UMS SAS. 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 Vaunix 129 VIA electronic GmbH 611 Voltronics Corp 113 Weinschel Associates 513 Wiley - Blackwell 512
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc. 230 Teledyne Labtech Ltd. 503 Thales Microelectronics 205 The IET. 624 TNO 614 Trackwise Designs Ltd. 428 Transcom Inc. 622 TriQuint Semiconductor 311 TTI 403 UMS SAS. 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 University of Cardiff 602 Vaunix 129 VIA electronic GmbH 611 Voltronics Corp 113 Weinschel Associates 513 Wiley - Blackwell 512 WIN Semiconductors Corp 320 WIPL-D doo 102 WL Gore & Associates GmbH
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc. 230 Teledyne Labtech Ltd. 503 Thales Microelectronics 205 The IET 624 TNO 614 Trackwise Designs Ltd. 428 Transcom Inc. 622 TriQuint Semiconductor 311 TTI 403 UMS SAS. 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 Vaunix 129 VIA electronic GmbH 611 Voltronics Corp 113 Weinschel Associates 513 Wiley - Blackwell 512 WIN Semiconductors Corp 320 WIPL-D doo 102
Sumitomo Electric Europe Ltd. 128 Swisstronics AG 100 Syfer 113 Taconic Advanced Dielectric Div. 606 Tafco Metawireless 304 Tegam Inc. 230 Teledyne Labtech Ltd. 503 Thales Microelectronics 205 The IET. 624 TNO 614 Trackwise Designs Ltd. 428 Transcom Inc. 622 TriQuint Semiconductor 311 TTI 403 UMS SAS. 514 Universidad Politecnica de Valencia (UPV) 402 University of Bristol 602 University of Cardiff 602 University of Cardiff 602 Vaunix 129 VIA electronic GmbH 611 Voltronics Corp 113 Weinschel Associates 513 Wiley - Blackwell 512 WIN Semiconductors Corp 320 WIPL-D doo 102 WL Gore & Associates GmbH

EuMW PRODUCT SHOWCASE Aisles 100-300

The following booth numbers are complete as of August 24, 2012. Shaded products have an ad featured in this issue.

WIPL-D d.o.o.

Booth 102

3D Electromagnetic Solver



WIPL-D Pro is a full, powerful package high-complexity modeling of EM problems, tended for users who want to

build their models in the quickest way possible. It is completely dedicated to providing fast and easy modeling of complex geometries, bringing significant improvement to the overall modeling process. The solid modeling that WIPL-D Pro CAD provides allows for fast modeling and manipulation for a wide range of EM applications, all the while relying on the proven WIPL-D's powerful kernel.

www.wipl-d.com

Pickering Interfaces

Booth 106 Relocated to Booth 224

PXI Switch



Pickering Interfaces is expanding its comprehensive range of PXI microwave switch solutions with the introduction of the

40-784 family. The 40-784 supports one or two microwave switches in just two slots of 3U PXI and is available in un-terminated SP4T and SP6T configurations. Each configuration can be supplied with a 6, 26.5 or 40 GHz specified frequency range. All versions offer excellent VSWR and insertion loss performance and the 6 and 26.5 GHz models feature extended life of 10 million operations per position.

www.pickeringtest.com

Agilent Technologies

Handheld Analyzers

Rohde & Schwarz

Booth 115



FSW signal and spectrum analyzer is now available in the frequen-

cy range up to 43 GHz. Its built-in multistandard radio analyzer allows development engineers to measure spectrum and modulation parameters on multiple signals simultaneously as well as analyze signal interactions. This important feature, combined with unrivalled RF performance and measurement speed, makes complex measurement tasks, such as those involved in satellite communications or in radar applications significantly, easier.

VENDORVIEW

www.rohde-schwarz.com

Connecticut Coining Inc.

Booth 123

Deep Drawn Parts

Connecticut Coining Inc. is a leading manufacturer of deep-drawn metal parts used in a variety of commercial, aerospace, medical, auto-



motive, and defense applications. The company specializes in short runs (25 to 25,000 pieces) and prototypes, using a variety of materials including stainless steel, aluminum, copper, Kovar®,

and assorted nickel-based alloys. Connecticut Coining's products include stand-alone parts and component parts, many of which are bonded to ceramic or glass at customer sites.

www.ctcoining.com

AR UK Ltd.

Test System



AR UK introduced the AR Benelux designed 10 channel high power RF system operating in Ku-Band. The full automatic system can create numerous multi carrier schemes to test components under high power RF multi car-

Booth 125

rier conditions. Key specifications include liquid cooling to eliminate audio noise and excessive heat dissipation; phase error < 3° during the entire test; accurate power leveling within 0.2 dB; cost effective frequency generation with arbitrary modulations; and intuitive software control interface to define multi carrier patterns.

VENDORVIEW

www.ar-europe.ie

Analog Devices

Booth 221

PLL Synthesizer



The ADF4159 13 GHz PLL synthesizer achieves breakthrough phase detector operating frequency of 110 MHz and simultaneously consumes less than 100 mW of power, which is

5× less than competitive solutions. In addition, the ADF4159 contains a 25-bit fixed modulus as well as on-chip functionality to generate highly linear ramp profiles, making it an ideal solution for Frequency Modulated Continuous Wave (FMCW) radar applications, including automotive radar systems, microwave Point-to-Point (PtP) systems, communications instrumentation and test equipment.

www.analog.com/rf

Anteral

Booth 303

Corrugated Horn



This K (Tx 21.3 to 22.1 GHz)/ Ka (Rx 27.7 to 29.6 GHz) dual band horn is 30 percent shorter than. conventional corrugat-

ed horns (170 \times 95 mm), with a gain of 23 dB in Tx-Band, and 24 dB in Rx-Band. The S_{11} parameter is below -30 dB with a cross-polar level below -40 dB and a phase-center variation inferior to a wavelength, in both bands. Anteral designs and fabricates corrugated horns from 1 to 140 GHz and smooth-walled horns (conical, pyramidal and spline) from 1 to 500 GHz.

www.anteral.com

Signal Generators

Carry precision with you: Agilent's FieldFox handheld analyzers are equipped to handle routine

Booth 114

maintenance, in-depth troubleshooting and anything in between. Whether you are installing or maintaining RF or microwave communication systems in the desert heat, or working on a radar system in freezing conditions, FieldFox will keep working and continue to deliver benchtop-instrument accuracy wherever you need to go.



Reveal the true performance of your best devices: Agilent's X-Series signal generators provide unmatched performance in

phase noise, output power, AĈPR, EVM and bandwidth. From the pure and precise MXG to the cost-effective EXG, the X-Series helps you develop components and receivers that address the complex challenges of increased interference, data throughput and signal quality in aerospace/defense and wireless communications. Learn more at www.agilent.com/find/X-Series_SigGen.



www.agilent.com

Eumw product showcase Aisles 300-400

Tafco Metawireless

ooth 30

Electromagnetic Research

Tafco Metawireless is a highly specialized consulting firm devoted to solving complex electromagnetic problems. The company's solid background in top-level electromagnetic research in wireless communications and the aerospace and defense sectors enable it to give high performance solutions to its clients.

www.tafcomw.com

Crane Aerospace & Electronics Microwave Solutions Booth 306

Fusion Process



Crane Aerospace & Electronics Microwave Solutions offers Multi-Mix, an innovative process for microwave, multilayer integrated circuits and micro-multifunction modules (MMFM®). This process is based on fluo-

ropolymer composite substrates, which are bonded together into a multilayer structure using a fusion bonding process. The fusion process provides a homogeneous dielectric medium for superior electrical performance at microwave frequencies.

www.craneae.com/merrimac

Linwave Technology Ltd. Booth 309 Nano Block Up Converter



Designed specifically for military SatCom and commercial mobile communication systems, the Nano BUC is ideally suited to com-

pact 'fly away' terminals and 'man pack' applications. The design utilizes chip and wire and SMD technologies to produce outstanding RF performance in a small size. The Nano BUC can drive an external SSPA or TWTA directly. Alternatively, compact higher output options (up to 20 W) can be achieved by integrating with Linwave's chip and wire GaN based SSPA modules. www.linwave.co.uk

TriQuint Semiconductor VSAT RF Chipset



TriQuint has released a complete Ka-Band VSAT RF chipset that delivers cost-effective, high performance pack-

Booth 311

mance packaged convenience. The TGA4539-SM 1 W amplifier offers superior linearity and 20 percent lower power consumption. The TGC4407-SM upconverter combines a low power amplifier and mixer. The TGC4408-SM downconverter combines a VCO with LNA and mixer. The TGA4541-SM variable gain driver amplifier provides wide attenuation, high linearity and gain. For complete solutions and new GaN, GaAs, SAW and BAW innovation, see TriQuint in booth 311.

www.triquint.com

EMSCAN Booth 314D

Antenna Measurement Equipment



EMSCAN is a developer of real-time magnetic very-nearfield measurement solutions. It provides realtime visual test

solutions for antenna and PCB designers and verification engineers. RFxpert is the bench-top antenna measurement equipment that calculates accurate FF patterns and radiated power levels based on NF measurements in under a second. EMxpert is a bench-top EMC/EMI diagnostic tool enabling designers to rapidly diagnose and solve EMC/EMI problems in a single design cycle.

1DIDID.emscan.com

WIN Semiconductors

Booth 320

Foundry Services

WIN Semiconductors Corp. is a provider of dedicated foundry services to design- and system-based clientele. The company's advanced 6" HBT and HEMT MMIC technologies support RF applications from 100 MHz up to 100 GHz. WIN's current customers cover various applications including mobile communications, satellite and auto radar.

www.winfoundry.com

Norden Millimeter Inc. Dual Down Converter

Booth 310



Norden Millimeter introduces an 18 to 40 GHz down converter with an integrated 0.5 to 18 GHz bypass path for combining the 18 to 26.5 GHz and 26.5 to 40 GHz band into a single 0.5 to 18 GHz IF output. This dual converter can be configured to accept three inputs from three different antennas (i.e., 0.5 to 18 GHz, 18 to 26.5 GHz and 26.5 to 40 GHz) to one output for all three bands.

www.nordengroup.com

Technical University of Valencia (UPV)

Booth 402

The Technical University of Valencia (UPV) leads the Regional R&D Institute on Space Technologies and Applications (SPACE-

CV), which is set up for coordinating research lines, experimental facilities, technology transfer actions and educational programmes in the satellite communication area for the period 2012-2015. As an official partner of the Val-Space Consortium (VSC), UPV hosts the joint ESA-VSC High Power RF Laboratory and a VLC/CAMPUS (International Excellence Campus Programme) facility for manufacturing microwave and mmwave components in Low Temperature Co-fired Ceramics (LTCC) technology.

www.upv.es

ERZIA Space

Booth 405 Relocated to Booth 302

European RF and MW Amplifiers



Erzia offers space, military and industrial grade power amplifiers and low noise ampli-

fiers customizable to specific science applications (i.e., AOTF/AOM drivers). They are ITAR free, up to 50 GHz and up to 200 W (depending on frequency). They offer several customization options, including power meter, On-Off control, variable gain, and temperature sensors.

www.erzia.com

Southwest Microwave Inc. Booth 406 End Launch Connector



Southwest Microwave's high performance 1.85 mm end launch connector is now offered with a 5 mil diameter launch pin. This connector is designed to pro-

vide low VSWR, wideband response up to 67 GHz for single-layer or multi-layer printed circuit boards where the microwave layer is on top. It is ideally suited for high frequency chip set evaluation/demo boards, test fixtures and board characterization. It provides optimum performance when board launch geometry is grounded coplanar (CPWG) or top ground microstrip. The connector requires no soldering and is repairable and reusable.

www.southwestmicrowave.com



Different cables for different needs—and all built to last.

For almost 40 years we searched for reliable, high-performance cables that could stand up to the heavy use our 100% testing policy demands. Finally, we were able to acheive our goal, and we're proud to make these cables available to the rest of the industry, backed with our unprecedented 6-month guarantee.* Just go to minicircuits.com and order some for yourself! You'll quickly find that consistent long-term performance, less retesting, and fewer false rejects really add up to bottom-line savings, test after test!

Model Family		Connectors	•	Temp
	(GHz)	(male)	(ft)	(°C)
Performance Test (CBL)	DC-18	SMA [‡] , N	1.6-25	-55/+105
Quick Lock (QBL)	DC-18	SMA	1.0-6.6	-55/+105
Armored (APC)	DC-18	Ν	6.0-15	-55/+105
Low Loss (KBL-xx-LOW)	DC-40	2.92	1.5-6.6	-55/+85
Phase Stable (KBL-xx-PHS)	DC-40	2.92	1.5-6.6	-55/+85

*Mini-Circuits will repair or replace your test cable at its option if the connector attachment fails within six months of shipment. This guarantee excludes cable or connector interface damage from misuse or abuse.

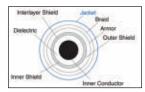
- [†] Custom lengths available by special order.
- [‡] SMA female connectors featured on some models, or via special order.
- K-Connector is a registered trademark of Anritsu Company.



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Eumw Product Showcase **Aisles 400-500**

ETS-Lindgren

Booth 414

Relocated to Booth 314C

Curvilinear Absorber



ETS-Lindgren curvilinear absorber is an advanced RF absorber that is optimized for broadband reflection suppression. It is specially designed for chamber backwalls and other "hot

spots" that require a higher attenuation at normal incidence than an equally-sized, conventional absorber provides. This curvilinear absorber preserves the high frequency performance and extends the lower range down to 300 MHz, without the use of expensive ferrite tiles. For both retrofits and new installations, ETS-Lindgren's curvilinear absorber can improve performance and maximize available work space.

www.ets-lindgren.com

AWR

Booth 416

Simulation and Analysis Software



Analyst, AWR's newest product, is a powerful 3D Finite Element Method (FEM) electromagnetic (EM) simulation and analysis software that is seamlessly integrated

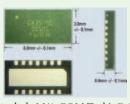
seamlessly integrated within the AWR Design Environment[™]. Analyst lets you move from circuit concept to full 3D EM verification of bumps, bond wires, ribbons and more with a single mouse click. With 3D EM and circuit design in one integrated workflow, your time is well spent designing, optimizing and tuning for performance.



www.awrcorp.com

M/A-COM Technology Solutions

GaN in Plastic



The new products M/A-COM Technology Solutions will be showcasing at EuMW 2012

Booth 421

include M/A-COM Tech's GaN in plastic for radar applications, modulator drivers and transimpedance amplifiers for 40 G and 100 G applications, switch-limiter for radar applications, GaN Smart Pallets for aerospace and defense radar applications, and 42 GHz Smartset Chipset for point-to-point wireless backhaul.

www.macomtech.com

AA-MCS

PIN Diode Switches



AA-MCS is a European leader in design, development and manufacturing of passive and active radio frequency and mi-

crowave components. The company has launched its new product line dedicated to pin diode switches (SPDT and SP3T). Covering frequency up to 6 GHz, the new switches handle hot switching up to 150 W CW and switching speed close to 1 us. Applications covered are amplifier's harmonics filtering, high power antenna switching and high power switching matrix.

www.aa-mcs.com

INGUN Pruefmittelbau GmbH

RF Probe



For contacting plug connectors in the field of high-speed data

Booth 517

transfer, INGUN Pruefmittelbau GmbH has developed numerous innovative solutions for routine test. The shielded RF-Probe HFS-821 is designed for contacting digital signals with the highest quality (LVDS, GVIF). Due to the moveable guidesection the spring-loaded test probe aligns itself optimally to the connector to be tested, e.g., JAE MX38 and MX49. The test probe can be mounted on an existing connector approach mechanism.

www.ingun.com

Elbit Systems EW and SIGINT – Elisra

Booth 518

Solid-State Power Amplifier



This new solidstate power amplifier is based on innovative GaN transistor modules technology. It has a

broadband frequency range of 30 to 520 MHz, full RF power output of 1 KW for up to a VSWR of 2:1 and a new amplifier module design for more convenient maintenance and better configuration. It is fully qualified to meet the most extreme environmental conditions. The amplifier's height is only 7U and it contains a new cooling heat-pipe combination of air conduction.

www.mw-elisra.com

Booth 507

Hittite Microwave Corp. Booth 521

Clock Generator

Hittite's new HMC1031MS8E is an ultralow power integer-N PLL clock generator. It includes a phase/frequency detector with



a charge pump current output, a low power integer-N divider resulting in reference fre-

quency multiplication ratios of $\times 1$, $\times 5$ and $\times 10$. The HMC1031MS8E may be used with a low phase noise VCXO to multiply 10 MHz TCXO or OCXO sources with excellent long-term stability to 50 or 100 MHz. The integrated phase detector and charge pump are capable of operating up to 140 MHz.

VENDORVIEW

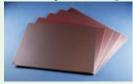
www.hittite.com

Rogers Corp.

Booth 525

High Performance Laminates

Rogers Corp.'s Advanced Circuit Materials Division provides high performance



laminates for use in high frequency and/or high reliability applications. Rogers will

be showcasing its wide range of products including RO4000® LoPro $^{\rm IM}$, RT/duroid® 6035HTC and RT/duroid 5880LZ high frequency laminates, and the new 2929 bondply.

VENDORVIEW

www.rogerscorp.com

Mini-Circuits

MMIC Amplifier

Mini-Circuits' CMA-545+ is an E-PHEMT based ultra-low noise MMIC amplifier operating from 50 MHz to 6 GHz with a unique combination of low noise and high IP3. This



design operates on a single 3 V supply and is internally matched to 50 Ohms.

The MMIC amplifier is bonded to a multilayer integrated LTCC substrate and then hermetically sealed under a controlled nitrogen atmosphere with gold-plated covers and eutectic AuSn solder. They have been tested to MIL requirements for gross leak, fine leak, thermal shock, vibration, acceleration, mechanical shock and HTOL.



www.minicircuits.com

MICRO-ADS

Rugged....



What makes our switches rugged? All AST switches come 100% sealed, but when outdoor weather is a factor, AST switches are unbeatable. Our unique "Weather" option provides protection against the most severe weather that mother nature can dish out. Our "Weather Cap" protects the manual override and can be removed without the use of tools. Come and see why AST switches are used in a majority of outdoor applications

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DI OPEN RESONATORS

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The Book End



Radio Interferometry and Satellite Tracking

Seiichiro Kawase

Microwave Week focus on space applications, we are reviewing Radio Interferometry and Satellite Tracking. Worldwide growth of space communications has caused a rapid increase in the number of satellites operating in geostationary orbits. Satellites are being placed in orbit with less and less distance separating them plus planned satellites are competing for vacant orbital positions. Thus, we are faced with the problem of an overcrowded orbit.

Satellites are faced with an additional problem as RF interference tends to occur when an Earth station emits un-

wanted signals to satellites (see our article from last month on solving satellite interference). Locating such an Earth station on the map requires a special tracking method, which is based on the same principle as the satellite tracking interferometer so this topic is also covered in the book.

Radio Interferometry and Satellite Tracking is designed to help professionals overcome these problems. This book provides a solid understanding of the use of radio interferometers for tracking and monitoring satellites in overcrowded environments. Practitioners and students can learn the fundamentals of radio interferometer hardware, including antennas, receiving equipment, signal processing and phase detection, and measurement accuracies.

The book describes the nature of the targets to be tracked by the interferometer, helping to clarify the movement of target satellites and what specific information has to be caught by the interferometer. Additionally, engineers and students find details on applications to practical cases of satellite tracking, covering different types of interferometers, recent technical developments, orbital monitoring and safety control. This book covers the subject very thoroughly and is a good learning and reference tool on the subject.

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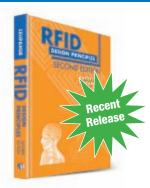
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Agilent Technologies, Inc.	35, 95, 135, 137, 139	MILCOM 2012	183
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American Technical Ceramics	28		57, 107, 121,
Anaren Microwave	75		157, 187, 193
Anatech Electronics, Inc.	126	MITEQ Inc.	3, 165
Anritsu Company	81	Modco, Inc.	189
Ansys, Inc.	31	Modpak, Inc.	189
AR RF/Microwave Instrumentation	69	Munich International Trade Fairs,	
Artech House	158, 190	German American Chamber of Commerce, Inc. (Electronica 2012)	68
ASELSAN	84	Narda Microwave-East, an L3 Communications Co.	26, 154
Astrolab, Inc.	105	National Instruments	37
Avago Technologies, Inc.	99	Nexyn Corporation	90
AWR	11	NoiseWave Corp.	8
AWT Co., Ltd.	136	Norden Millimeter Inc.	38
B&Z Technologies, LLC	33	NXP Semiconductors USA, Inc.	89
Bonding Source	83	OML Inc.	163
Boonton Electronics (a Wireless Telecom Group Company)	COV 2	Pascall Electronics Limited	46
Carlisle Interconnect Technologies	13	Pico Technology	56
CDM Electronics	158 80	Pivotone Communication Technologies, Inc.	151 131
Cernex, Inc.		Planar Monolithic Industries, Inc.	COV 3
Ciao Wireless, Inc. Coilcraft	40 15	Programmed Test Sources, Inc. Pulsar Microwave Corporation	42
COMSOL, Inc.	29	Quest Microwave Inc.	94
Comtech PST Corp. (Hill Engineering Division)	32	R&K Company Limited	166
Copper Mountain Technologies	55	Radio Waves, Inc.	127
CPI Beverly Microwave Division	113	Reactel, Incorporated	43
Crane Aerospace & Electronics	54	Remcom	129
Cree, Inc.	39	RFHIC	22-23, 167
CST of America, Inc.	27	RFMD	111
CTS Valpey	30, 156	RFMW, Ltd.	103
Custom MMIC Design Services, Inc.	146	Richardson RFPD Inc.	18, 19, 21
Damaskos Inc.	189	RLC Electronics, Inc.	25
dBm, LLC	140	Rogers Corporation	73
Dielectric Laboratories Inc.	97	Rohde & Schwarz GmbH	59
diminuSys	118	Rosenberger	67
Dynawave Incorporated	141	Santron Inc.	115
Eastern Wireless TeleComm, Inc.	109	Satellink, Inc.	189
EDICON 2013	173	Sector Microwave Industries, Inc.	189
EMC Technology Inc.	143	SGMC Microwave	159
ES Microwave, LLC	166	Shanghai Huaxiang Computer Communication Engineering Co., Ltd.	181
ET Industries EuMW 2012	66, 148	SignalCore, Inc.	189 98
Fairview Microwave	175, 179 171	Sivers IMA AB	98 117
Feko	61	Skyworks Solutions, Inc. Special Hermetic Products, Inc.	189
Florida RF Labs Inc.	143	Spectrum Elektrotechnik GmbH	85
Frontlynk Technologies Inc.	96	Spinner GmbH	82
G.T. Microwave Inc.	102	Stanford Research Systems	125
Herley Industries, Inc.	100	State of the Art, Inc.	134
Herotek, Inc.	92	SV Microwave, Inc.	149
Hittite Microwave Corporation	91, 93	Synergy Microwave Corporation	53, 161
Holzworth Instrumentation	142	Tecdia, Inc.	88
Huber + Suhner AG	63	Teledyne Coax Switches	145
IEEE MTT-S International Microwave Symposium 2013	191	The IÉT	44
IMST GmbH	72	Times Microwave Systems	155
Ingun Prufmittelbau GmbH	64	United Monolithic Semiconductors	71
International Manufacturing Services, Inc.	38	Universal Microwave Components Corporation	128
JFW Industries, Inc.	101	UTE Microwave Inc.	133
K&L Microwave, Inc.	7	Vaunix Technology Corporation	178
KR Electronics, Inc.	189	Virginia Diodes, Inc.	119
Krytar	70	W.L. Gore & Associates, Inc.	106, 108
Kunshan Advanced Microwave Technologies Co., Ltd.	122	Waveline Inc.	112
Linear Technology Corporation	51	Weinschel Associates	60
M/A-COM Technology Solutions	79 177	Wenzel Associates, Inc.	114
Maury Microwave Corporation MECA Electronics, Inc	177	Werlatone, Inc. WIN Semiconductors Corp.	COV 4 65, 169
MegaPhase	.6 34	Win Semiconductors Corp. Wright Technologies	65, 169 50
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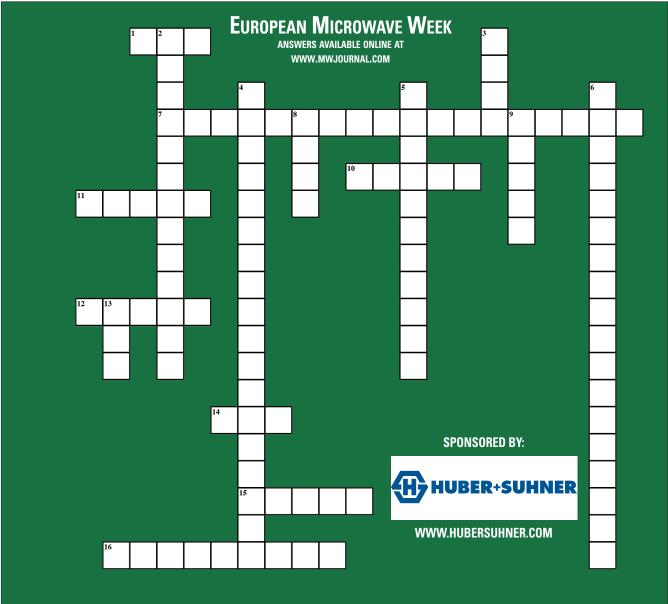
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applications

1 Short for Seventh F	ramework Programme
7	_ is spending roughly €10 billion per year on FP7 (2 words)
10 About 100 MHz o	f space is available but is more likely to be used for M2M

- 11 Short for World Interoperability for Microwave Access
- 12 Short for European Microwave Integrated Circuits
- 14 Popular ______ topologies are the inductive source-degeneration common-source, common-gate and resistive feedback
- 15 Short for European Radar Conference
- 16 A ______ laminate can significantly reduce the spurious second harmonic response of a microstrip edge coupled bandpass filter without increasing design complexity

Down

- throughout Europe (3 words)

 5 The name of the proposed €80 billion investment programme for research and
- innovation for 2014 through 2020 (2 words)

 6 New method of data acquisition/signal processing that allows sparse signals to be sampled at a much lower frequency than the Nyquist rate (2 words)
- 8 Short for European Microwave Conference
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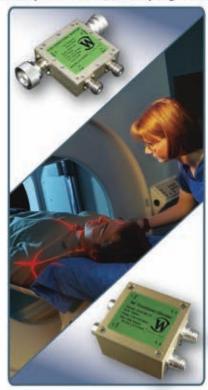
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D7801	8-Way (90°)	121-124	75	7,500	0.75	1.25	5	20	10 x 8 x 2.25
D7743	16-Way (22.5°)	125-128	400	8,000	0.85	1.40	5	20	12 x 12 x 4
QH8589	2-Way (90°)	126-130	500	5,000	0.3	1.20	5	20	3 x 3 x 1.88
D6861	8-Way (45°)	290-300	200	4,000	0.5	1.25	5	20	10 x 8 x 2.25
D7167	16-Way (22.5°)	290-300	400	8,000	0.65	1.30	5	20	12 x 12 x 4
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