Vol. 55 • No. 12

December 2012

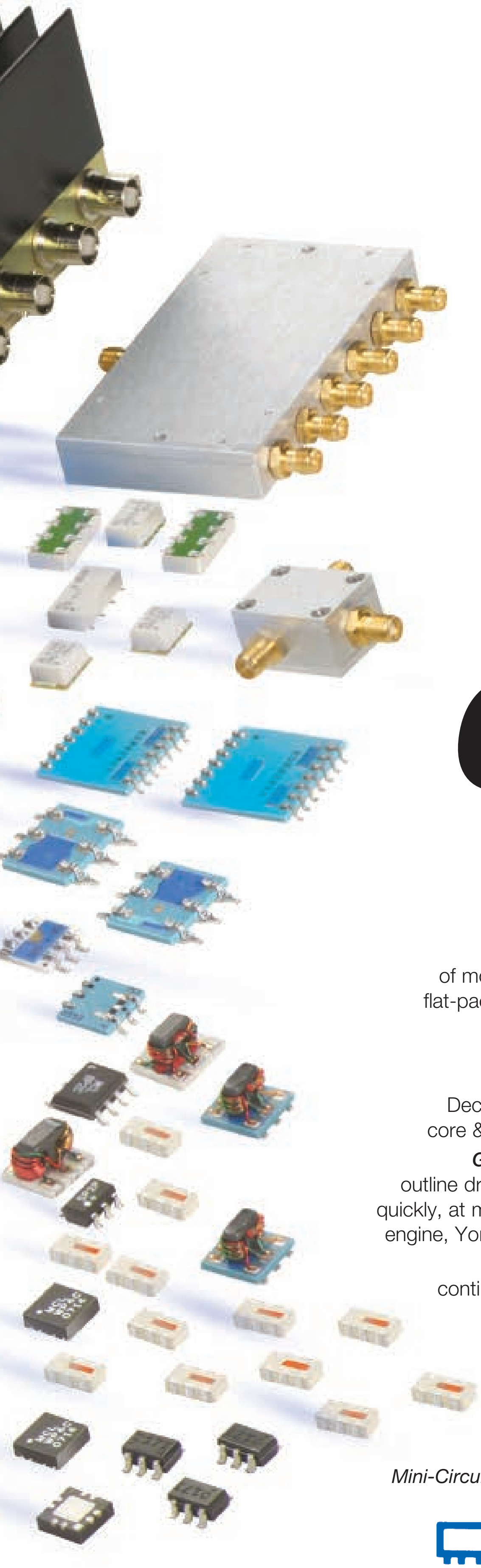
Microwave Journal®

horizon house®

Founded in 1958

mwjournal.com


MCL B 744
ADP-2-10



World-Class
Technology & Support
Worldwide Availability
JZ
4.5 x 3.2 x 1.5 mm
JR
3.5 x 3.1 x 1.15 mm
JV
3.2 x 2.5 x 1.25 mm
JQ
2.7 x 2.2 x 1.0 mm
JN
1.7 x 1.5 x 0.9 mm
NEW
J-Series
Half-Turn
Ceramic Trimmer
Capacitors
Product Features Include:
• High Performance, High Q
• Small Size
• Surface Mount Installation
• Less than 1% Capacitance Drift
• Frequencies to 1 GHz
• High Volume and Small Lots Available
• Crosses to Sanshin Part Numbers
• Tape and Reel Packaging
• New High Voltage JZ Series Supporting up to 300 Volts
The Trimmer Capacitor Company
RF & Microwave Filters and Trimmer Capacitors at One Location
Same Experienced and Knowledgeable Staff
Same Well-Respected and Reliable Products
K&L Microwave and Voltronics, both part of the Ceramic & Microwave Products Group, are now located at the same facility in Maryland.
K&L MICROWAVE
www.klmicrowave.com
Voltronics
A DOVER COMPANY
CMP
www.voltronicscorp.com
CERAMIC & MICROWAVE PRODUCTS
A DOVER COMPANY
BSC FILTERS • DOW-KEY MICROWAVE • NOVACAP • SYFER TECHNOLOGY
DIELECTRIC LABORATORIES • K&L MICROWAVE • POLE/ZERO • VOLTRONICS


WHY
NATE
National Association of Tower Erectors
?
NATE has something for EVERYONE in the tower industry.
NATE STAR Initiative
Safety & Education
Access to key players in the tower industry
Annual Conference & Exposition
NATE membership list
Standards
Training
Networking
Legal counsel
Tower Times magazine
Strong voice in Washington, D.C.
Opportunities to feature your products/services
NATE 2013
February 18-21
Fort Worth, Texas
www.natehome.com
You Tube
Photo Courtesy of Stuart Goettsch, Wallen Communications

Microwave Journal

DECEMBER 2012 VOL. 55 • NO. 12

NOTE FROM THE EDITOR

COVER FEATURE

MVP: MOST VALUABLE PRODUCT

PERSPECTIVE

TECHNICAL FEATURES

Microwave Journal (USPS 396-250) (ISSN 0192-6225) is published monthly by Horizon House Publications Inc., 685 Canton St., Norwood, MA 02062. Periodicals postage paid at Norwood, MA 02062 and additional mailing offices.

Photocopy Rights: Permission to photocopy for internal or personal use, or the internal or personal use of specific clients, is granted by *Microwave Journal* for users through Copyright Clearance Center provided that the base fee of $5.00 per copy of the article, plus $1.00 per page, is paid directly to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 USA (978) 750-8400. For government and/or educational classroom use, the Copyright Clearance Center should be contacted. The rate for this use is 0.03 cents per page. Please specify ISSN 0192-6225 *Microwave Journal* International. *Microwave Journal* can also be purchased on 35 mm film from University Microfilms, Periodic Entry Department, 300 N. Zeeb Rd., Ann Arbor, MI 48106 (313) 761-4700. Reprints: For requests of 100 or more reprints, contact Barbara Walsh at (781) 769-9750.

POSTMASTER: Send address corrections to *Microwave Journal*, PO Box 3256, Northbrook, IL 60065-3256 or e-mail mwj@omeda.com. Subscription information: (847) 291-5216. This journal is issued without charge upon written request to qualified persons working in the RF & microwave industry. Other subscriptions are: domestic, $120.00 per year, two-year subscriptions, $185.00; foreign, $200.00 per year, two-year subscriptions, $370.00; back issues (if available) and single copies, $10.00 domestic and $20.00 foreign. Claims for missing issues must be filed within 90 days of date of issue for complimentary replacement.

Posted under Canadian international publications mail agreement #PM40612608

Microwave Journal

SPECIAL REPORTS

PRODUCT FEATURES

TECH BRIEF

Departments

STAFF

Publisher: Carl Sheffres
Editor: David Vye
Managing Editor: Jennifer DiMarco
Technical Editor: Patrick Hindle
Associate Technical Editor: Dan Massé
Staff Editor: Laura Glazer
Editorial Assistant: Barbara Walsh
Consulting Editor: Harlan Howe, Jr.
Consulting Editor: Frank Bashore
Consulting Editor: Peter Staecker
Consulting Editor: Dan Swanson
Web Editor: Chris Stanfa
Audience Development Manager: Michelle Barry
Traffic Manager: Edward Kiessling
Marketing and Event Coordinator: Kristen Anderson
Director of Production & Distribution: Robert Bass
Art Director: Janice Levenson
Graphic Designer: Sachiko Stiglitz

EUROPE
International Editor: Richard Mumford
Office Manager: Nina Plesu

CORPORATE STAFF
CEO: William M. Bazzy
President: Ivar Bazzy
Vice President: Jared Bazzy

Executive Editorial Office:
685 Canton Street, Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
e-mail: mwj@mwjournal.com

European Editorial Office:
16 Sussex Street, London SW1V 4RW, England
Tel: Editorial: +44 207 596 8730 Sales: +44 207 596 8740
FAX: +44 207 596 8749

www.mwjournal.com

Printed in the USA


High pressure,
time sensitive, mission critical.
It's all in a day's work.
Your team depends on you for mission-critical accuracy. And you can depend on the compact Agilent FieldFox spectrum analyzer. At only 6.6 lbs., it ensures peak accuracy without warm-up time and its precise measurements agree with trusted benchtop results. Which means, you'll always be ready to accelerate your team's success.
FieldFox Spectrum Analyzers
Four models up to 26.5 GHz
MIL-PRF-28800F Class 2 rugged
Agrees with benchtop measurements
± 0.5 dB amplitude accuracy (full band)
See how FieldFox measures up— watch the video. Scan the code or visit http://qrs.ly/gb20ppv
Agilent and our Distributor Network
Right Instrument.
Right Expertise.
Delivered Right Now.
Buy from an Authorized Distributor
www.agilent.com/find/distributors
Learn about interference analysis and more with our application note series
www.agilent.com/find/FieldFoxSA
© Agilent Technologies, Inc. 2012
Anticipate ___Accelerate ___Achieve
Agilent Technologies

Microwave Journal Online

Visit us @ mwjournal.com

Free Webinars

Technical Education Training Series
Presented by: Henry Lau, Lexiwave Technology
RF PCB Design — On Demand after 12/4
Sponsored by: AWR and LPKF Laser & Electronics

Technical Education Training Series
Presented by: John McNeill
VCO Fundamentals
Sponsored by: Mini-Circuits — On Demand after 12/5

CST Webinar Series 2012
Chip/Package/Board:
Constraint Driven Co-Design — 12/6, 11:00 AM ET

CST Webinar Series 2012
Simulation of EMI in Hybrid Cabling for
Combining Power and Control Signaling — 12/13, 11:00 AM ET

Innovations in EDA
by Agilent Technologies
Envelope Tracking Simulation and Analysis — 12/13, 1:00 PM ET

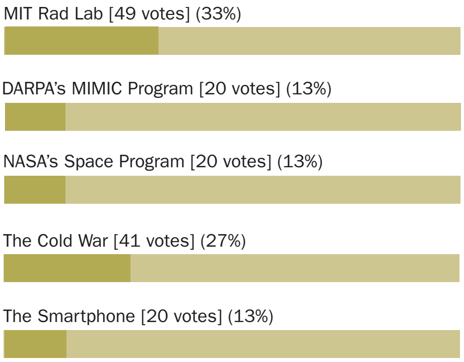
Web Survey

What was the big news of 2012?

Look for our multiple choice survey online at mwjournal.com

October Survey

"...Had the Biggest Impact on the Development of Microwave Technology"



Executive Interview

Robert Stephens, President of Aeroflex / Weinschel, talks about the RF/microwave control components market, the evolution of the technology to support today's systems and test instrumentation and the company's 60 year milestone.

White Papers

Higher Data Rates Require New De-embedding Techniques
White Paper, Anritsu

Arbitrary Waveform (AWG)
White Paper, Agilent Technologies

Understanding and Correctly Predicting Critical Metrics for Wireless RF Links
Joel Kirschman, AWR Corp.

CVD Diamond High Power Resistors and Terminations
Application Note, EMC Technology and Florida RF Labs

High Voltage Inverting Charge Pump Produces Low Noise Positive and Negative Supplies
Application Note, Linear Technology

Join Us

(direct links at www.mwjournal.com)

LinkedIn Group "RF and Microwave Community"

Facebook
Microwave Journal Fan Page

Follow us on **Twitter**
@mwjournal
@pathindle
@KAatMWJ
@mphallman
@mwjournalnews

.COM

6GHz Mixer Delivers 32dBm OIP3

LTC5544

Excellent Performance at 5.8GHz

IIP3 = 25.8dBm
Conversion Gain = 6.4dB
NF = 12.8dB

OR

Take Your Chances

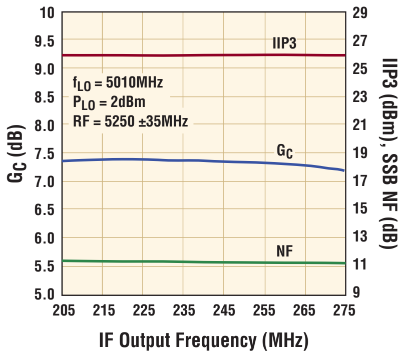
High Level Integration with LO Buffer, IF Amplifier and Balun Transformer

With its high level of integration, the LTC®5544 brings an unprecedented level of compactness, ease of use and outstanding performance that you can count on.

Features

- 4 to 6GHz Frequency Range
- 32.2dBm OIP3 at 5.8GHz
- 14.6dBm P1dB
- 2dBm LO Drive
- 50Ω Matched Single-Ended RF and LO Inputs
- Outstanding Blocking Performance
- IF Output up to 1GHz

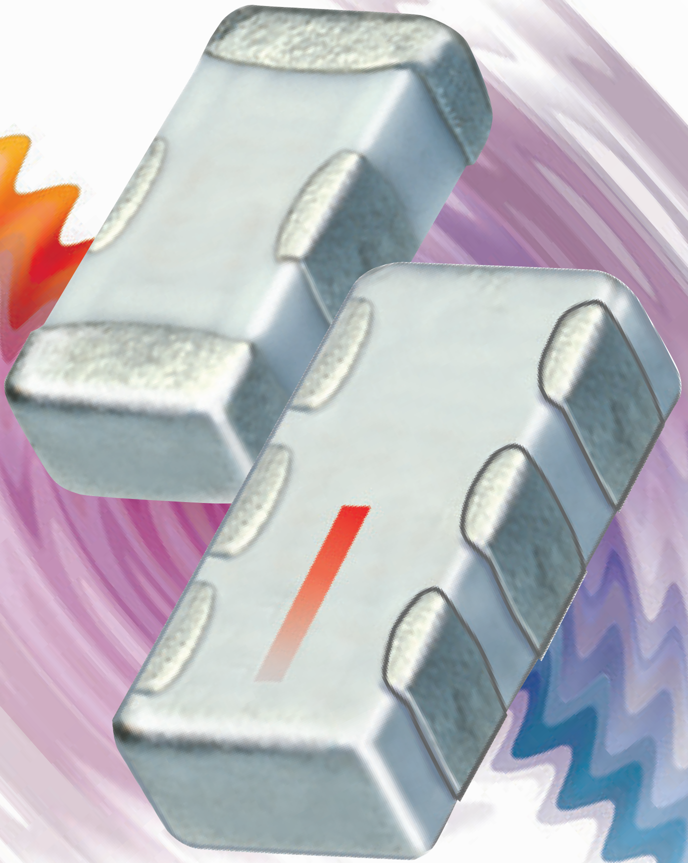
Wideband Conversion Gain, IIP3, NF at 240MHz IF



Info & Free Samples

www.linear.com/product/LTC5544
1-800-4-LINEAR

LINEAR TECHNOLOGY



CERAMIC FILTERS

LOW PASS BANDPASS HIGH PASS

45 MHz to 13 GHz from 99¢ *ea. qty.3000*

Over ~~167~~ 179 models...only 0.12 x 0.06" These tiny hermetically sealed filters utilize our advanced Low Temperature Co-fired Ceramic **(LTCC)** technology to offer superior thermal stability, high reliability, and very low cost, making them a must for your system requirements. Visit our website to choose and view comprehensive performance curves, data sheets, pcb layouts, and everything you need to make your choice. You can even order direct from our web store and have units in your hands as early as tomorrow!

***Wild Card* KWC-LHP LTCC Filter Kits** *only $98*

Choose any 8 LFCN or HFCN models
Receive 5 of ea. model, for a total of 40 filters
Order your KWC-LHP FILTER KIT TODAY!

RoHS compliant U.S. Patents 7,760,485 and 6,943,646

Now available in small-quantity reels at *no extra charge:*
Standard counts of 20, 50, 100, 200, 500, 1000 or 2000. Save time, money, and inventory space!

Mini-Circuits…we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yoni2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

JANUARY 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
30	31	1	2	3	4	5
6	7 RFIC 2013 Call for Papers Deadline	8	9	10 **Webinar:** **Freescale's PA Design Methodology Innovations** Sponsored by Agilent Technologies	11	12
13	14	15 **Webinar:** **FieldFox Microwave Analyzer Series** Sponsored by Agilent Technologies	16	17 **Webinar:** **Measurement Uncertainty Basics** Sponsored by Agilent Technologies	18	19
20 IEEE Radio and Wireless Symposium (20–23) MEMS 2013 (20–24)	21	22	23	24 **Webinar:** **HetNets** Sponsored by Agilent Technologies	25	26
27	28 DesignCon 2013 (28–31)	29	30 **Webinar:** **Signal Generation Fundamentals** Sponsored by Agilent Technologies	31	1	2

IEEE Radio and Wireless Symposium

MEMS 2013 — The 26th IEEE International Conference on Micro Electro Mechanical Systems, January 20-24, 2013

DesignCon 2013 — CONFERENCE January 28-31, 2013 | EXPO January 29-30, 2013, Santa Clara Convention Center | Santa Clara, CA

Go to: mwjournal.com/events

Coming Events

CALL FOR PAPERS

WAMICON 2013
December 26, 2012

RFIC 2013
January 7, 2013

ARFTG 2013
February 15, 2013

EuMW 2013
February 17, 2013

mwjournal.com

JANUARY

IEEE RWS 2013
Radio and Wireless Symposium
January 20–23, 2013 • Austin, TX
www.radiowirelessweek.org

IEEE MEMS 2013
26th IEEE International Conference on Micro Electro Mechanical Systems
January 20–24, 2013 • Taipei, Taiwan
www.mems2013.org

DesignCon 2013
January 28–31, 2013 • Santa Clara, CA
www.designcon.com

FEBRUARY

ISSCC 2013
IEEE International Solid-State Circuits Conference
February 17–21, 2013 • San Francisco, CA
http://isscc.org

NATE 2013
18th Annual Conference and Exposition for the National Association of Tower Erectors
February 18–21, 2013 • Fort Worth, TX
http://natehome.com/annual-conference

MWC 2013
Mobile World Congress
February 25–28, 2013 • Barcelona, Spain
www.mobileworldcongress.com

MARCH

ISQED 2013
International Symposium on Quality Electronic Design
March 4–6, 2013 • Santa Clara, CA
www.isqed.org

IWCE 2013
International Wireless Communications Expo
March 11–15, 2013 • Las Vegas, NV
www.iwceexpo.com

EDI CON 2013
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

ACES 2013
29th International Review of Progress in Applied Computational Electromagnetics
March 24–28, 2013 • Monterey, CA
http://aces.ee.olemiss.edu/conference/2013

PSATS 2013
5th International Conference on Personal Satellite Services
March 28–29, 2013 • Toulouse, France
www.psats.eu

APRIL

WAMICON 2013
IEEE Wireless and Microwave Technology Conference
April 7–9, 2013 • Orlando, FL
www.wamicon.org

Microwave & RF 2013
April 10–11, 2013 • Paris, France
www.microwave-rf.com

IWS 2013
IEEE International Wireless Symposium
April 13–18, 2013 • Beijing, China
www.iws-ieee.org

SPACOMM 2013
5th International Conference on Advances in Satellite and Space Communications
April 22–26, 2013 • Venice, Italy
www.iaria.org/conferences2013

MAY

NCMMT 2013
National Conference on Microwave and Millimeter Wave

MWIE 2013
Microwave Industry Exhibition
May 18–21, 2013 • Chongqing, China
www.cnmw.org

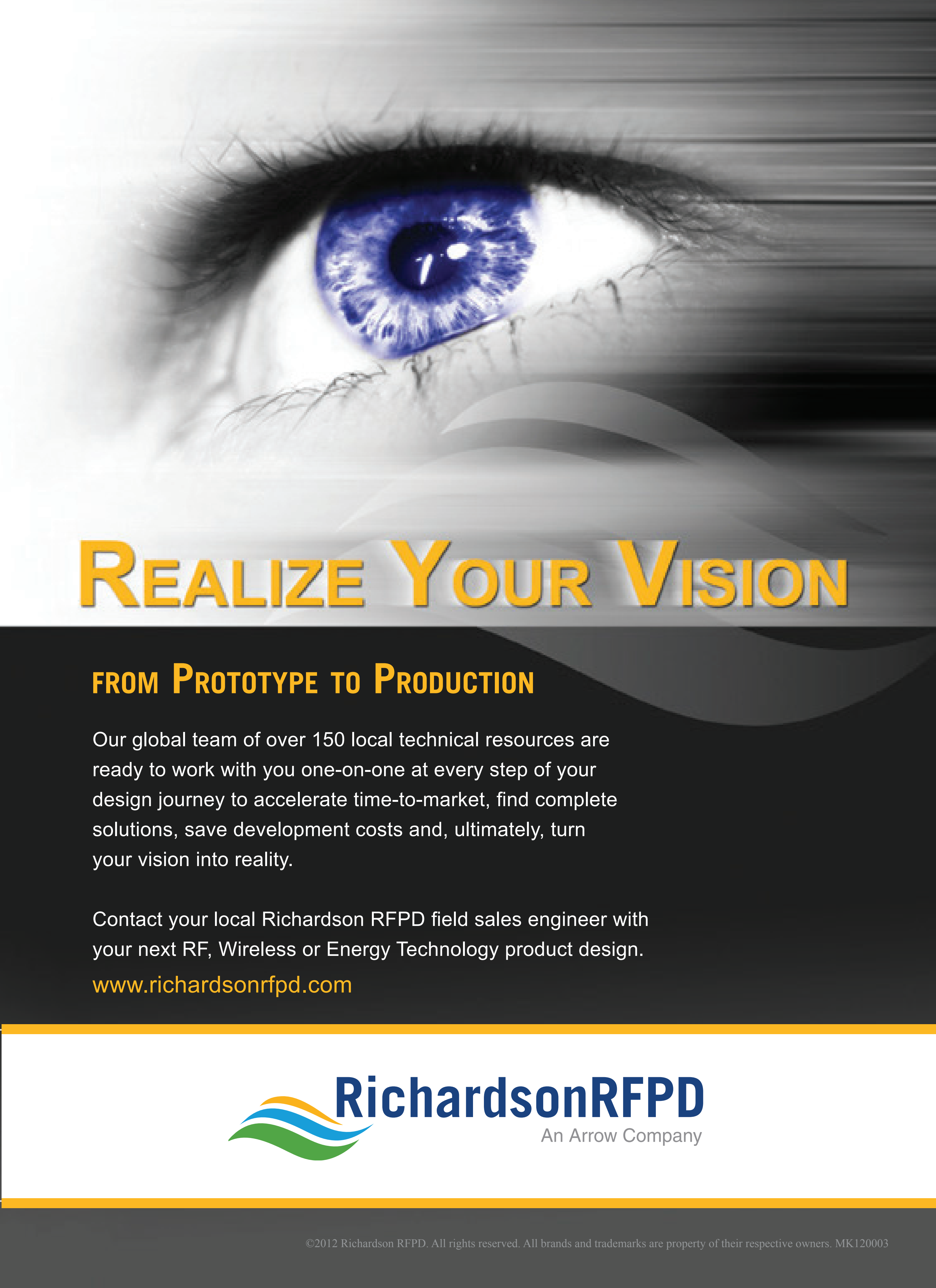
CTIA WIRELESS 2013
May 21–23, 2013 • Las Vegas, NV
www.ctiawireless.com

JUNE

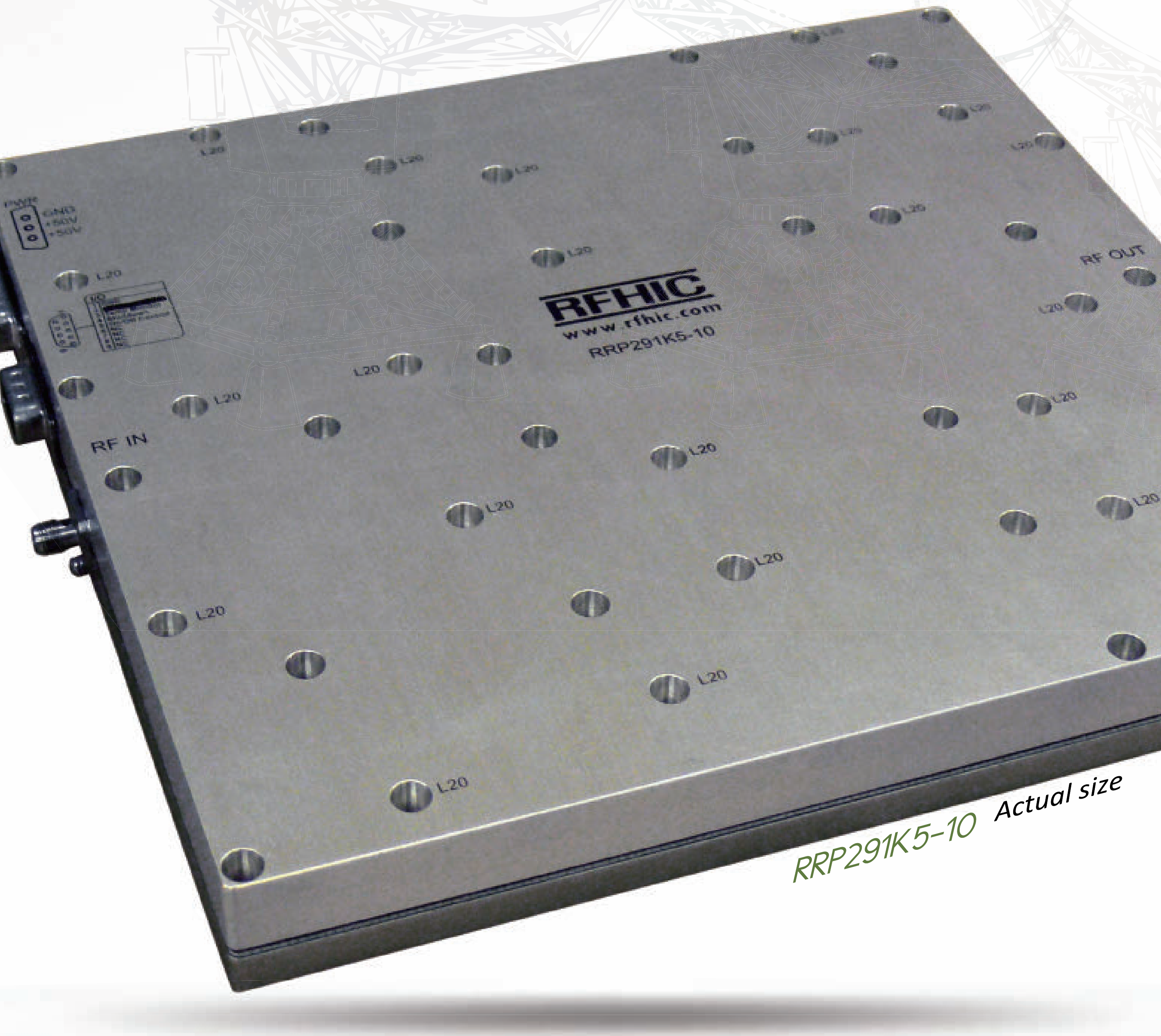
RFIC 2013
IEEE Radio Frequency Integrated Circuits Symposium
June 2–4, 2013 • Seattle, WA
www.rfic2013.org

IMS 2013
IEEE MTT-S International Microwave Symposium
June 2–7, 2013 • Seattle, WA
www.ims2013.org

81st ARFTG Microwave Measurement Symposium
June 7, 2013 • Seattle, WA
www.arftg.org


REALIZE YOUR VISION
FROM PROTOTYPE TO PRODUCTION
Our global team of over 150 local technical resources are ready to work with you one-on-one at every step of your design journey to accelerate time-to-market, find complete solutions, save development costs and, ultimately, turn your vision into reality.
Contact your local Richardson RFPD field sales engineer with your next RF, Wireless or Energy Technology product design.
www.richardsonrfpd.com
RichardsonRFPD
An Arrow Company
©2012 Richardson RFPD. All rights reserved. All brands and trademarks are property of their respective owners. MK120003

RFHIC means Affordable GaN



RRP291K5-10 Actual size

L20
L20
L20

The Year That Was…

David Vye, *Microwave Journal* Editor

2012 was an Olympic year, a political year, a jubilee year (at least in the UK); a year of celestial aspirations and turmoil back on planet Earth. It was a year spent vacillating between tepid and propitious economic forecasts. In business, the year offered opportunities and challenges – and no lack of uncertainty thanks to the European debt crisis, a potential course-changing election and looming fiscal cliff. Altogether, the economical, political and global security issues of 2012 will undoubtedly impact the pace and direction of technology funding.

For microwave technology, it was a year in which GaN and CMOS devices (switches and power amps) increased their respective market penetration, DPD and envelope tracking techniques continued to gain interest and the need for spectral capacity provided opportunities for small cell data off-loading and carrier aggregation, while over-the-air testing became essential to validating the benefits of MIMO. And at the *Journal,* it was a year to advocate for global growth with the launch of *Microwave Journal China* and EDI CON (Beijing, 2013).

Reaching for the stars was a common theme in 2012. The United States set the bar high with a successful Mars rover landing, a challenging feat portrayed in a NASA video, "Seven minutes of Terror," that went virile. For North Korea, the dream was slightly out of reach as its long-range Uhna-3 rocket carrying an observation satellite exploded 80 seconds after launch. The attempt was viewed by the U.S. and its allies as a poorly-disguised missile test.

Fairing considerably better, a Shenzhou-9 capsule carrying three Chinese astronauts successfully docked to an orbiting space module, which China had launched the previous year. The space module is to be replaced by a permanent space station around 2020 as China hopes to be the third country to send an independently manned space station into orbit. Returning from space in style, Austrian daredevil Felix Baumgartner jumped from more than 24 miles above the Earth to break the speed of sound along with the record for highest free-fall. This interest in space bodes well for future commercial activity and the microwave industry.

Back on Earth, Global security continued to be a growing concern. One year after the Arab Spring, the region's democracy movement struggled to establish stable governments in Egypt and Libya, leading to attacks on American diplomats, while an escalating civil war in Syria, fighting in Gaza, and a belligerent and defiant Iran served to demonstrate the continuing need for embedded intelligence gathering and stealthy, rapidly deployable security forces to operate beyond the limits of defense systems designed for conventional warfare. Asymmetrical conflicts continue to drive the need for more sophisticated spectrum monitoring, cognitive and coherent radio technology, ad hoc communication networks, wireless sensors, miniaturization and low-power electronics.

Infrastructure, safety and security were put to the test in a number of circumstances from the blackouts in India that left over half a billion people without power, to the devastation left in the wake of Hurricane Sandy. Storm hardened infrastructure and a smarter electric grid should be the investors' take-away from these events. Meanwhile, the tsunami that hit Japan in 2011 and its impact on the Fukushima Daiichi nuclear power plant alerted many to the risks associated with natural disasters and potential disruption to the global electronics supply chain. Mitigating this risk with manufacturing centers in Germany, the United States and Singapore, GLOBALFOUNDRIES, a foundry business launched in 2009 through the integration of the former manufacturing arm of AMD and Chartered Semiconductor, became the fastest growing semiconductor company in 2012. GLOBALFOUNDRIES is poised to address the demand for outsourced semiconductor manufacturing and the high-volume production of wireless semiconductors.

With the prospect of future wireless connectivity exemplified in this month's cover story, and the ensuing need to drive down component and system costs, many companies took steps to strengthen their technology offerings. Considerable merger and acquisition activity took place in 2012. RFMD acquired Amalfi Semiconductor, a fabless semiconductor company specializing in CMOS RF, Gaas Labs acquired Nitronex to add to its portfolio of communication semiconductor companies that include M/A-COM Technology Solutions. Device modeling was on the minds of several test equipment manufacturers as Agilent acquired Accelicon Technologies (a device modeling company from Beijing) and National Instruments strengthened its position in RF design and active device modeling expertise by acquiring NMDG. ANSYS expanded its multi-physics simulation portfolio to include embedded software development with the acquisition of Esterel Technologies.

EMC emission and immunity testing system provider, Teseq Holding AG, added two leading amplifier manufacturers to its organization with the acquisitions of IFI and Milmega, while Teledyne made big news by acquiring LeCroy. Agilent expanded its vast array of test solutions with the acquisition of AT4 Wireless Test Systems and Centellax's test and measurement business (BER testers and signal generators), while Rohde & Schwarz addressed QoS testing in wireless networks with the acquisition of SwissQual. Dragonwave acquired Nokia Seimens Networks' microwave transport business, API Technologies entered into a definitive merger agreement with Spectrum Control, Mercury Computer acquired Micronetics and Thales acquired Tampa Microwave.

The industry continues to morph and grow in support of the systems that define our changing world. The editors at the *Journal* look forward to covering your achievements in 2013 and being among the first to say, "well done."


Explore the limits.
T&M solutions for aerospace and defense.
R&S® LegacyPro
Perfect Code Emulation and Long-Term Support
Today's aerospace and defense technologies demand ever more sophisticated test and measurement solutions to stretch the limits of what is feasible. As a full-range supplier, Rohde & Schwarz offers a broad portfolio that proves its capabilities in even the most demanding applications. Our leading-edge expertise in microwave, RF and EMC helps customers assess performance, optimize platforms and get the most out of systems. Convince yourself.
www.rohde-schwarz.com/ad/space
ROHDE & SCHWARZ

A 5G Wireless Communications Vision

Everybody acknowledges that wireless communications technology has developed rapidly. It empowers our modern life, enables modern societies to operate efficiently, and has had a major impact on modern politics, economy, education, health, entertainment, logistics, travel and industry. In the last 20 years, wireless technologies have changed the world we live in. It seems as if life without modern wireless communications, as it existed before 1990, is difficult to comprehend.

Major breakthroughs and advances in communications are heavily related to the basic interests of humans. Nature has empowered us to talk and listen, leading to the demand for telephony. We are interested in information and want to share, requiring data communications. We like to collect and hunt, driving the demand for monitoring and sensing. Also, we like to steer and control within our environment, demanding control communications. Today we enjoy the power of telephony and data communications. Machine type communication and control is yet to fully enter the market. This article provides a recollection of our current state for motivating and sketching a vision of our future.

When reviewing today's situation, we see a chronology of revolutionary applications and technologies that have shaped everyday life. First and foremost, the need for untethered telephony, and therefore wireless real-time communication, has dominated the success of cordless phones, followed by cellular communications. Soon thereafter, two-way paging implemented by SMS text messaging became the second revolutionary application. With the success of wireless local area network technology (i.e., the so-called "IEEE 802.11" standard), Internet browsing, and the widespread market adoption of laptop computers, untethered Internet data connectivity became interesting and ultimately a necessity for everyone. This phenomenon opened the market for wireless data connectivity. The logical next step was the shrinkage of the laptop and merging it with the cellular telephone, which evolved into today's smartphone. We now enjoy access to the world's information at our fingertips, in any situation and at any place.

Gerhard P. Fettweis
TU Dresden, Dresden, Germany

The next wave is the connectivity of machines with other machines, referred to as "M2M." During the past years we have seen a multitude of wireless M2M applications being deployed, for example information dissemination in public transport systems. However, the commercial success has been somewhat limited. Why? The previous revolutionary applications have been clearly driven by addressing a human need, whereas M2M, by nature, needs more analysis before we can understand the basic human need it serves. Identifying that need could cause a breakthrough.

Today it is accepted that M2M is developing, without knowing how to create the large market pull. This leaves us in a situation where a coarse analysis of driving forces behind data services over the last decades needs to be undertaken.

THE WIRELESS ROADMAP

Over the years it has become evident that wireless data rates are continuously increasing over time. This is mainly driven by the need to transfer files of ever increasing size, as well as the rapid adoption and growth of streaming/podcast services. In this section, a quick review of data rate increases of wireless data applications (non-voice) over time is given, as this is seen to be the main driver of wireless technology development.

The International Technology Roadmap for Semiconductors (ITRS) shows for flash memories a history, as well as projection, of a factor of 10× in memory increase every five years, as seen in ***Figure 1***.

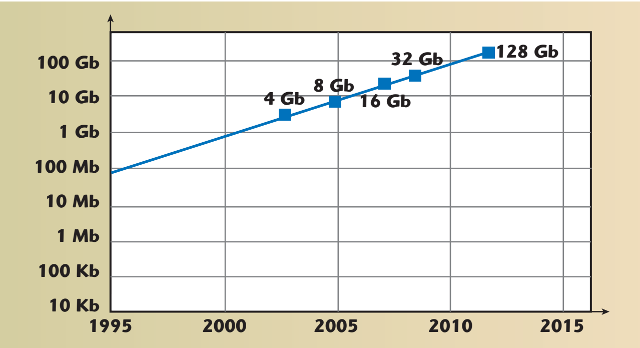
Flash memory is seen as the most important storage technology for the majority of "wireless gadgets," which require broadband connectivity. Devices that use flash memory include cellular (smart) phones, game consoles, cameras, camcorders, subnotebooks and e-books, as well as modern laptops. Hence, the storage size increase of flash memory directly drives the size and amount of data stored. As stored data needs to be moved from one device to another, storage increase also drives the need for communications bandwidth. Perhaps another perspective is the use of cloud technologies for storage. As more businesses continues to take advantage of the cloud, the demand for wireless bandwidth could potentially further accelerate wireless bandwidth and network capacity needs by several orders of magnitude over current usage.

Wireless gadgets, as previously defined, also need connectivity at different levels. USB is the transport media of choice, being an easy way of moving data quickly between two devices that are closely positioned to each other (approximately 1 meter apart). From USB 1.0 at 2 Mb/s, data rates have now increased to 4.8 Gb/s with the introduction of first USB 3.0 interfaces in 2009. Wireless USB is often considered as an alternative, in particular for connecting devices that have their own power supply and do not need the 2 W powering capability via the USB cable. For example, when downloading pictures from a digital camera to a laptop, both have batteries for operations.

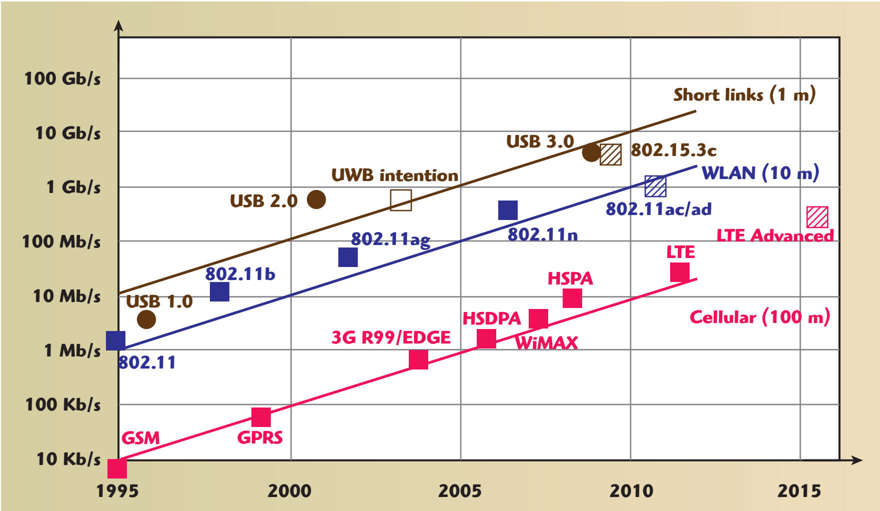
So far, however, wireless USB has not been economically successful. The main reason being that IEEE 802.11 wireless LAN (WLAN) standards have also been providing increasing data rates, as can be seen in ***Figure 2***. So far the difference in data rates between wireless USB and 802.11 is not large enough to make a noticeable difference in user experience. In addition, the cost difference for a chip set is negligible and the 802.11 protocol stack is well integrated into PC and cellular phone operating systems, whereas an 802.15 wireless USB protocol stack would require a whole new design effort with unknown engineering and debugging problems.

Therefore, even though WLAN systems are specified for a 10-meter range of operations and are intended for client-server applications in offices, hot spots or homes, they have also been able to eliminate the business case for wireless USB. The negligible speed difference between wireless USB and WLAN has virtually eliminated wireless USB's market viability.

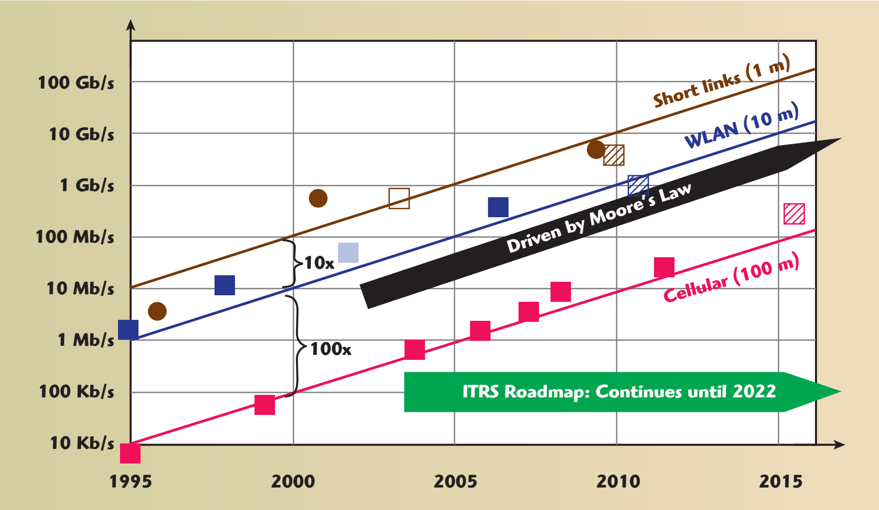
Cellular, on the other hand, has a very different business. The most important feature of cellular is to provide coverage, meaning reliable connectivity no matter where a customer is located and/or positioned. Once connectivity is available and a connection is established, the speed of data communications becomes the next challenge. With coverage and reliability sufficiently addressed, consumers are demanding higher data rates for cellular, as can be



▲ *Fig. 1 Moore's Law doubling single-chip memory capacity every 18 months leading to a 10× increase every five years.*



▲ *Fig. 2 The Wireless Roadmap.*



▲ *Fig. 3 The Wireless Roadmap matching Moore's Law.*

seen. Currently the next generation cellular, LTE, is providing data rates in the order of 36 Mb/s. This clearly fits very neatly in the projected 10× data rate increase every five years mentioned previously. Remarkably, the data rates provided by USB, WLAN and cellular all increase by 10× every five years; exactly at the same rate as the increase in size of flash memories according to the ITRS roadmap.

The speed difference of 100× in data rates between cellular and WLAN (see ***Figure 3***) has, so far, created a large enough differentiator for both technologies to be able to succeed in the market place (see Clay Christensen's "The Innovator's Dilemma," Harvard Business Press).

Cellular service providers now offer consumers femto base stations or "femto cells" in the home to improve cellular connectivity and coverage, ultimately providing access to a faster and more reliable cellular network. As small (femto) cells enter the home, and due to an improved link budget in this case, data rates in this heterogeneous network topology combined with future cellular technologies may deliver data rates approaching WLAN. This could create a situation where cellular may encroach upon the WLAN value proposition. However, due to the fact that cellular chip sets are typically more expensive than WLAN, in part because of the cellular technology high IP licensing costs, it is anticipated that WLAN will remain a dominant player in the market.

One question remains: "Is there a need for data rates beyond 100 Mb/s in the future?" Today, more than 50 percent of the data volume measured in cellular networks is generated by users' increasing use of streaming applications. As high-definition 3D streaming with user-enabled vision angle control requires data rates in the order of 100 Mb/s, and users want quick downloads of typically above 100× real-time of multiple streams, we will see more than 10 Gb/s wireless connectivity as a future requirement. Obviously this does not lead to a need for a continuously sustainable very high bandwidth for one user over long periods of time. Instead, for example, 100 Gb/s data rates will be shared via the wireless medium.

SETTING THE STAGE FOR LTE AND BEYOND

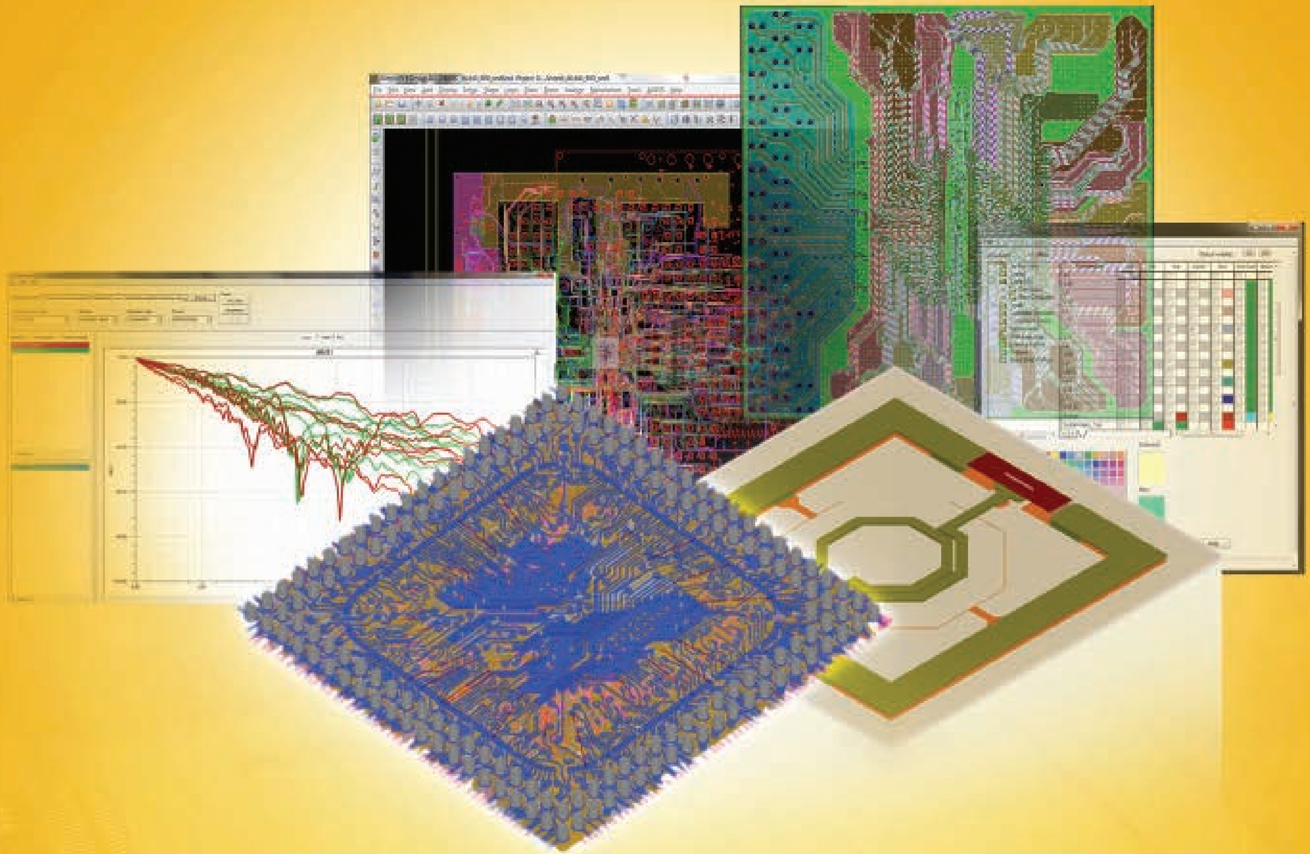
Cellular technologies will continue to be driven by demands for not only reliable coverage but also high data rate access. Cellular service providers are introducing 4G LTE with a new Orthogonal Frequency Division Multiple Access (OFDMA) transmission scheme acting as a stepping stone for providing higher data rates with future improvements, which will enter the standardization process later. Initially, LTE networks will offer the same speed order as HSPA+, its predecessor. This repeats the case we have seen at the time of 3G UMTS introduction, which was also rolled out with data rates comparable with previous second generation enhancements of 384 kb/s EDGE. The new OFDMA air interface of LTE will provide the foundation for developing enhanced standards, what is currently referred to as LTE-Advanced. LTE-Advanced technologies therefore can be seen as a further stepping stone for cellular evolution along the data rate increases in the projections of Moore's Law and as required by the market.

Considering the technology and market forces in 10 years, we must be able to address speeds of 10 Gb/s or more. Current systems do not scale to this requirement. Using OFDMA for these data rates, the analog/digital conversion with 10-bit resolution alone would represent a power consumption challenge that cannot be resolved with current technology projections. Hence, the power consumption determines that a new physical layer approach needs to be found for 5G cellular communications.

DRIVING TECHNOLOGY BY HUMAN NEEDS: SENSING, MONITORING, COLLECTING

One of human nature's greatest desires is to hunt and collect information in order to learn more about the status of our environment. This natural trait has found its way into a plurality of smartphone apps, which are available for tracing and tracking not only weather information, but the status of many different items and things. Obviously, this is not even a start when taking this to a more extreme view. For example, given that the status of every individual flower plant could be monitored and classified according to the kind of plant, we could ensure proper light and moisture for optimum growth and health. What is true in terms of desire for monitoring of flower plants is also true for many other applications. Examples are environmental status, traffic status, vehicle status, heating, ventilation, and air conditioning (HVAC) and its environmental status, and health monitoring. Clearly a large amount of monitoring can be achieved only if monitoring terminals can be designed to operate very simply, and for an extremely long duration.

An example of simple handling could be that such a sensing device would be activated by connecting the battery. The strip has a number or barcode which must be entered into a smartphone, initiating the download of an app and connecting the



app with the device. By repeating this procedure for any additional device of the same kind, it would be added automatically to the same app. This is true for large deployment of M2M, at very low data rates, but with very large numbers of devices. This vision can come true if the M2M devices are connected via cellular networks and not only via WLAN or ZigBee. The reasons are the availability of cellular coverage, combined with the simplicity of handling as users do not have to set up and connect to a ZigBee or WLAN hotspot. This makes it simple enough for every person to be able to buy M2M sensors and participate in the collection of data.

The vision is that of "Things 2.0." In Web 2.0, every person participates in social networks by disclosing personal information as well as their current status, documented in text, pictures, and relationships to others. In the world of Things 2.0, every M2M device participates by communicating its type and its status, and this information needs to be grouped in communities for aggregating and providing information. These communities could include hobby devices of the same class, for example, skis. If every ski communicated the current status of the run, you could instantaneously select the type of slope you are looking for considering elements such as ice for speed, moguls, powder, etc., and create "Skis 2.0." The same would be true for other activities, Surfing 2.0 for instance. The wave coming could be monitored and classified, not missing your chance for catching a great ride. Other M2M communities could be Cars 2.0, Homes 2.0 and Environment 2.0. Clearly, this vision could lead to a number of connected devices, which could easily cross the number 1 trillion.

TECHNOLOGY CHALLENGES: SENSING, MONITORING, COLLECTING

When addressing the need for M2M sensing, it must be translated into technical requirements specification, which serves as a design goal. As the M2M sensing requirements differ widely from one application scenario to another, a sensible specification must be developed that serves the needs of a dominating majority.

The best solution would be a device that could be activated, runs for 10 years on an AAA battery, and transmits, for example, 25 bytes of information in a duty cycle of every 100 seconds. This duty cycle could be an average, as it is moderated according to the instantaneous need. The skis from our previous example could be sitting in storage and would only be updated once a day, whereas on the slope a 1-second duty cycle might make sense. However, the question that needs to be answered is whether the power budget is reasonable. Taking the communication need of 25 B per 100 s, the resulting average data rate equals 2 b/s. Assuming a 2 MHz channel with a net capacity of 0.1 b/s/Hz (roughly GSM, and 5 percent of LTE) this results in an average of 100,000 M2M devices per cell. If every device would be billed by the operator with $1 a year this would result in $100k per cell addressable revenue.

Data rate 25 B/100s → 2 b/s average

2 MHz channel available at 2b/s/Hz → 100,000 devices per cell

$1 revenue per device per year → $100,000 revenue per cell

Assuming 16-QAM modulation with net 2 bit/symbol (after error correction coding) results in 4 Mb/s within the 2 MHz channel. Each 25 B (200 bit) packet would then require a 0.5 ms duration; adding preambles and ramp-up/down of the transceiver, roughly 1 ms duration per packet can be assumed. For this case, 25 B for uplink as well as for downlink packets results in 2 ms transceiver uptime per duty cycle, or 2×10^{-6}.

16-QAM modulation → 0.5 ms packet duration → average on-time activity of 2×10^{-6}

Considering an AAA battery with 1000 mAh @ 1 V and 10 years of M2M battery life operations, this leads to 10 µW average power available. Dividing this average by 2×10^{-6} results in a power budget of 5 W during transmit and receive, allowing for 1 W transmit power. Even when taking a standby power of 1 µW into consideration, the numbers only change marginally.

Average on-time activity of 2×10^{-6} → AAA battery allows for 10-year operation.

All the calculations above further improve when taking energy scaveng-

ing into consideration. Scavenging energy is a term for generating energy through exploiting the low power from the environment, e.g., through solar power, or exploiting vibration power through piezo elements. Therefore, the good news is that this kind of M2M Things 2.0 vision is technically possible. However, this is not true with current cellular systems as their protocols require too much communications overhead for synchronization and channel allocation that 10 years of operations off an AAA battery is far more than one order of magnitude away. Hence, a new 5G standard is needed.

DRIVING TECHNOLOGY BY HUMAN NEEDS: TACTILE REAL-TIME CONSTRAINTS

The wireless roadmap clearly shows how technology continues to drive data rates. However, other forms of human interaction besides Internet browsing and multimedia distribution can be analyzed to understand basic needs, which will be serviced by drastically new innovations over the coming decades. For this, real-time experience can be analyzed in more detail. Obviously, real time is experienced whenever the communication response time is fast enough when compared with the time constants of the application system environment. There are four types of physiological real-time constants to consider: muscular, audio, visual, and tactile.

As humans we have the ability to react to sudden changes of situations with our muscles – for example, by hitting the brakes in a car due to an unforeseen incident, or by touching a hot platter on a stove. If unprepared, the sensing to muscular reaction time is in the range of 0.5 to 1 seconds. This clearly sets boundaries for technology specification in comparable situations. An example is Web browsing. The page buildup after clicking on a link has to be in the same order of time. Henceforth, real-time browsing interaction is experienced if new Web pages can be built up after clicking on a link within 0.5 seconds. A shorter latency, that is, a faster reaction time of the Web is not necessary for creating a real-time experience. This reaction time has been serviced by initial 802.11b and 3G cellular systems.

The next shorter real-time latency constant is experienced when analyzing the hearing system. With humans, it is known that real-time interaction is experienced in conversations if the corresponding party receives the audio signal within 70 to 100 ms. This requirement means when standing more than 30 m (100 ft) apart, due to the speed of sound, real-time discussions cannot be carried out. This fact has led the International Telecommunications Union (ITU) to set this as a minimum latency requirement for telephony. Since the speed of light is 1 million times faster than sound, many applications have been designed that adhere to this restriction. For engineering system specifications, the impact has been that speech delays on telephone lines have to be in that order of magnitude. Also, lip synchronization between the video stream and the sound track needs to be within the same time lag, otherwise the sound seems disconnected to the moving image. The 4th generation cellular standard LTE meets this requirement, as well as modern 3rd generation systems, making Internet video conferencing (e.g., Skype) viable over cellular.

Our eyes, the visual sensing system of human beings, have a resolution slower than 100 Hz, which is why modern TV sets have a picture refresh rate in the order of 100 Hz. This allows for seamless video experience, translating into 10 ms latency requirement.

The toughest real-time latency is given by the tactile sensing of human bodies. It has been noted that we can distinguish latencies in the order of 1 ms accuracy. Examples are the reso-

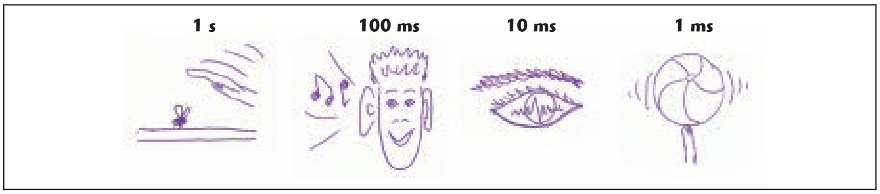


Fig. 4 Physiological real-time constants.

RFMD.

RFMD's New Highly-Integrated FEM for AMI/AMR Smart Meter Applications

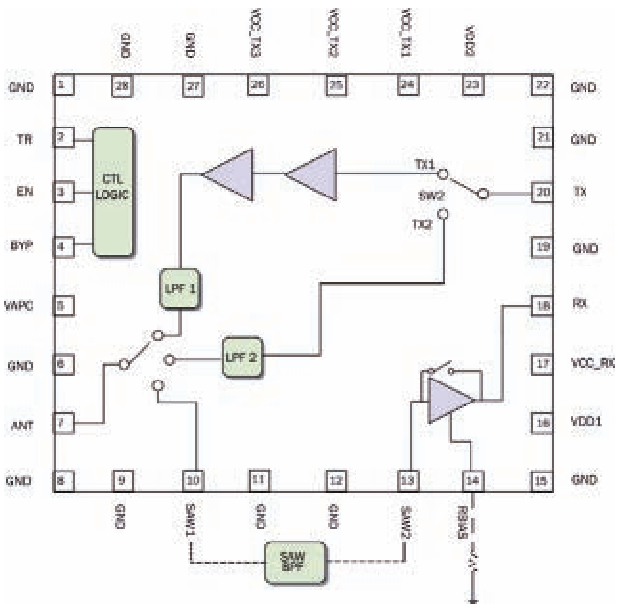
The RFFM6903 front end module meets or exceeds the system requirements for AMI/AMR Smart Meter applications operating in the 868MHz to 960MHz frequency band and supports multiple applications, including Smart Energy/advanced metering infrastructure (AMI), portable battery powered equipment, and general 868/915MHz ISM band systems.

This feature-rich FEM is ideal for advanced metering systems operating with high efficiency requirements and a minimum output power of 30 dBm. The fully integrated design approach shortens customer design time and accelerates time-to-market, while delivering industry leading product performance.

SPECIFICATIONS

Freq Range (Min) (MHz)	*Freq Range (Max) (MHz)*	*PA Gain (dB)*	*P_{OUT} (dBm)*	*OP1dB (dBm)*	*V_{SUPPLY} (V)*	*PAI_{SUPPLY} (mA)*	*Efficiency (%)*	*Switch*	*Package*	*Part Number*
868	960	21.0	30.0	30.5	3.6	800	36	SP3T	LGA, 28-pin	RFFM6903

RFFM6903 BLOCK DIAGRAM



FEATURES

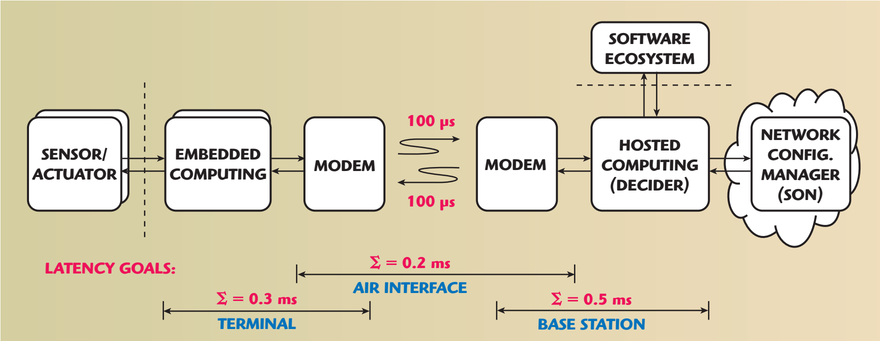
- Integrated 50Ω input/output match
- Tx output power: 30dBm
- Seperate 50Ω Tx/Rx transceiver interface
- Integrated PA, Tx filtering and LNA with bypass mode
- Transmit thru path

APPLICATIONS

- 868MHz/900MHz ISM bands
- Single chip RF front end module
- Wireless automatic metering
- Portable battery powered equipment
- Smart Energy

Come see us at CES in the ZigBee® Pavilion

RFMD
Mobility. Connectivity. Energy.



▲ *Fig. 5 The impact of breaking down the 1 ms roundtrip delay.*

lution of our tactile sensing when we move our fingers back and forth over a table with a scratch. By our high sensing resolution, we can experience the scratch in the same position. Also, tactile-visual control is in the same order of magnitude, when moving an object on a touch screen for example. If we move our hand at a rate of 1 m/s, at 1 ms latency the image follows the finger with a displacement of approximately 1 mm. A latency of 100 ms would create a 100 mm (4") displacement. A similar experience can be made by moving a mouse and tracking the cursor on the display. Since we see a differential signal over a static background, a screen update resolution finer than 10 ms is necessary. More extreme situations where the 1 ms latency requirement can be experienced are when moving a 3D object with a joy stick or in a virtual reality environment. A real-time cyber physical experience can only be given if the electronic system adheres to this extreme latency time constraint. This is far shorter than current wireless cellular systems allow for, missing the target by nearly two orders of magnitude (see ***Figure 4***).

TECHNOLOGY CHALLENGES: REAL TIME

When a wireless engineer deals with latency restrictions, they need to consider the speed of light. In 1 ms, light travels 300 km. However to consider a 1 ms roundtrip latency constraint, see the possible distribution over the individual components depicted in ***Figure 5***. It is a very rough distribution of latency within the chain of communication from the sensor through the operating system, the wireless/cellular protocol stack, the physical layer of terminal and base station including the latency of speed of light, the base station's protocol stack, the trunk line to the compute server, the operating system of the server, the network within the server to the processor, the computation, and back through the equivalent chain to the actuator.

Each and every element of this communications and control chain must be optimized for latency. Clearly, as the time budget on the physical layer is 100 µs maximum, LTE with OFDMA symbol duration of 70 µs is

not going to be the solution. A completely new and revamped 5G cellular standard needs to be designed.

CONCLUSION

At Technical University of Dresden (TU Dresden), research on the new technologies of 5G wireless systems is being conducted using National Instruments (NI) RF and communications tools, including NI LabVIEW system design software and NI PXI products. The TU Dresden 5G wireless lab is one of the first in the world that is comprehensively addressing these challenges. Research results will be used to influence and drive the global standards for the next phase of wireless communications.

The new challenges of 5G cellular communications can be derived from a user-centric perspective, requiring 10 Gb/s data rates to address network traffic constraints of today's 4G systems, 10 years of operations for M2M sensing devices, as well as 1 ms real-time latency (see ***Figure 6***). As all three dimensions may not need to be addressed simultaneously for any class of service, it can be assumed that it is feasible to design a new 5G system that can meet these differing requirements, and that it will clearly differ from 4G LTE.

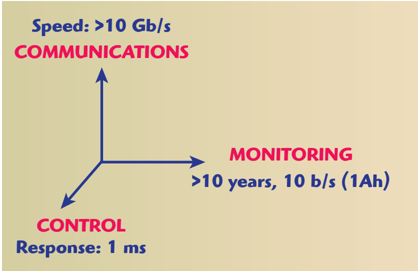


Fig. 6 The wireless network moving from communications to monitoring to control.

- Data rates of 10 Gb/s will enable immersive virtual reality at levels not foreseen.
- Communicating sensors embedded in our environment will enable a new world of Things 2.0. We will move from cellular/wireless communications to a new level of wireless monitoring.
- And a roundtrip latency of 1 ms will move the world from enjoying today's wireless communication systems into the new world of wireless control systems. It will dramatically change our life, impacting all aspects of application areas such as health, safety, traffic, education, sports, games and energy.

The result will be that we will see revolutionary steps from today's wireless communication to future monitoring and to future control networks. The wireless opportunities lying ahead are larger than anyone can foresee. What we experience today is only the very first glimpse. Obviously, with challenges as pointed out here, 5G cellular communication will be the base for our future, impacting societies in ways which cannot be foreseen yet.■

Gerhard P. Fettweis *earned his Ph.D. from RWTH Aachen in 1990. Thereafter he was at IBM Research and TCSI Inc., California. Since 1994 he is Vodafone Chair Professor at TU Dresden, Germany, with main research interest on wireless transmission and chip design. He is an IEEE Fellow and an honorary doctorate of TU Tampere.*

For more information about the NI platform that enabled this research, go to www.mwjournal.com/tudresdenNI.

High Performance...

Mixers

Model Number	RF/LO Frequency (GHz)	IF Frequency (GHz)	LO Power (dBm)	Conversion Loss (dB) Typ./Max.	LO-to-RF Isolation (dB) Min.
DOUBLE-BALANCED VERSIONS					
DM0052(L)A2	0.5 - 2	DC - 0.5	7 - 13	6.5/8.5	25
DM0104(L)A1	1 - 4	DC - 1	7 - 13	5.5/7	30
DM0208(L)W2	2 - 8	DC - 2	7 - 13	7/8	30
DM0408(L)W2	4 - 8	DC - 2	7 - 13	5/6	30
DM0812(L)W2	8 - 12	DC - 4	7 - 13	4.5/6	30
DM0416(L)W2	4 - 16	DC - 4	7 - 13	7/8	30
DB0218(L)W2	2 - 18	DC - 0.75	7 - 13	6.5/8.5	22
DB0226(L)A1	2 - 26	DC - 0.5	7 - 13	9/10	20
DB0440(L)W1	4 - 40	DC - 2	10 - 15	9/10	20
TRIPLE-BALANCED VERSIONS					
TBR0058(L)A1	0.5 - 8	0.05 - 3	10 - 15	10.5/12.5	15
TB0218(L)W2	2 - 18	0.5 - 8	10 - 15	7.5/9.5	20
TB0426(L)W1	4 - 26	0.5 - 8	10 - 15	10/12	20
TB0440(L)W1	4 - 40	0.5 - 20	10 - 15	10/12	18

DYNAMIC RANGE OPTIONS

(*) Add Letter	LO/IF Power Range	Input 1 dB C.P. (dBm) (Typ.)
L	10 - 13 dBm	+6
M	13 - 16 dBm	+10
H	17 - 20 dBm	+15

Image Rejection Mixers

Model Number	RF/LO Frequency (GHz)	Conversion Loss (dB) Max.	Image Rejection (dB) Min.	LO-to-RF Isolation (dB) Min.
IMAGE REJECTION MIXERS				
IRM0204(*)C2(**)	2 - 4	7.5	18	20
IRM0408(*)C2(**)	4 - 8	8	18	20
IRM0812(*)C2(**)	8 - 12	8	18	20
IRM1218(*)C2(**)	12 - 18	10	18	20
IRM0208(*)C2(**)	2 - 8	9	18	18
IRM0618(*)C2(**)	6 - 18	10	18	18
IR1826NI7(**)	18 - 26	10.5	18	20
IR2640NI7(**)	26 - 40	12	18	20

Model Number	RF/LO Frequency (GHz)	Conversion Loss (dB) Max.	Balance Phase (±Deg.) Typ./Max.	Balance Amplitude (±dB) Typ./Max.	LO-to-RF Isolation (dB) Min.
I/Q DEMODULATORS					
IRM0204(*)C2Q	2 - 4	10.5	7.5/10	1.0/1.5	20
IRM0408(*)C2Q	4 - 8	11	7.5/10	1.0/1.5	20
IRM0812(*)C2Q	8 - 12	11	5/7.5	.75/1.0	20
IRM1218(*)C2Q	12 - 18	13	10/15	1.0/1.5	20
IRM0208(*)C2Q	2 - 8	12	7.5/10	1.0/1.5	18
IRM0618(*)C2Q	6 - 18	13	10/15	1.0/1.5	18
IR1826NI7Q	18 - 26	13.5	10/15	1.0/1.5	20
IR2640NI7Q	26 - 40	15	10/15	1.0/1.5	20

IF FREQUENCY OPTIONS

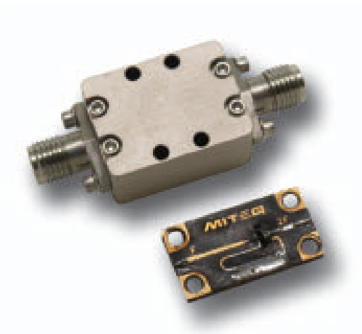
(**) Add Letter	IF Frequency Range (MHz)
A	20 - 40
B	40 - 80
C	100 - 200
Q	DC - 500 (I/Q)

Mixer Products

Passive Doublers

Model Number	Input Frequency (GHz)	Input Power (dBm)	Output Frequency (GHz)	Conversion Loss (dB) Typ./Max.	Rejection (dBc) Typ. Fund.	Rejection (dBc) Typ. Odd Harm.
DROP-IN VERSIONS						
SXS01M	0.5 - 3	8 - 12	1 - 6	13/16	-20	-25
SXS04M	2 - 9	8 - 12	4 - 18	13/15	-20	-25
SXS07M	3 - 13	8 - 12	6 - 26	13/18	-18	-25
CONNECTORIZED VERSIONS						
SXS2M010060	0.5 - 3	8 - 12	1 - 6	13/16	-20	-25
SXS2M040180	2 - 9	8 - 12	4 - 18	13/15	-20	-25
SXS2M060260	3 - 13	8 - 12	6 - 26	13/17	-18	-25
MX2M130260	6.5 - 13	8 - 12	13 - 26	11/13	-15	-15
MX2M004010	0.02 - 0.5	8 - 12	0.04 - 1	10.5/13	-25	-25

SSB Upconverters or I/Q Modulators



Model Number	RF Frequency (GHz)	Conversion Loss (dB) Max.	Carrier Suppression (dBc) Min.	Carrier Suppression Carrier - Fundamental IF (dBc) Min.
IF DRIVEN MODULATORS				
SSM0204(*)C2MD(**)	2 - 4	9	20	20
SSM0408(*)C2MD(**)	4 - 8	9	20	18
SSM0812(*)C2MD(**)	8 - 12	9	20	20
SSM1218(*)C2MD(**)	12 - 18	10	20	18
SSM0208(*)C2MD(**)	2 - 8	9	20	18
SSM0618(*)C2MD(**)	6 - 18	12	20	18

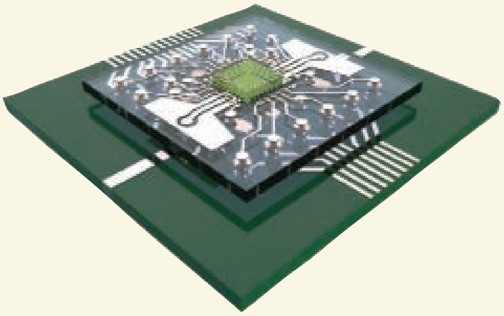
For full data sheets on the products shown, please visit www.miteq.com/mixers
For Carrier Driven Modulators, please contact MITEQ.

For additional information or technical support, please contact our
Sales Department at (631) 439-9220 or e-mail components@miteq.com

ISO 9001 Registered · ANAB Accredited · AS9100 Registered · RoHS compliant Available

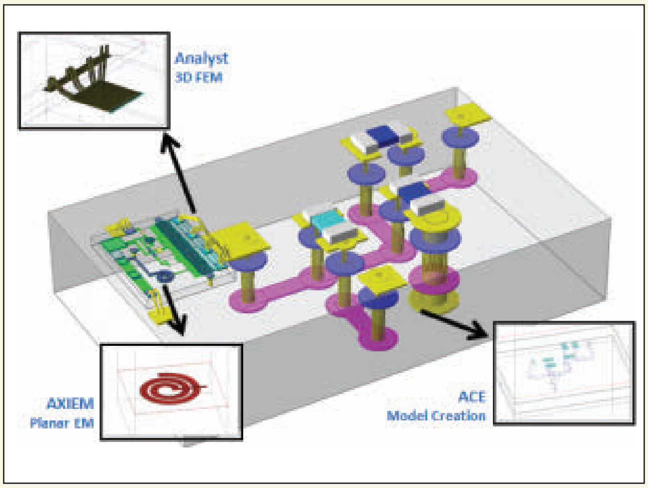
MITEQ
100 Davids Drive, Hauppauge, NY 11788
TEL.: (631) 436-7400
www.miteq.com

Most Valuable Product



Analyst: Fully Integrated 3D EM Simulation

Analyst™ is a full featured, 3D electromagnetic (EM) industry-standard finite element method (FEM) simulator that is completely integrated into AWR's Microwave Office™ circuit design environment (see ***Figure 1***). It is the first software to give designers the ability to use 3D EM simulation when needed from within their circuit design software, without having to work in a third party/CAD drawing and simulation environment.



▲ *Fig. 1 Analyst is part of the AWR Design Environment™ integrated workflow.*

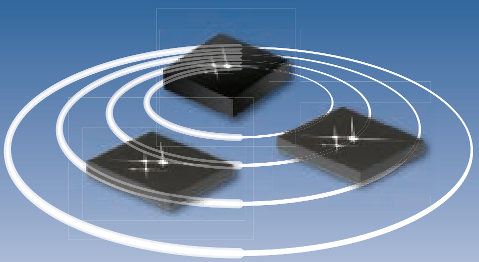
Analyst benefits those circuit designers who need to rely upon 3D FEM EM analysis for both the design and verification of their designs prior to manufacture. For RF/microwave designers of on-chip passive components, monolithic microwave integrated circuits (MMIC), microwave integrated circuits (MIC), RF printed circuit boards (PCB), modules and packaging, and hierarchical designs such as system-on-chip (SoC) and system-in-package (SiP), ease-of-use and minimal simulation setup time coupled with the elimination of manual drawing means maximum EM accuracy with minimal overhead.

3D EM TOOL FOR THE PRACTICAL CIRCUIT DESIGNER

The underlying philosophy of Analyst is to give the designer the power of 3D simulation in an easy-to-use circuit environment. This premise is made possible in two ways.

First, Analyst gives designers the ability to use 3D simulation in their normal design environment. Most circuit designs are planar, whether developed for ICs, modules or boards; consequently, 3D EM simulators are really only needed in the few places where planar EM simu-

AWR Corp.
El Segundo, CA



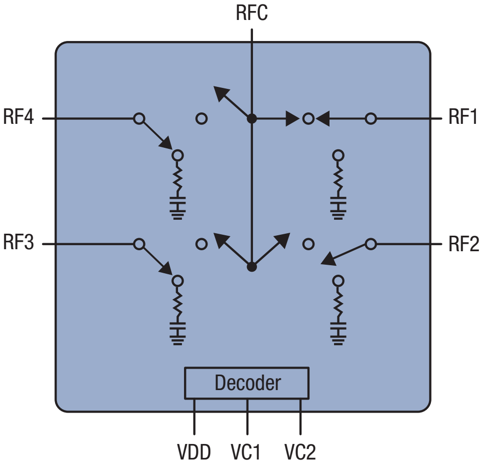
SKYWORKS®

High Isolation and Low Loss SPST–SP8T RF Switches

For Cellular Infrastructure, Military Communication, Test & Measurement, and Broad Market Wireless Applications

Skyworks offers a wide variety of broadband, high performance RF switches utilizing both GaAs pHEMT and silicon-on-insulator (SOI) technologies. These newly released high isolation switches offer system designers many key performance features including:

- Broadband frequency coverage: 0.02–6 GHz
- Very high isolation: >50 dB
- Low insertion loss: 0.4–1.0 dB
- Fast switching time: < 100 ns
- High linearity: >60 dB IIP3
- Control voltage: 1.8 V and 3 V logic
- Small footprint: 2 x 2, 3 x 3, and 4 x 4 mm²



SKY13392-359LF Functional Block Diagram

Part Number	Description (Absorptive / Reflective)	Frequency (GHz)	Typ. IL (dB)	Typ. Isolation (dB)	Typ. IIP3 (dBm)	Typ. $IP_{1\,dB}$ (dBm)	Package (mm)
SKY13347-360LF	SPST (A)	0.1–3.0	0.7	35	40	21	QFN 8L 2 x 2 x 0.9
SKY13372-467LF	SPDT (A)	0.1–6.0	0.8	65	45	26	QFN 16L 4 x 4 x 0.9
SKY13373-460LF	SP3T (R)	0.1–3.5	0.4	35	70	39	QFN 12L 2 x 2 x 0.55
SKY13384-350LF	SP4T (A)	0.02–4.0	0.7	45	50	30	QFN 16L 3 x 3 x 0.75
SKY13392-359LF	SP4T (A)	0.02–4.0	1.0	55	47	30	QFN 16L 4 x 4 x 0.9
SKY13415-485LF	SP5T (R)	0.1–3.0	0.4	32	70	38	QFN 14L 2 x 2 x 0.55
SKY13416-485LF	SP6T (R)	0.1–3.0	0.4	30	69	39	QFN 14L 2 x 2 x 0.55
SKY13417-485LF	SP7T (R)	0.1–3.0	0.65	30	69	38	QFN 14L 2 x 2 x 0.55
SKY13418-485LF	SP8T (R)	0.1–3.0	0.5	30	69	38	QFN 14L 2 x 2 x 0.55

Skyworks' Green™ products are compliant to all applicable materials legislation and are halogen-free. For additional information, please refer to Skyworks Definition of Green™, document number SQ04-0074.
New products indicated in **blue, bold** are continually being introduced at Skyworks.

Join our customer email program instantly by scanning the QR code with your smartphone, or visit our Web site at ***www.skyworksinc.com***.

Samples and Evaluation Boards Available at www.skyworksinc.com.

USA: 781-376-3000 • Asia: 886-2-2735 0399 • Europe: 33 (0)1 43548540 • Email: sales@skyworksinc.com
www.skyworksinc.com • NASDAQ: SWKS •

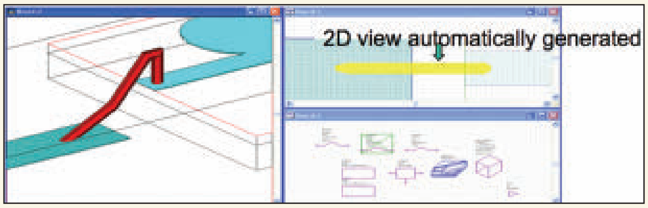


Fig. 2 *Analyst automatically generates parameter controlled layout cells (Pcells).*

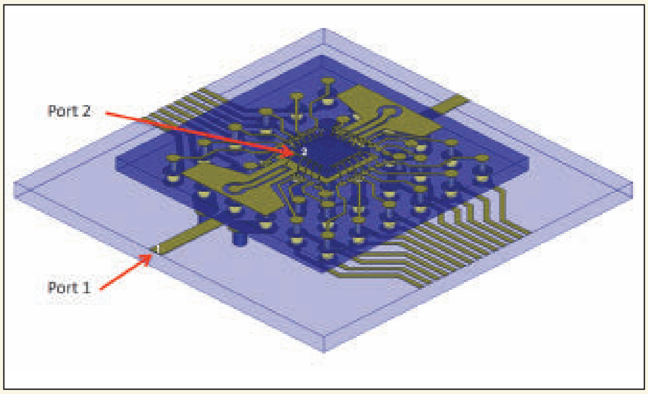


Fig. 3 *The performance of the transition from Port 1 on the board to Port 2 on the chip is analyzed.*

lators are not practical, for example, a gap in the dielectric substrate from a recessed chip on a board. Therefore, it makes complete sense to provide 3D EM simulation capabilities directly and seamlessly within a circuit design environment.

Second, Analyst comes preconfigured with settings (boundary, ports, mesh, modes) that are tailored to the class of problems specific to these IC, module, and board designs. Prior to Analyst, designers had to define, specify, and ship their 3D problems to an external EM tool, set up and simulate them, and then import the results back into their circuit environment. The first issue with this method is one of time and potential error in carrying out the export/import of the project. The second is that these simulators require many esoteric settings of ports and solver options that the average designer can feel uncomfortable with and overwhelmed by and therefore less confident with the end result. In the Analyst approach, the settings are already optimized for the typical problems designers are likely to encounter, therefore the manual interactions are minimized, reducing potential user error and increasing confidence in results.

ANALYST IN THE DESIGN FLOW

Microwave Office has traditionally given designers the flexibility to easily use EM simulation in a variety of ways. This use model has been evolving for a number of years, including the concept of extraction, where the layout can be automatically selected, EM simulated, and the results included into the circuit.

AWR continues to improve the functionality of the EM environment (Extraction flow/EXTRACT block) within Microwave Office by now offering 3D FEM EM analysis via Analyst. Even before Analyst, layouts could be controlled by variables, allowing the creation of models with swept parameters. For example, a custom model of a discontinuity like a notched tee is easy to create. Designers can tune the parameters of the model, and can even run optimizations. Layouts can also take advantage of preconfigured layout cells (Pcells), as shown in ***Figure 2***, the shapes of which are controlled by parameters. And now with Analyst, the EM environment has been enhanced to handle 3D structures common to planar circuit topologies. For example, Pcells now automatically create 3D bond wires, ball grid arrays (BGA), tapered vias, and bond straps. Common 3D discontinuities like finite sized dielectric bricks and package walls can also be easily included.

REAL-WORLD CHIP/PACKAGE/BOARD EXAMPLE

The key advantage of Analyst is its tight integration within AWR's Microwave Office circuit design and simulation environment. To demonstrate the real-world value of this unique feature, let's look at an example: the optimization of a board-to-module-to-chip signal path.

Figure 3 shows the board, module and periphery of the chip being investigated. The signal goes from Port 1 on a trace on a PC board, onto a module by means of a BGA, along a trace on top of the module, and over to Port 2 on the chip by means of a bond wire. The design goal is to have a return loss of better than 20 dB over the frequency range of interest, 10 to 20 GHz.

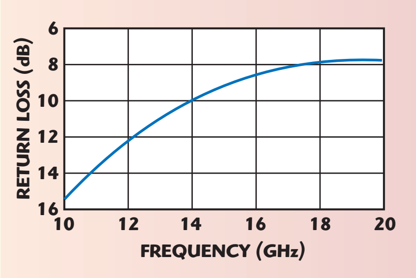


Fig. 4 *The return loss is shown from 10 to 20 GHz before optimization.*

Analyst simulation results, shown in ***Figure 4***, for the layout of the product photo indicate that the design goal is not yet being met. To remedy this, Analyst is used within the Microwave Office design environment to enable easy design optimization via a three-stage approach:

- Isolate specific area(s)
- Identify electrically their behavior
- Modify the layout to bring behavior into spec

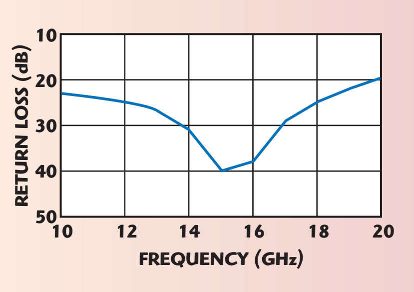
Analyst has a number of features that designers can take advantage of as the design is modified. The tool has the ability to simulate only portions of the layout, thereby reducing problem size and increasing simulation flexibility (Step 1). The Analyst results are inserted into a schematic, capacitors are attached to the ports, and their values tuned and optimized (Step 2). The layout is then augmented to give the desired extra capacitance or inductance (Step 3). Again, only the portion of the layout of interest is simulated. In this manner, Analyst has been designed to minimize the amount of setup time required for a simulation. The final solution that results from this three-stage approach is one in which the bond wire has been doubled and shortened to reduce inductance, the gap between the bond wire pad and side grounds has been decreased to increase capacitance, and the ground vias on the board have been moved away from the ground balls to increase the loop inductance and compensate for the ball capacitance. The entire structure is then simulated as a final verification check to ensure the design meets with success. The resulting data is shown in ***Figure 5***.


Congratulations to the ROG Award Winners!
Most Challenging Board Build
Endicott Interconnect Technologies
Mark Schadt
Most Innovative Design
Emerging Microwave Technologies
Humberto Lobato-Morales
Longest Product Life
Anaren Microwave
Bo Jensen
Most Extreme Conditions
The Boeing Company
Ryan Pang
Best Digital Application
Spectrum Integrity Inc
Michael Ingham
Most Unique & Creative Use of Material
Rock Creek Scientific
NASA Goddard Space Flight Center
Kevin Black
WINNER
CERTIFICATE
Winner of ROG Award
ROGERS
Bruce Hoechner, President and CEO Congratulates our ROG Award Winners.
ROGERS CORPORATION
Advanced Circuit Materials Division
USA: +1 480-961-1382 Europe: +32 9 235 3611
www.rogerscorp.com/acm

ANALYST APPLICATIONS

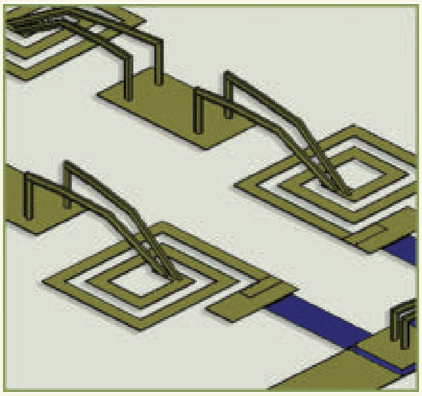
Analyst is specifically designed with the knowledge that RF/microwave designers need to perform analysis on interconnects commonly found within high-frequency packages, boards and modules.

- Die-level interconnect: Analyst enables designers to simulate and accurately capture the electrical behavior resulting from die-level interconnects (see ***Figure 6***) such as air bridges, spiral inductors, capacitors and tapered vias within gallium arsenide (GaAs), gallium nitride (GaN), silicon germanium (SiGe), or bipolar junction complementary metal oxide semiconductor (BiCMOS) ICs so that IC design performance can be fully optimized.
- IC/package/board/module interconnect: Analyst is equally capable of solving the challenges of IC packaging and chip/package/board and module interconnect (see ***Figure 7***) that include bond wires, bumps, ribbons and/or solder balls. Analyst accurately accounts for each interconnect and its associated parasitics.

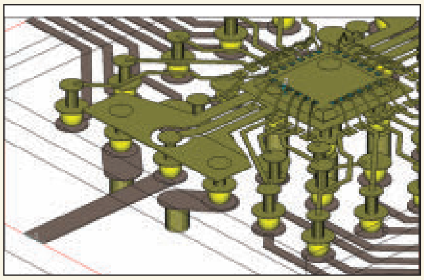


▲ *Fig. 5 The entire signal path is simulated — the return loss meets the specification of being less than 20 dB over the desired frequency range.*

Electromagnetic simulators are commonly used to help designers gain a more accurate understanding of the physical layout and interconnect common to ICs, PCBs, modules and associated packaging. The main advantage of Analyst is its tight integration into the AWR Microwave Office circuit design environment. With Analyst seamlessly embedded into the Microwave Office environment, circuit designers save time (fewer mouse clicks and menu options) while gaining greater EM-insight into design performance. For example, layout setup and drawing are simplified by preconfigured 3D Pcells for the bond wires and BGA balls. Hierarchy is supported in the EM layout, making for easier design reuse. Tuning, optimization and sensitivity and yield analysis can be quickly implemented through the use of parameterized layout, without having to leave the Microwave Office environment. Since Analyst is optimized for RF and microwave designers, the designer is not required to become an expert on EM simulation software settings. It is now possible to seamlessly include 3D EM simulation in critical circuit simulations such as optimization, tuning of circuits like filters, sensitivity and yield analysis, and even nonlinear circuit simulation using harmonic balance. The designer can fully concentrate on his/her design, easily using 3D EM simulation when needed, without having to spend time learning a complex EM point tool. The key point is that designers can now focus more of their time on circuit designs/behavior and less on the nuances of using a 3D EM point tool.



▲ *Fig. 6 Die-level interconnect.*

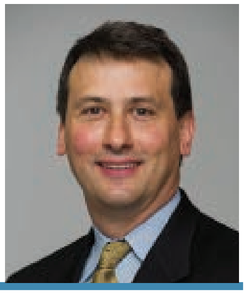


▲ *Fig. 7 IC/package/board interconnect.*

VENDORVIEW

AWR Corp.,
El Segundo, CA,
info@awrcorp.com,
www.awrcorp.com.

Wireless Communications in the Massively Broadband® Era

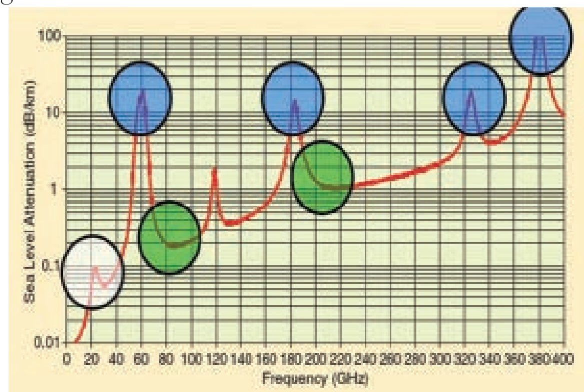


Theodore S. Rappaport, *Director of* NYU WIRELESS, *New York, NY*

As the cellular industry rolls out fourth-generation Long Term Evolution (LTE) across the world, one has to believe that we are witnessing the dawn of an amazing new era, where wireless becomes so pervasive and intertwined with everything we do in life, just as the pen and paper are today. We are at the dawn of the Wireless Renaissance. Since I wrote "The Wireless Revolution" article for the *IEEE's Communications Magazine* in 1991[1], we have witnessed the transition from first generation analog FM cellular phones, operating at carrier frequencies of 850 MHz, to today's 4G LTE devices and smartphones with download speeds that will, in a year or two, approach 500 Megabits per second at carrier frequencies of approximately 2 GHz. With multi-gigabit per second, 60 GHz Personal Area Networks (PAN) now available under the IEEE 802.11ad standard and the WiGig and Wireless HD labels, the ability to retrieve from the cloud all of the content in our lives within seconds is now a reality. What is more, the required engineering know-how needed to catapult wireless to its renaissance is being born in these new LTE and 60 GHz technologies. But as awesome as the capabilities of LTE and 60 GHz Wireless LAN are, these are simply cumbersome first steps toward what the future holds in the coming decade.

Truth be told, our modern wireless technologies are only a shell of what we should expect, given the past advances of the computing and semiconductor industries and the abundance of untapped spectrum above 3 GHz. In 1991, many of us were learning about the new field of wireless mobile communications, while the PC industry offered personal computers with clock speeds of approximately 10 MHz and memory sizes of 10 megabytes. Today, when considering the parallelization of multi-core processors, both the equivalent clock speed and memory size of a mid-range PC have increased by three orders of magnitude – a factor of 1000 – and the consumer pays less than half the price for today's more powerful PC, adjusting for inflation. Yet, over the same 22 year period, the carrier frequencies used by the cellular industry across the globe have advanced from 850 MHz to only about 2 GHz, not even approaching one order of magnitude increase in frequency. Today's low-cost CMOS circuitry can be made to operate with an f_t of 1 THz, meaning that cellphones and WLAN devices can now operate at many tens or hundreds of GHz, orders of magnitude greater in carrier frequency than today's commercial devices. Such an increase in carrier frequency brings with it a similar increase in useable bandwidth, thus allowing future mobile or PAN services to have many orders of magnitude greater raw bandwidth (and capacity), as well. By proportionally increasing the carrier frequency (that is, decreasing the wavelength) and increasing the spectrum bandwidth available for future mobile devices, these future millimeter-wave systems will exploit new high gain, electrically steered, integrated antennas to find the best signals in a mobile environment, while being physically no larger than a fingernail or as small as a human freckle, as carrier frequencies approach a few hundred GHz.

Consider this — the contiguous spectrum of every commercial wireless service known to man (such as satellite, cellular, Wi-Fi, broadcast television, FM radio, amateur radio, etc.) easily fits within the bandwidth of today's 60 GHz unlicensed band. It is hard not to be giddy about the emerging impact of such massive transfer rates, as carrier frequencies begin to ramp up to take advantage of today's semiconductor capabilities[3] (see **Figure 1**). As this Massively Broadband® era is reached, incredible bandwidth and spatial steering of radio waves will be new dimensions that can be traded with power to yield unparalleled flexibility and power efficiency, allowing revolutionary form factors for everything we enjoy today, such as laptops (where the magnetic or electronic hard drive will become a high speed tetherless device you can carry in your wallet or clothing), vehicles (where the control wiring harnesses and connections in cars are replaced with broadband wireless interconnec-



▲ *Fig. 1 Carrier frequencies will ramp to take advantage of semiconductor capabilities and natural attenuation characteristics.[3]*

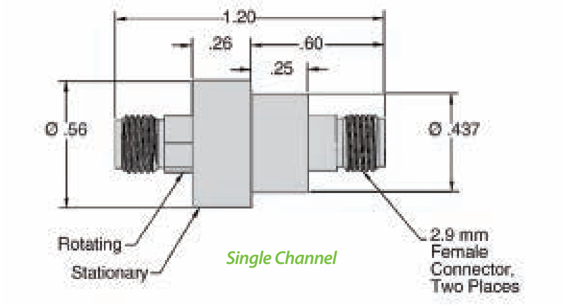
PERFECTION

*When you need perfection in **satellite high frequency** communication.*

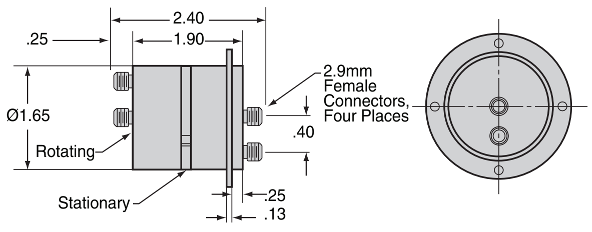
Family of Broadband High Frequency Coaxial Rotary Joints

Single Channel & Dual Channel Rotary Joints — Frequency DC to 40.0 GHZ
MDL's short low torque, high performance coaxial rotary joints as well as our extensive line of waveguide rotary joints have set the standards of the industry .

You've never been in better hands.
Quality from CAD to crate, quick turnaround, and tight economy is what we're all about.
Call an MDL specialist today at 800-383-8057 or visit us at mdllab.com.
You'll find that we specialize in perfection.



Single Channel



Dual Channel

SINGLE CHANNEL SPECIFICATIONS:

ELECTRICAL

FREQUENCY	DC - 18 GHz	
VSWR	DC - 10 GHz	1.20 : 1 MAX.
	10 - 26 GHz	1.35 : 1 MAX.
	26 - 40 GHz	1.75 : 1 MAX.
WOW	1.05 MAX.	
INSERTION LOSS	DC - 10 GHz	0.2 dB MAX.
	10 - 26 GHz	0.4 dB MAX.
	26 - 40 GHz	0.6 dB MAX.
PEAK POWER	Equal to connector rating	

DUAL CHANNEL SPECIFICATIONS:

ELECTRICAL	Channel 1	Channel 2
FREQUENCY	7.0 - 22.0 GHz	29.0 - 31.0 GHz
VSWR	1.50:1 MAX.	1.70:1 MAX.
WOW	0.15	0.25
INSERTION LOSS	0.5 dB MAX.	1.0 dB MAX.
ISOLATION	Channel to Channel	50.0 dB MIN.

Scan here to visit our website

Microwave Development Laboratories, 135 Crescent Road, Needham Heights, MA 02494
V: 781-292-6680/6684 • F: 781-453-8629 • E-mail: mdlsales@mdllab.com • www.mdllab.com

tions operating in the "whisper radio" band of 380 GHz (see Figure 1), making cars less expensive to build and lighter weight with better gas mileage), to data centers (where today's expensive optical or fiber interconnects are replaced with wireless transceivers to enable unprecedented deployment flexibility with less cost and power). This unparalled spectrum will unleash revolutionary uses of our cellphone, and will enable new concepts in the home, such as the "information shower," where all of your past and present content in your life is downloaded to you as you walk from the living room to the bedroom. This wireless "peace dividend" spawned by investments and advances in the semiconductor and computing industries, and new advances in miniature on-chip and in-package antennas, integrated beam formers and continued advances in spatial processing, will bring about the renaissance of wireless communications, as the copper wire is relegated to the important job of carrying power to increasingly efficient devices that are wirelessly interconnected. This renaissance will also bring the cloud to our cellphones, wireless into the operating room of hospitals, medical and patient care, homes and vehicles, and telepathy (yes, telepathy, where wireless monitoring of the brain has been shown to deliver 3 bits/second telepathy rates today — and we expect these rates to ramp dramatically, following in the footsteps of cellular). To study these areas and more, a new research center called NYU WIRELESS has been created at NYU and NYU-Poly (formerly known as Brooklyn Poly and now the engineering college of NYU). At NYU WIRELESS, a focus on wireless communications, computing and medicine combined with nearly $10 million in investment, has brought together researchers and students in an unparalleled collaborative environment, with access to the world's leading wireless, computational and medical researchers. Our recent pioneering work on urban multipath propagation at NYU WIRELESS shows that at the millimeter-wave frequencies of 28 and 38 GHz[2], cellular phones using adaptive antennas will actually be more reliable than today's 2 GHz systems, with data rates that are orders of magnitude greater than LTE's greatest plans. Our work also shows that for cell radii of two hundred meters in New York City and Austin, Texas, neither urban propagation nor rain is an issue whatsoever. Other universities, such as MIT and the University of Surrey have also recently launched centers to investigate aspects of future wireless networks.

For the renaissance of wireless to take hold, the first step will be to enable ubiquitous multi-gigabit per second data rates to cellphones of the future. Carriers using LTE will not realize this in today's low microwave bands that are currently the focus of spectrum regulators, but 5G will enable this, if the millimeter-wave bands are opened up to mobile usage. Governments around the world should make this millimeter-wave spectrum available without delay, and should begin to contemplate much larger spectrum allocations, on the order of several GHz bandwidths as shown in Figure 1. While governments attempted to do this with LMDS spectrum at 28 and 38 GHz in the late 1990s, the spectrum availability at that time was far ahead of the capabilities of semiconductors, and electronics were too costly. Today, however, the world is different, as the move to 60 GHz PAN and 77 GHz automotive electronics are creating the reservoir of technical experts needed to bring wireless into its renaissance. As massive spectrum allocations in the mmWave bands begin to provide a playing field for the modern capabilities of wireless devices using state-of-the-art CMOS circuit designs, computing and signal processing, all of us will soon experience such amazing data transfer rates and new wireless applications that promise to transform our lives in ways that few could have imagined in 1991.

NOTE: Massively Broadband is a registered trademark of the author. ■

References

1. T.S. Rappaport, "The Wireless Revolution," *IEEE Communications Magazine*, 29 (11), November 1991, pp. 52-71.
2. T.S. Rappaport, Y. Qiao, J.I. Tamir, J.N. Murdock and E. Ben-Dor, "Cellular Broadband Millimeter Wave Propagation and Angle of Arrival for Adaptive Beam Steering Systems," IEEE Radio and Wireless Symposium (RWS) 2012, pp. 151-154.
3. T.S. Rappaport, J. Murdock and F. Gutierrez, " State-of-the-Art in 60 GHz Integrated Circuits and Systems for Wireless Communications," *Proceedings of the IEEE*, August 2011, Vol. 99, No. 8, pp. 1390-1436.

Defense News

Dan Massé, Associate Technical Editor

Patriot Air and Missile Defense System Receives U.S. Army Stamp of Approval

Raytheon Co.'s new-production Patriot Air and Missile Defense System has received the U.S. Army's final stamp of approval after undergoing stringent testing. During the testing, Patriot's performance was outstanding when subjected to challenging climatic and electromagnetic environments.

"This approval validates the modernized Patriot system's readiness to counter evolving threats and protect warfighters and allies in a combat situation," said Sanjay Kapoor, vice president for Integrated Air and Missile Defense at Raytheon's Integrated Defense Systems business. "This will only build on the confidence that our Patriot partners have in the system's performance and reliability, a confidence we look forward to extending to the partners who join the Patriot family."

Patriot performance consistently exceeded expectations in all eight flight tests in a variety of terrain and weather conditions.

Since last year, the Patriot system has undergone the U.S. Army's rigorous testing of every component of the modernized system. Patriot performance consistently exceeded expectations in all eight flight tests in a variety of terrain and weather conditions.

Harris Team Selected for Global Tactical Advances Communications Systems

A team led by Harris Corp. has been selected for the Global Tactical Advanced Communication Systems (GTACS) contract, which was awarded by the U.S. Army's Program Executive Office — Command Communications and Control.

Harris was one of 20 prime contractors selected to compete for work under the five-year, $10 billion Indefinite Delivery/Indefinite Quantity contract, which enables both defense and civilian federal agencies to quickly and cost-effectively procure a wide range of tactical communications products, systems and engineering services.

Under GTACS, the Harris team will pursue opportunities to supply the Department of Defense, as well as U.S. government agencies such as Homeland Security, with advanced communications solutions that range from wireless networking to tactical satellite communications and handheld JTRS-compliant radios.

"The GTACS contract vehicle makes it very efficient for customers to acquire a comprehensive mix of products and services from the Harris team," said Sheldon Fox, group president, Harris Government Communications Systems. "Harris and its partners will work together to provide advanced, networked communications systems that meet the critical needs of our warfighters and security agencies."

Lockheed Martin Submits Final Proposal for Medium-Range Ballistic Missile

Lockheed Martin announced that it has submitted its final proposal revision for the Medium-Range Ballistic Missile (MRBM) Targets contract. The Lockheed Martin team delivered its final offer to the U.S. Missile Defense Agency's (MDA) Targets and Countermeasures Program Office in Huntsville, AL.

The contract will provide MRBM targets to support Ballistic Missile Defense System element and system flight tests. Requirements include development and manufacturing of MRBMs, integrated logistics support to include inventory storage and maintenance, pre- and post-mission analysis, launch preparation and execution and engineering services. The final proposal revision responds to amendments to the request for proposals made by the MDA following Lockheed Martin's submission of its proposal in June. The MDA anticipates contract award in 2012.

"Lockheed Martin is dedicated to developing reliable and affordable Medium-Range Ballistic Missile Targets that will meet the Missile Defense Agency's requirements for tests of the nation's Ballistic Missile Defense System," said John Holly, vice president of Missile Defense Systems and deputy for Strategic and Missile Defense Systems, Lockheed Martin Space Systems Co. "Our offer represents the next step in cost-efficient systems engineering that will maintain the quality required to produce and launch these next-generation ballistic missiles."

To meet the government's requirements, Lockheed Martin will apply more than 15 years of experience as a leading provider of target missiles for missile defense testing. Lockheed Martin has achieved an unmatched 98-percent success rate in 43 out of 44 target missions since 1996, including legacy and next-generation ballistic missile targets. Target reliability contributes to the overall affordability of a flight test, due to costs associated with the weapon system and sensors. Lockheed Martin has implemented innovations in next-generation target production and operations that focus on cost effectiveness without sacrifices in reliability.

Northrop Grumman Begins Sampling GaN MMIC Product Line for the Military

Northrop Grumman Corp. has developed a line of GaN MMICs for military and commercial uses. These devices represent the first commercial availability of GaN-based components from the company.

Initial engineering evaluation sampling is underway with quantities of three GaN MMIC products. They were

Go to mwjournal.com for more defense news items

developed for defense and commercial ground satellite communication terminal markets and the commercial wireless infrastructure market, said Frank Kropschot, general manager of the Microelectronics Products and Services (MPS) business unit of Northrop Grumman Aerospace Systems.

"We have been producing gallium nitride-based devices since 2002 at Northrop Grumman's dedicated wafer fabrication facility in Redondo Beach, which the Department of Defense has designated as a Trusted Foundry," Kropschot said. "We have achieved outstanding performance and reliability from our high-frequency gallium nitride process and are extremely confident that these GaN MMICs will improve performance, efficiency and bandwidth for military and commercial users."

The initial set of three MMICs has these performance characteristics:

- The APN149 is a GaN high electron mobility transistor (HEMT) MMIC power amplifier chip that operates between 18 and 23 GHz. This power amplifier provides 20 dB of linear gain, +36 dBm (4 W) of output power at 1 dB gain compression and +38 dBm (6.3 W) in saturation with physical address extension (PAE) of greater than 30 percent.
- The APN180 is a GaN HEMT MMIC power amplifier chip that operates between 27 and 31 GHz. This power amplifier provides 21 dB of linear gain, +38 dBm (6.3 W) of output power at 1 dB gain compression and +39 dBm (8 W) in saturation with PAE of 30 percent at midband. For less demanding applications, the APN180 can be operated from a drain voltage as low as +20 V while still producing +37 dBm (5 W) of saturated output power.
- The APN167 is a GaN HEMT MMIC power amplifier chip that operates between 43 and 46 GHz. This power amplifier provides 20 dB of gain, +35.5 dBm (3.5 W) of output power at 1 dB gain compression and +38.5 dBm (7 W) in saturation with PAE of 19 percent at midband.

"These new products are the first of several we plan to introduce into the marketplace during the next few months as we roll out a new family of products using Northrop Grumman's 0.2 µm GaN HEMT process developed partially under the Defense Advanced Research Projects Agency's (DARPA) Wide Band Gap Semiconductors for Radio Frequency program (WBGS-RF)," Kropschot said. He added the DARPA program was the first of several key GaN technology development contracts awarded to Northrop Grumman beginning in 2002. He noted that GaN devices are key components the new low-cost terminals recently introduced by an industry team consisting of Northrop Grumman, Lockheed Martin Space Systems and Telecommunication Systems.

Galileo IOV Satellites 3 and 4 Deployed

The second pair of in-orbit validation (IOV) satellites forming part of Europe's Galileo navigation system, developed and manufactured by Astrium, has been launched aboard a Soyuz rocket from the European Space Centre in French Guiana.

This initial constellation of four IOV satellites marks an important milestone in putting the core of the Galileo system in place. The two latest IOV satellites will soon enter service in orbit alongside IOV satellites 1 and 2 and the constellation will be activated in order to validate the Galileo system. With these four satellites, launched into two different orbit planes, Galileo will prove it can deliver ultra-precise three-dimensional positioning.

"…we have accomplished our task of laying the foundations for the European navigation system."

Galileo is Europe's first global satellite navigation system under civilian control. It will supply ultra-reliable and precise positioning data worldwide. The Full Operational Capability phase of the Galileo programme is managed and fully funded by the European Commission.

The Galileo IOV satellites were designed and built by an Astrium team led from Ottobrunn, Germany. The state-of-the-art navigation payload was designed, integrated and tested at the company's payload centre of excellence in Portsmouth, UK.

Astrium Satellites' CEO Evert Dudok said: "Astrium's teams have been providing their unique know-how and experience to the Galileo programme for more than ten years, since the initial definition of the system and the entry into service of the GIOVE experimental satellites. With the successful launch of the four IOV satellites, we have accomplished our task of laying the foundations for the European navigation system. And our involvement does not end here: Astrium and its subsidiaries will be contributing half of the workshare for the next satellites, delivering the Ground Control Segment (GCS), taking part in system support activities and adapting Ariane 5 for the launch of 4 Galileo satellites at a time."

Harmonized 79 GHz Frequency Band Sought for Automotive Radars

In November, the International Telecommunications Union (ITU) hosted a workshop in Geneva, Switzerland to demonstrate the progress made over the past year in developing short-range high-resolution automotive radar systems in the 79 GHz frequency band that will contribute to increased transport efficiencies and road safety. The developments have been made within the automotive industry, working together with international bodies such as the ITU and the European Commission.

…to establish a harmonized worldwide frequency allocation for vehicular radars…

The workshop organized by the industry-based 79 GHz Consortium in coordination with the ITU's Radiocommunication Bureau focused on the use of automotive radars for future Intelligent Transport Systems and featured a live demonstration of automotive short-range high-resolution radar operations in the 79 GHz frequency band.

The 79 GHz Consortium, in partnership with ITU's Radiocommunication Sector, aims to establish a harmonized worldwide frequency allocation for vehicular radars in line with the frequency range allocated by the European Commission in 2004. This standardization process is in the framework of the upcoming ITU World Radiocommunication Conference in 2015 (WRC-15).

UK Adds £60 M to Europe's Space Programme

The UK's £9 billion space sector is about to become even bigger after the government pledged an extra £60 million to Europe's space programme. Industry has already identified projects to the value of £1 billion that should follow in train from this additional funding.

The investment through the UK Space Agency will also secure the future of the ESA facility in Oxfordshire, including transferring ESA's telecoms satellite headquarters to the UK and creating over 100 new high-tech jobs. This will put Harwell at the centre of space technology and development, reinforcing the work of the Satellite Applications Catapult Centre and RAL Space. The hub will work with partners in the UK, across Europe and around the world to drive an ever-increasing range of exciting new opportunities for industry and academia.

The new resources will be focussed on projects that will bring economic growth to the UK. One example is a new generation platform for telecommunications satellites. This will provide a 20-year horizon for new satellite sales that are competitive in the global market. Another is the next generation of weather satellites, where a UK contribution to ESA programmes will bring significant business through future orders.

UK Minister for Universities and Science, David Willetts said: "This increase will bring the UK's total investment in the European Space Agency to an average of £240 million per year over the next five years. This will allow the UK to play a leading role in the next phase of European space collaboration. It will drive growth, create extra skilled jobs and help the UK to realise its ambition to have a £30 billion space industry by 2030."

Go to mwjournal.com for more international news items

> *"...UK to play a leading role in the next phase of European space collaboration ..."*

Jean-Jacques Dordain, director general of the European Space Agency said: "With this substantial increase in investment, the UK is helping to promote competition in and encourage the growth of the European space sector by developing space capacities in the UK. In addition to the increased use of UK industry, our commitment to growing ESA's facility here in Harwell confirms that the UK Space Agency is taking up more of a leadership role in key parts of the space sector."

BoF Group Investigates Sensor Integration in Mobile Systems

The Mobile Industry Processor Interface (MIPI®) Alliance has formed an open 'Birds of a Feather' (BoF) group that will investigate the requirements related to integrating sensors into mobile systems. The group will address current challenges facing the sensor and wireless markets including a fragmented digital interface landscape, rapidly expanding sensors per device, varied signals per device and non-scalable architectures.

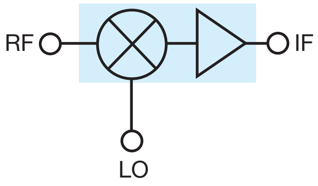
"The massive proliferation of sensors in diverse applications is driving the trend toward standardization of sensor interfaces," said MEMS Industry Group® (MIG) managing director Karen Lightman. "With MEMS playing a major role in the adoption of sensors worldwide, we recognize the importance of investigating the requirements needed to address this rapidly growing space. We are excited to work with MIPI Alliance as they explore the issues at stake in sensor-interface standardization."

"MIPI Alliance members – from semiconductor manufacturers to mobile device OEMs – have been considering this issue for some time," said Joel Huloux, chairman of the board of MIPI Alliance. "The Sensor BoF gives us an opportunity to talk with key sensor stakeholders, and insures we develop technology that the market truly wants and needs."

As one of the group's first efforts, MIPI Alliance joined with MIG to conduct member-based market research. While the need for a sensor interface standard was not immediately apparent, there was a clear gap between the technology of today and the needs of the future. Closing that gap will be a primary focus of the Sensor BoF group.

NEW ULTRA-REL®

High Gain MIXERS



1.0-4.2 GHz   Conversion Gain 12 dB

$8.95 *ea. (qty. 10)*

Mini-Circuits has married rugged LTCC construction with advanced semiconductor manufacturing technology to create our new, ultra-reliable MRA high gain mixer family! The more we test them, the better they look—delivering excellent performance, from -55 to +125°C, in the harshest, most demanding environments.

Consistent, robust wideband performance and a tiny 0.3 x 0.25" footprint make them ideal for instrumentation and military applications, and their ***remarkably low prices*** are a perfect fit anywhere long-term reliability adds bottom-line value. So why wait? Go to minicircuits.com today and see what MRA high gain mixers can do for your application!

MIL Standard Qualifications

(see website for complete list and details)

Gross and Fine Leak	*HTOL (1000 hours/+125°C)*
Mechanical Shock	*Thermal Shock*
Vibration	*Multiple Reflow*
Acceleration	*Bend Test (and more)*

Electrical Specifications *(-55 to +125°C)*

Model	LO Level (dBm)	RF/LO Freq. (GHz)	IF Freq. (MHz)	Conv. Gain (dB typ)	Price $ ea. (qty. 10)
MRA-42+	7	1.0-4.2	10-800	12	8.95
MRA-42LH+	10	1.0-4.2	10-800	12	8.95
MRA-42MH+	13	1.0-4.2	10-800	12	8.95

LO/RF isolation 35 dB   LO/IF isolation 20 dB   *RoHS compliant*

Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

YONI2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see minicircuits.com

U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

500 rev org

The Microwave Tube is Still Strong at Nearly $1 B

While microwave and millimeter wave high-power vacuum electron devices (VED) remain "below the radar" of many industry observers, the total available market (TAM) for this segment is nearly $1 billion in 2012. Despite its size, and although these tubes remain essential elements in specialized military, scientific/medical and space communications applications, this market is generally under-reported and poorly understood by those not directly involved in it.

This is now a stable industry after several rounds of consolidation in recent years. There is potential for some further consolidation, but there are no signs of that happening yet.

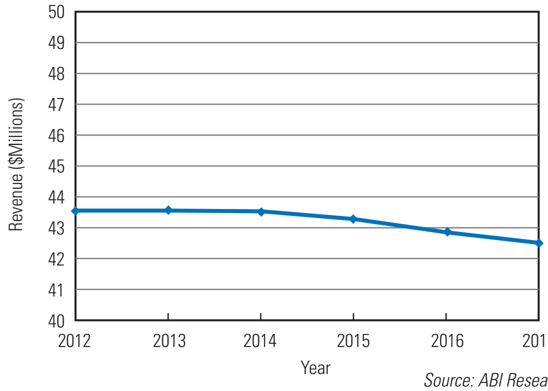
GaN will continue to be a threat to some aspects of the microwave and millimeter wave VED marketplace.

However, one new RF semiconductor technology – gallium nitride (GaN) – may change the landscape but has not yet done so to any meaningful scale. While it is not yet near monopolizing the RF/microwave power industry, GaN is advancing steadily and is a technology that should be closely watched, as it will continue to be a threat to some aspects of the microwave and millimeter wave VED marketplace.

Lance Wilson, research director says, "The size of this historic market continues to surprise everyone and its longevity and firm resistance to RF power semiconductor encroachment is as surprising."

"These specialized vacuum electron devices may at first seem anachronistic," Wilson adds, "but in some cases there is no other way to generate such high levels of RF power within an acceptably small space. Certain microwave and millimeter wave VEDs can generate megawatts, and it would take tens of thousands of transistors to do that."

Total Crossed-Field Amplifier Device Revenue World Market, Forecast: 2012 to 2017



Source: ABI Research

Close to 80% of Base Station Silicon Will Be SoC Based by 2017

ABI Research expects sales of base station processors to grow at 17 percent annually and reach $1.1 billion in 2017, driven by the growth in compact format femto-, pico- and microcell small cell base stations, which will account for the majority of the processor market in 2017. With macrocells declining at 13 percent per year over the next 5 years and microcells growing at a modest 7 percent, the large growth in picocells and outdoor femtocells will consume the majority of next generation base station processors. As the number of these compact femtocells and picocells grows, the penetration of system-on-chip basebands will grow at 108 percent annually to reach almost 80 percent of the total market in 2017.

"With the latest SoCs available or becoming available over the next 6-9 months in 28 nm silicon technology, these will be some of the most advanced baseband ICs ever produced and raise the bar in terms of complexity."

With a capacity shortfall looming, service providers are deploying Heterogeneous Networks (HetNets) with small cell underlays in dense urban areas and using distributed Radio Access Networks (RAN) to narrow the gap between capacity and demand, and all of these techniques are driving integration into the next generation base station baseband.

"These next generation baseband processors are heterogeneous multicore SoC devices including both DSP and CPU cores for control and data plane processing, along with hardware acceleration and connectivity for backhaul and radio interfaces," says Nick Marshall, principal analyst, mobile networks.

Merger and acquisition activity is high in this segment – Broadcom's acquisition of Provigent, Percello and NetLogic, Mindspeed's purchase of Picochip, Wavesat's sale to Cavium, Xilinx's acquisition of Modesat, and Qualcomm's purchase of DesignArt, all indicate that there are significant revenue opportunities for baseband SoCs in the evolving distributed RAN and HetNet segments and that vendors are positioning themselves to challenge current leaders Freescale Semiconductor and Texas Instruments.

"With the latest SoCs available or becoming available over the next 6 to 9 months in 28 nm silicon technology, these will be some of the most advanced baseband ICs ever produced and raise the bar in terms of complexity," continued Marshall.

Go to mwjournal.com for more commercial market news items

Wiping Off Download Bots Pulls iPhone's Share of Smartphone App Downloads

The iPhone's share of quarterly global smartphone app downloads stood at 29 percent in the second quarter of 2012, significantly below the 47 percent attributed to Android smartphones, shows new market data from ABI Research.

Senior analyst Aapo Markkanen comments, "The iPhone's download share tends to see a lot of seasonal fluctuation, but over the past year or so it has stayed surprisingly resiliently between 30 and 37 percent of the total. In our estimates the second quarter represented the first time the iPhone dipped below 30 percent. The iPhone 5 will most likely cause a second-half hike to the download count, but that may be of a rather temporary nature."

The main reason for the declining market share is Apple's clampdown on download bots earlier this year, which some developers utilized to manipulate their charts positions.

The main reason for the declining market share is Apple's clampdown on download bots earlier this year, which some developers utilized to manipulate their charts positions. For example, app-marketing firm Fiksu has published data indicating that, at the high end of the download chart, the bot squeeze may have alone wiped off even one-fourth of daily volumes. For Android, the bots have not been as big a factor to begin with, owing to Google's different app-ranking methods, as well as to the fact that in its app economy there is still far less money changing hands than on iOS.

As another reason, Markkanen points to the growing prominence of the iPad, adding, "It is notable that, among the iOS apps, the momentum is also shifting up the value chain and towards iPad applications and this change is happening definitely faster than what Google is experiencing. We estimate in the first half of this year the iPad saw over five times more app downloads than all Android tablets combined."

These findings are from ABI Research's Mobile Application Markets Research Service, which focuses on distribution and the economics of mobile apps, providing data-driven insights on areas such as download volumes, revenues and business models and trends within different applications categories.

Around the Circuit

Laura Glazer, Staff Editor

INDUSTRY NEWS

RFMD announced a definitive agreement to acquire **Amalfi Semiconductor**, a fabless semiconductor company specializing in cost effective, high performance RF and mixed-signal ICs for the entry-level smartphone market. RFMD intends to accelerate the market adoption of Amalfi's RF CMOS and mixed-signal ICs. Under the terms of the agreement, RFMD will acquire Amalfi with cash on hand for total consideration of approximately $47.5 million, net of cash received.

National Instruments (NI) announced the acquisition of **NMDG**, a company with more than 20 years of experience and technology in high-frequency stimulus-response and large-scale network analysis measurements. The new team serves as the foundation to establish a Network Analysis Center of Excellence located in Brussels, Belgium to work worldwide with NI partners, lead user programs and develop measurement and modeling architectures on NI's platform, influencing the future product roadmaps of NI.

Teseq Holding AG acquired **Instruments for Industry** (IFI), a designer and manufacturer of solid state and traveling wave tube amplifiers. The acquisition expands Teseq's model range from an upper limit of 6 up to 40 GHz and power levels from an upper limit of 1 to 10 kW. The IFI brand remains the same, while the company's product range will be harmonized with the ones of Teseq and MILMEGA and offered in a new price list valid as of January 1, 2013.

AML Microtechnique Lorraine S.A. of Metz, France joined with **Diamond Antenna and Microwave Corp.** of Littleton, MA to form **Diamond Antenna Europe BVBA**. The new entity combines AML Microtechnique's capabilities as a manufacturer of high precision components with Diamond Antenna and Microwave's capabilities in microwave rotary joint design and production.

Cobham plc established a new strategic business unit – **Cobham SATCOM** – that combines all of the group's satellite communications businesses into one organization, following the successful acquisition and integration of Danish SATCOM company **Thrane & Thrane** earlier this year. Headquartered in Denmark, Cobham SATCOM is led by Thrane & Thrane CEO Walther Thygesen with assistance from a multinational management team. Thrane & Thrane will trade as Cobham SATCOM from November 2012. Rebranding of Thrane & Thrane will begin immediately and is expected to be complete during 2013.

Space Data Corp. and **Lemko Corp.** announced the successful deployment of the world's first satellite-based commercial LTE network. The network was deployed in Atqasuk, Alaska and offers subscribers mobile broadband data speeds of over 70 Mbps. LTE over satellite is enabled by Lemko's patented DiMoWiNe software solution. This allows commercial carriers to economically deploy LTE using satellite in areas where it was not previously practical or possible to connect cell towers with fiber.

Colt Technology Services, in partnership with **NEC**, is conducting the first ever live trials of small cells using Femto-as-a-Service with a leading, large-scale European mobile operator, using a multi-operator small cell (Femto) gateway. This breaks down the investment barrier for mobile operators to start their own small cell service.

ON Semiconductor has joined the multi-partner, industrial research and development program at **imec**, a leading nanoelectronics research center, to collaborate on the development of next-generation GaN on silicon (Si) power devices. Imec's broad-scale research program is focused on developing GaN-on-Si technology on 200 mm wafers, as well as reducing the cost and improving the performance of GaN devices.

The U.S. Patent and Trademark Office has issued **SRC Inc.** a patent for the "Interleaved Beam Coherent Radar Apparatus and Processing Method," an advanced radar scanning and processing technique that improves a radar's ability to detect very slow moving targets with a very high scan rate.

Anritsu Corp. announced the opening of an India subsidiary in Bangalore. The new office brings together marketing, sales, engineering, services and support. By co-locating all the departments, the company expects to accelerate the rate of delivery of new products and provide better support to its growing customer base in India.

M/A-COM Technology Solutions recently moved its Torrance, CA operations into a new facility in Long Beach, CA. The new building is ISO 9001 certified and has 23,000 square feet, of which 7000 square feet is for manufacturing and 4000 square feet for engineering.

I.F. Engineering announced the opening of its newly constructed world class manufacturing and engineering development facility. The company moved from a previous 6700 sq. ft. building in Fabyan, CT to its new 20,000 sq. ft. facility in Dudley, MA. This new facility provides the needed manufacturing space for the production of the company's increasing line of components and subsystems.

CONTRACTS

Raytheon Co. received a $349 million five-year contract to provide heavy anti-tank, wireless precision-assault missiles for the **U.S. Government**. Raytheon received the award during its third quarter. Under this contract, Raytheon will deliver 6676 of the new wireless tube-launched, optically

For up-to-date news briefs, visit mwjournal.com

tracked, wireless-guided (TOW) missiles that receive commands from the gunner through a wireless guidance link.

ITT Exelis has been awarded an indefinite delivery, indefinite quantity (IDIQ) contract from the **U.S. Army** to provide Generation 3 aviation night vision systems, spare parts and accessories. The contract allows Exelis to compete for deliveries of the AN/AVS-6 aviator night vision goggle and spare aviation image intensifiers during a five year period. The contract is valued at up to $217.5 million.

Cobham has reached an agreement with the **Australian Customs and Border Protection Service** to extend the existing Sentinel aerial maritime surveillance contract by two years. This £105 million contract extension secures the contract until the end of 2021.

Communications & Power Industries LLC (CPI) has received initial orders totaling more than $5 million from a prime contractor for high-power, Ka-Band satellite communications amplifiers. These SATCOM amplifiers will be used in a U.S. military communications program intended to provide worldwide communications connectivity to tactically deployed forces.

RFMD has been awarded a $2.1 million contract from **DARPA** to enhance the thermal efficiency of GaN circuits used in high power radar and other military systems. The award is in association with the Near Junction Thermal Transport (NJTT) effort of DARPA's Thermal Management Technologies program. The goal of the NJTT initiative is to achieve a 3× or greater improvement in power handling from GaN power amplifiers through improved thermal management of the near junction region.

Harris Corp. received $7 million in orders to deliver public safety and tactical communications systems to the **U.S. Department of Homeland Security** (DHS) and its component agencies; the Federal Emergency Management Agency (FEMA); and the U.S. Coast Guard. The orders were awarded through the five-year, $3 billion DHS Tactical Communications IDIQ contract vehicle.

Eutelsat Communication selected **Thales Alenia Space** to build the EUTELSAT 8 West B satellite, which will boost satellite broadcasting resources in the Middle East and North Africa. It will be equipped with 40 operational Ku-Band transponders designed primarily to serve DTH markets in North Africa and the Middle East.

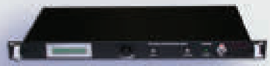
NEW MARKET ENTRY

Rakon, a provider of frequency control solutions, announced MEMS technology is being utilized to develop new products to further broaden its oscillator product portfolio and capabilities. The addition of MEMS products supports Rakon's growth in telecommunications, smart wireless devices and high reliability markets, as well as fuels growth in networking, storage, servers, portable electronics, consumer and computing applications. Rakon has begun sampling oscillators using MEMS to select customers, with volume production ramping up in the fourth quarter of 2012.

SWITCH MATRICES

Solid State Switch Matrices & Switching Networks to 40GHz

- Amplifiers
- Attenuators - Variable
- DLVA & ERDLVA & SDLVA's
- DTO's
- Filters
- Form, Fit & Function Products
- Hybrids, Dividers & Couplers
- IFM's & Frequency Discriminators
- Integrated MIC/MMIC Modules
- I/Q Vector Modulators
- Limiters & Detectors
- Log Amplifiers
- Pulse & Bi-Phase Modulators
- Phase Shifters
- Rack & Chassis Mount Products
- Receiver Front Ends
- Single Sideband Modulators
- SMT & QFN Products
- Solid-State Switches
- Switch Matrices
- Switch Filter Banks
- Threshold Detectors
- USB Products



- SWITCH MATRICES & SWITCHING NETWORKS
- HANDOVER TEST SYSTEMS
- RF SWITCH ASSEMBLIES
- PROGRAMMABLE ATTENUATOR ASSEMBLIES
- BLOCKING & NON-BLOCKING
- FAN-IN & FAN-OUT CONFIGURATIONS
- BIDIRECTIONAL
- RS-232, RS422/485, PECL, ETHERNET, USB, TOUCH SCREEN & OTHER CONTROL SYSTEMS AVAILABLE
- OTHER INTEGRATED FUNCTIONS AVAILABLE: PHASE SHIFTING, PULSE MODULATION, DETECTION, ATTENUATION, RF FILTERING, ETC.
- LINUX OR WINDOWS OPERATING SYSTEMS, MODULAR DESIGNS, PLUG & PLAY, REMOVABLE COMPACT FLASH WITH BOOT AND OPERATING SOFTWARE
- CUSTOM DESIGNS AVAILABLE TO SUIT YOUR APPLICATION NEEDS

PMI STANDARD SWITCH MATRICES

Model Number	Frequency Range (GHz)	Number Of Inputs To Outputs	Insertion Loss (dB)	Isolation (dB)	OIP3 (dB)	Switching Speed (nSec)	VSWR	Max. Input Power (dBm, CW)
SM-20M3G-4X4	0.02 - 3.0	4 / 4	10	60	45	100	2.0:1	20
SM-20M3G-8X8	0.02 - 3.0	8 / 8	14	60	45	100	2.0:1	20
SM-20M3G-16X16	0.02 - 3.0	16 / 16	16	60	45	100	2.0:1	20
SM-20M3G-32X32	0.02 - 3.0	32 / 32	19	60	45	100	2.0:1	20
SM-2G18G-4X4	2.0 - 18.0	4 / 4	14	60	45	100	2.0:1	20
SM-2G18G-8X8	2.0 - 18.0	8 / 8	16	60	45	100	2.0:1	20
SM-2G18G-16X16	2.0 - 18.0	16 / 16	19	60	45	100	2.0:1	20
SM-2G18G-32X32	2.0 - 18.0	32 / 32	23	60	45	100	2.0:1	20
SM-18G40G-4X4	18.0 - 40.0	4 / 4	16	60	45	100	2.0:1	20
SM-18G40G-8X8	18.0 - 40.0	8 / 8	18	60	45	100	2.0:1	20
SM-18G40G-16X16	18.0 - 40.0	16 / 16	22	60	45	100	2.0:1	20
SM-18G40G-32X32	18.0 - 40.0	32 / 32	25	60	45	100	2.0:1	20

PLANAR MONOLITHICS INDUSTRIES, INC.

7311-F Grove Road, Frederick, Maryland 21704 USA
Tel: 301-662-5019 | Fax: 301-662-1731
Email: sales@pmi-rf.com | www.pmi-rf.com

ISO9001:2008 Certified

Around the Circuit

PERSONNEL

▲ John Croteau

John Croteau will be joining M/A-COM Tech as its president and will be reporting to Charles Bland, CEO. As president, Croteau will assume responsibility for worldwide sales, operations, R&D, marketing and business unit management. Croteau joins M/A-COM Tech with nearly 30 years of global semiconductor experience.

▲ Alan Hallberg

RFMD announced the appointment of **Alan Hallberg** as the company's corporate vice president and CMO. In the role of CMO, Hallberg will oversee RFMD's global marketing activities and will be based in RFMD's growing Silicon Valley, CA location. He will report to RFMD's president and CEO Bob Bruggeworth. Hallberg is a seasoned industry veteran with extensive experience in marketing and branding.

SenarioTek, a leading designer and manufacturer of RF and microwave products, named **Stephen Pettis** as its new aerospace and defense business development manager. This is a new position that focuses on expanding SenarioTek's growing defense ATE business. Prior to joining SenarioTek, Pettis spent over 30 years working with Hewlett-Packard and Agilent Technologies.

REP APPOINTMENTS

Delta Microwave announced the appointment of **Component Solutions**, San Jose, CA, as the company's exclusive representative in northern CA and northern NV.

Hirose Electric has signed a worldwide distribution agreement with **Mouser Electronics** that expands its product availability and customer support.

L-com Inc. has signed an agreement to have its products distributed by **Carlton-Bates Co.** (CBC), a subsidiary of WESCO Distribution Inc.

NuWaves Engineering announced it has increased its international presence by adding authorized resellers in Europe, Southeast Asia and the Middle East. **MEDs Technologies** will represent NuWaves in several Southeast Asia countries, including Indonesia, Malaysia, Thailand and Singapore. **Mel Sivan Technologies** will represent NuWaves in Israel. Two European companies join NuWaves' reseller network as well: **Tech-Inter** of France and **Medeos Srl** of Italy.

Pasternack Enterprises Inc. announced that it has appointed **Medición y Electrónica S.A. de C.V.** (MESA) as its exclusive distributor for Mexico, Guatemala and Honduras. The company has also appointed **Altaix Electronica S.A.** as its exclusive RF distributor for Spain and Portugal.

NOW

PRECISION TEST Cables DC to 40 GHz!

from $68.95 ea. (qty.1-9)

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!

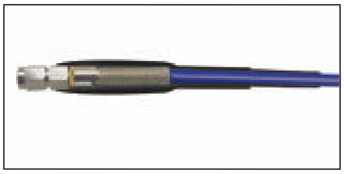
Model Family	Freq. (GHz)	Connectors (male)	Lengths† (ft)	Temp (°C)
Performance Test (CBL)	DC-18	SMA‡, N	1.6-25	-55/+105
Quick Lock (QBL)	DC-18	SMA	1.0-6.6	-55/+105
Armored (APC)	DC-18	N	6.0-15	-55/+105
Low Loss (KBL-xx-LOW)	DC-40	2.92	1.5-6.6	-55/+85
Phase Stable (KBL-xx-PHS)	DC-40	2.92	1.5-6.6	-55/+85

**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.*

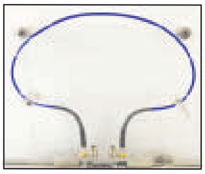
† Custom lengths available by special order.

‡ SMA female connectors featured on some models, or via special order.

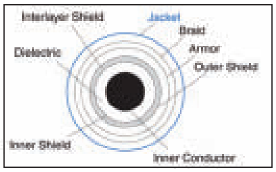
K-Connector is a registered trademark of Anritsu Company.



Full solder wick protected by stainless collar and three different layers of strain relief.



Flex Test™ setup shows triple strain relief, effective through 20,000 flex cycles for all models.



Armored Test Cables: rugged, triple shielded construction, flexible enough to pass 20,000+ Flex-Test cycles.

40 GHz cables compatible with SMA, K®, 2.9 & 3.5 connectors.

See minicircuits.com for cable lengths, specifications, performance data, and surprisingly low prices!

Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

YONI2® **The Design Engineers Search Engine** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

507 rev org

A Four-Element "Clover" Transceiver Array for 3 Tesla Cardiac MRI

The design of radio frequency (RF) coils is of paramount importance to the quality and safety of Magnetic Resonance Imaging (MRI). Being the signal generator and detector of MRI, RF coils are required to generate a uniform excitation in the target during transmission and high signal-to-noise ratio (SNR) during reception.[1] In the meantime, RF coils must not cause subject overheating in in-vivo human studies.[2] This requires that RF energy deposited inside the human body and coupled to receivers should be minimized.

With the advent of clinical high-field MRI systems, that is B_0 = 3 Tesla or higher, the much improved SNR enables the development of fast and effective diagnostic and therapeutic techniques.[3] However, electromagnetic wave effects appear as an issue that challenges the conventional MR imaging methodology. Because the size of human torso is approximately several wavelengths at the MR resonant frequency, that is 123 MHz at 3 Tesla, standing waves appear and sufficient RF excitation is no longer guaranteed in the target region.[4] The volume-coil-induced eddy currents that circulate in the human body also make the use of a body transmit coil less appealing, for safety reasons, when a specific organ, such as the heart, is imaged.[2] Last but not least, the RF energy coupled to receiver cables and detuned circuits is a persistent concern of subject burning.[1,2]

As a feasible means of solving the above issues, the interest in surface transceiver arrays has been growing rapidly in high-field MRI.[4] Taking cardiac imaging as an example, a well-designed transmitter array positioned above the heart guarantees that a strong excitation field is inside the heart with less RF energy deposition than a volume body coil would deposit. Since transmitters and receivers are not separate in a transceiver array, there are no detuning circuits and energy pick-up issues involved.

Shumin Wang and Hai Lu
Auburn University, Auburn, AL
C.J. Reddy
EM Software & Systems (USA) Inc., Hampton, VA

Nevertheless, the design of transceiver arrays is more challenging than conventional receive-only arrays. In receive-only array design, high-impedance pre-amplifiers are extensively applied to help decouple neighboring coils.[5] Thus an array can be designed to accommodate various non-RF requirements, such as parallel imaging performance,[6,7] without much concern about mutual coupling. But this does not apply to transmitter arrays, which must be designed with sufficient field coverage and mutual decoupling at the same time.

In this article, a detailed workflow is presented for the design of a four-element transceiver array for 3 Tesla cardiac MRI. It will be demonstrated that by employing a "clover" layout, all coils can be arranged to achieve good field coverage and element mutual decoupling simultaneously.

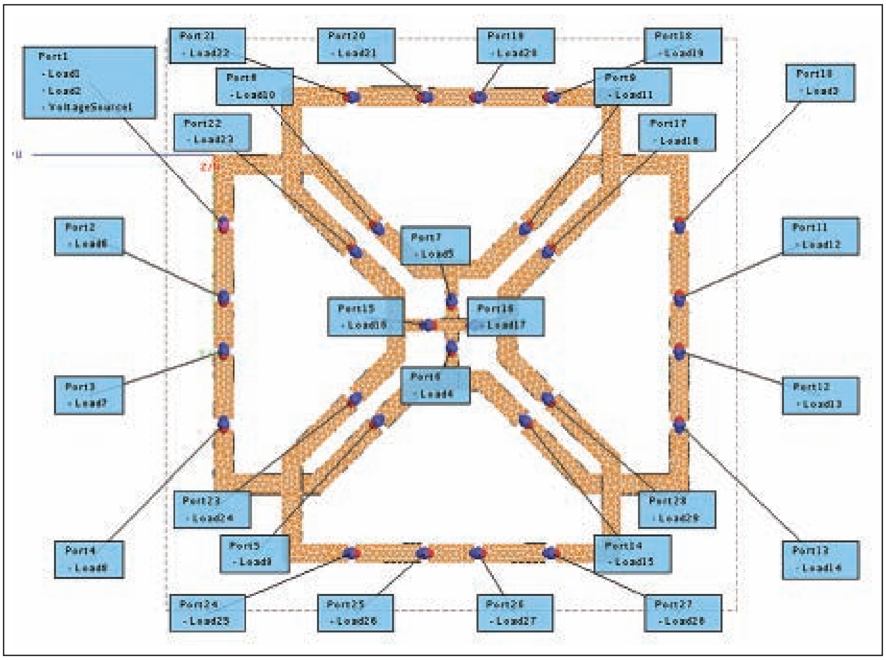


Fig. 1 Numerical model of the four-element cardiac transceiver array.

TRANSCEIVER DESIGN

Figure 1 shows the numerical model of the four-element cardiac transceiver array in the commercial software package FEKO.[8] The four coils were positioned in a rotational symmetric manner so that a geometric center can be uniquely defined. Aligning this center with the center of the heart helps to localize the transceiver to achieve the maximum transmit efficiency and receive sensitivity. The side-to-side dimension of the array was 5 inches, in order to provide a good field penetration into the heart.

Eight capacitors were used on each coil element. Six of them were for tuning a coil to the desired resonant frequency, that is 123.2 MHz for Siemens' 3 Tesla scanners. The number of capacitors was determined by the following criteria: 1) Each capacitor should be large enough (> 10 pF) to minimize the electric coupling with the human body; 2) The distance between adjacent capacitors should be no more than 1/10 of a wavelength to ensure current uniformity; 3) The capacitor values should be available from off-the-shelf vendors.

The six capacitors were positioned in a mirror-symmetric manner to create a virtual ground along the symmetry axis. By soldering the ground of RF feeding point to the virtual ground, the amount of parasitic currents induced on cable shields is minimized.[1] This is a very useful mechanism for reducing mutual coupling caused by shield currents. For the same reason, all capacitors were adjusted pair-wise in order to keep the mirror symmetry.

The capacitors on the edge shared by two opposite coils are in charge of decoupling the associated coils.[1] They introduce a voltage drop that is negative to the mutually induced electromotive force (EMF). For each pair of adjacent coils, decoupling was accomplished by adjusting the overlap size so that the magnetic flux produced by one coil goes through the other coil from two opposite directions canceling out.[5] It should be mentioned that applying two different decoupling methods in one array design is not common. In this case, this strategy brought great convenience for achieving good field coverage and mutual decoupling.

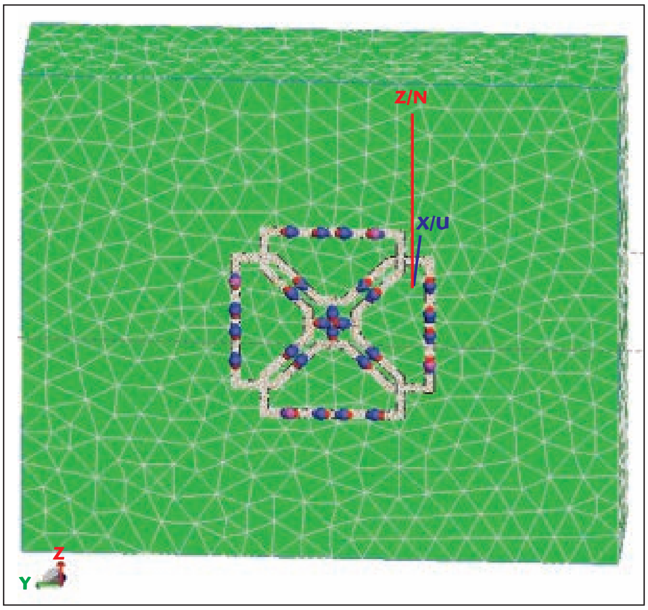
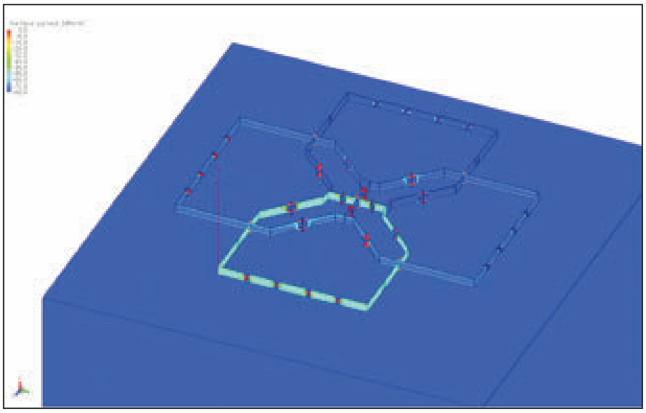


Fig. 2 The transceiver array positioned on top of a phantom.

Numerical tuning and decoupling were performed with a large phantom model which has a relative permittivity of 63.8 and conductivity of 0.72 S/m (see ***Figure 2***). These resemble the properties of human muscle at 123.2 MHz. The following procedure was applied:

1. Turn on each coil in turn and adjust all eight capacitors so that S_{11} reaches a minimum at 123.2 MHz.
2. Turn on the two opposite coils simultaneously and adjust the two decoupling capacitors so that S_{21} is less than –25 dB.
3. Readjust the six tuning capacitors of each coil to bring the resonant


You Have Our Undivided
ATTENTION
www.ewtfilters.com
We understand how critical your applications are. That's why you'll always have our *Undivided Attention*.
Offering more than 40 years of experience in custom design & manufacturing of RF and Microwave filters and filter based products to 50 GHz.
Military • Commercial
Wireless • Space
Eastern Wireless TeleComm, Inc.
Tel: 410.749.3800 Fax: 410.749.4852
sales@ewtfilters.com

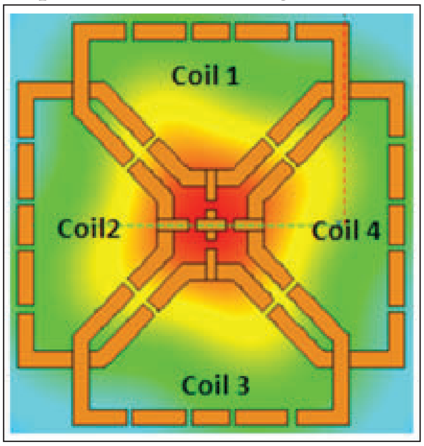


▲ *Fig. 3 Current distribution in four coils when one coil is excited and the three other coils are in perfect load matching condition.*

frequency back to 123.2 MHz.

4. Check S_{21} by turning on two opposite coils simultaneously. If they are coupled again, readjust the two decoupling capacitors.
5. Check S_{21} of two adjacent coils by turning them on simultaneously. Adjust the overlap size so that S_{21} is less than –25 dB.
6. Readjust the six tuning capacitors of each coil to bring the resonant frequency back to 123.2 MHz.
7. Check the S_{21} by turning on two adjacent coils simultaneously. If they are coupled again, readjust the overlap side. Since overlap decoupling is broadband, this readjustment is seldom needed.
8. Check the tuning of each coil and the decoupling of each pair of coils. Readjust if needed.

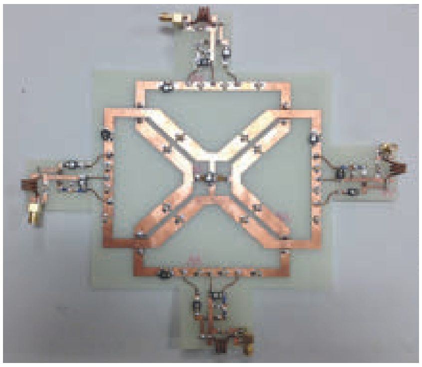
In numerical simulations, the coil cross-section was discretized into at least five triangles to ensure sufficient accuracy. ***Figure 3*** illustrates the current distribution when one coil was turned on and three other coils were in perfect load matching conditions.



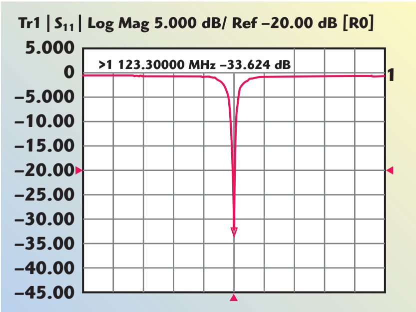
▲ *Fig. 4 Simulated RF magnetic field distribution when all coils are tuned on with phases prescribed in Table 1.*

As can be seen, the currents induced in other coils are nearly invisible. This serves as further proof that good decoupling was achieved.

In MRI, a circularly polarized magnetic field is required on planes perpendicular to the transceiver surface, in order to generate a transverse magnetization.[9] If the foot-to-head direction is defined as the z-direction, the polarization should be left-handed in a right-hand coordinate system. This can be accomplished by RF excitations with the phases listed in ***Table 1***. When the first and the third coils are excited in-phase, a magnetic field pointing out of the paper plane is generated. When the second and the fourth coils are excited out-of-phase, a right-to-left magnetic field is gener-



▲ *Fig. 5 The four-element transceiver array with matching boards.*

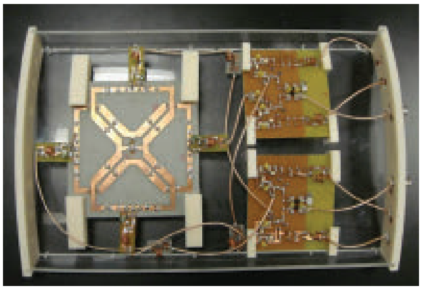


▲ *Fig. 6 Measured $|S_{11}|$ of one coil when other coils are terminated with a 50 Ω load.*

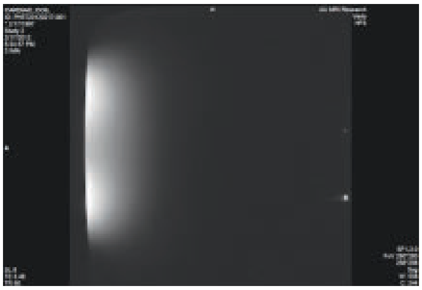
TABLE I

THE PHASE OF EACH COIL IN FIGURE 4

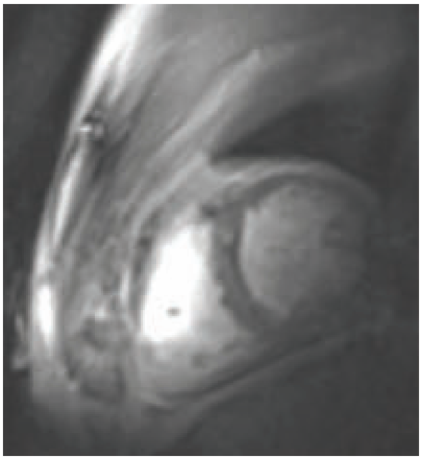
Coil	1	2	3	4
Phase	0°	90°	0°	-90°



▲ *Fig. 7 The complete transceiver array with power dividers and baluns.*



▲ *Fig. 8 MR image of a bucket of saline water.*



▲ *Fig. 9 Actual image of a subject's heart.*

ated. By introducing a 90° phase difference between these two groups of coils, a left-hand polarized transverse magnetic field can be generated.

Figure 4 shows the magnetic field distribution when all coils were turned on simultaneously with the phases prescribed in Table 1. Since all coils were sufficiently decoupled, a strong focus appears near the geometric center of the array. This is highly desired, since aligning this center with the center of the heart will result in optimized transmission efficiency and receive sensitivity. This will be demonstrated in the experimental results in the next section.

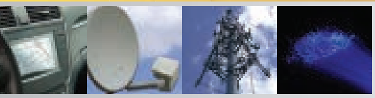
HARDWARE IMPLEMENTATION AND EXPERIMENT RESULTS

The transceiver array was fabricated on a 1/32" FR-4 printed circuit board (PCB) with 1 oz copper (see ***Figure 5***). The capacitance in simulations was directly applied for tuning and decoupling. Readjustment that follows the same procedure as in simulations was required. It was found that the actual capacitance differed from simulation results by 10 to 20 percent. Since the bought capacitors have a 10 percent tolerance, this agreement was considered to be very good.

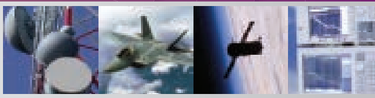
Each coil was matched to 50 Ω by a standard highpass L-network. ***Figure 6*** shows the measured S_{11} of one coil when all other coils were matched to a 50 Ω load. In this measurement, a bucket of saline water that mimics the loading of the human body was applied. A sharp resonant curve (<-30 dB) was observed, which indicates that good matching and decoupling were achieved at the same time.

SIGNAL CONDITIONERS

Linear Programmable Equalizer for 100 Gbps Backplane & Line Card Applications



Analog, Digital & Mixed-Signal
ICs, Modules, Subsystems & Instrumentation



HMC6545LP5E 32 Gbps Dual Channel Advanced Linear Equalizer

5 x 5 mm, 32-Pin QFN Package

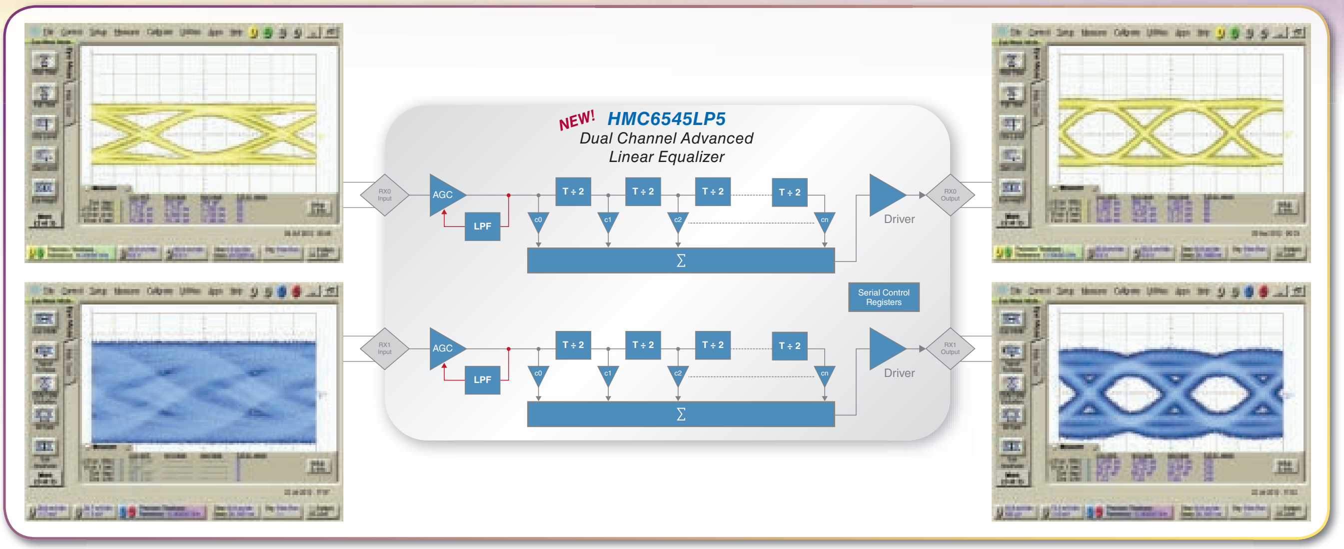
+3.3V Single Supply

Features

- ***Protocol & Data Rate Agnostic***
- ***Low Latency (<170 ps)***
- ***No Reference Clock is Required***
- ***Up to 20 dB Programmable Multi UI Input Equalization at 25G - 28G Data Rates***

Applications

- ***Extend the Reach of 40G/100G (RZ)-DQPSK Receivers***
- ***16G FC, 32G FC & Infiniband Signal Conditioning***
- ***Lower the Cost of 100G-LR/ER Solution Optics***
- ***Test & Measurement/Stress Eye Generation***



	Part Number	Data Rate Max. (Gbps)	Function	Number of Taps	Input Sensitivity (mVp-p)	Tap Delay	Total Harmonic Distortion (%)
NEW!	HMC6545LP5E	32	Advanced Linear Equalizer	9	40	18	5

Hittite MICROWAVE CORPORATION

2 Elizabeth Drive • Chelmsford, MA 01824
978-250-3343 tel • 978-250-3373 fax • sales@hittite.com

Visit Us: www.hittite.com
Contact Us: fo@hittite.com
Receive the latest product releases - click on "My Subscription"

Baluns made of wound semi-rigid coaxial cables were connected to each coil to choke unwanted shield currents.[10] Each coil was then connected to a T/R switch tuned with an insertion loss between 0.2 and 0.3 dB and an isolation less than –40 dB.[10]

On the transmit side, three Wilkinson power dividers were constructed to split a single RF input from the scanner equally four ways. Appropriate phases were implemented by phase shifters according to Table 1. Four receiver channels were connected to an interface box custom made by Stark Contrast Inc., Erlangen, Germany. Finally, the interface box was connected directly to a Siemens' 3T scanner. The complete transceiver array is shown in ***Figure 7***.

MR images were acquired with gradient echo sequence on the 3T scanner. The acquisition matrix size was 280 × 280, slice thickness = 8 mm, TE = 3.68 ms and TR = 10 ms. In the first experiment, the same bucket of water used in bench measurement was imaged. The result is shown in ***Figure 8***. As can be seen, a bright region appears underneath each coil due to the fact that image intensity is strongly modulated by receiver sensitivity profile. However, at the depth where the heart should be, peak image intensity locates near the symmetry axis. Thus aligning the geometry center of the coil with the heart should yield optimal image quality. This was confirmed in the second imaging experiment, in which the transceiver array was tested on the first author. As shown in ***Figure 9***, the image intensity in the heart is the strongest.

CONCLUSION

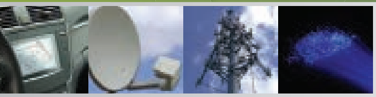
A complete design workflow for a four-channel transceiver array is detailed in this article. By employing a four-element clover layout, sufficient mutual decoupling and good transmit field coverage were achieved at the same time. Experimental results show that with careful hardware implementation, satisfactory signal intensity can be acquired in the heart. ■

References

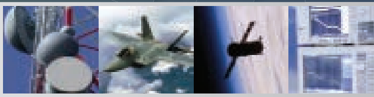
1. D. Hoult and C.N. Chen, *Biomedical Magnetic Resonance Technology*, Taylor & Francis: Oxford, UK, 1989.
2. T.O. Woods, "Standards for Medical Devices in MRI: Present and Future," *Journal of Magnetic Resonance Imaging*, Vol. 26, No. 5, November 2007, pp. 1186-1189.
3. K. Ugurbil et al., "Ultrahigh Field Magnetic Resonance Imaging and Spectroscopy," *Journal of Magnetic Resonance Imaging*, Vol. 21, No. 10, December 2003, pp. 1263–1281.
4. P.F. Van de Moortele et al., "B1 Destructive Interferences and Spatial Phase Patterns at 7 T with a Head Transceiver Array Coil," *Magnetic Resonance in Medicine*, Vol. 54, 2005, pp. 1503–1518.
5. P.B. Roemer et al., "The NMR Phased Array," *Magnetic Resonance in Medicine*, Vol. 16, No. 2, November 1990, pp. 196–225.
6. K.P. Pruessmann et al., "SENSE: Sensitivity Encoding for Fast MRI," *Magnetic Resonance in Medicine*, Vol. 42, 1999, pp. 952–962.
7. D. Spencer et al., "Design of a 32 Channel Cardiac Array for Parallel Imaging," *Proceedings of the 2005 International Society for Magnetic Resonance in Medicine*.
8. FEKO Suite 6.1, EM Software and Systems (www.feko.info), 2011.
9. E.M. Hackee et al., *Magnetic Resonance Imaging: Physical Principles and Sequence Design*, John Wiley & Sons: New York, NY, 1999.
10. X. Yang et al., "T/R Switches, Baluns, Traps and Active Detuning Elements," *Proceedings of the 2006 International Society for Magnetic Resonance in Medicine*.

DATA CONVERTERS

Wideband Sampling Platform Using High Speed ADC with Track & Hold Amplifier

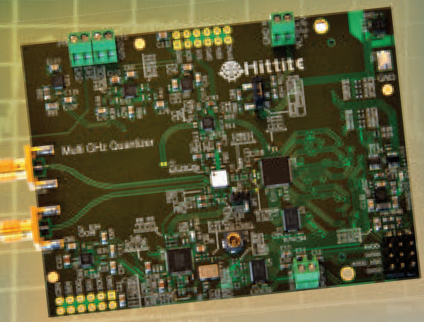


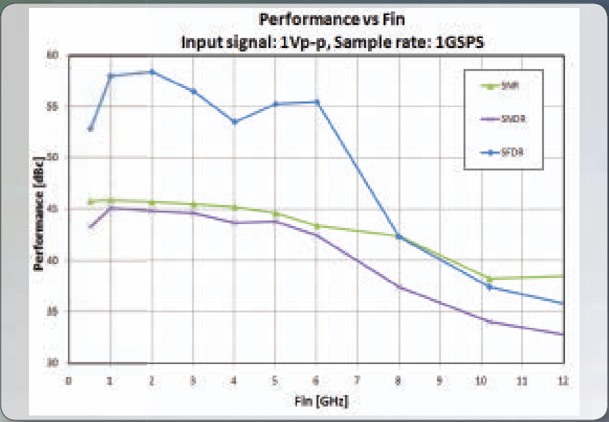
Analog, Digital & Mixed-Signal
ICs, Modules, Subsystems & Instrumentation



EKIT01-HMC9000 Multi-GHz Quantizer

Exceptional Performance for Microwave Frequencies



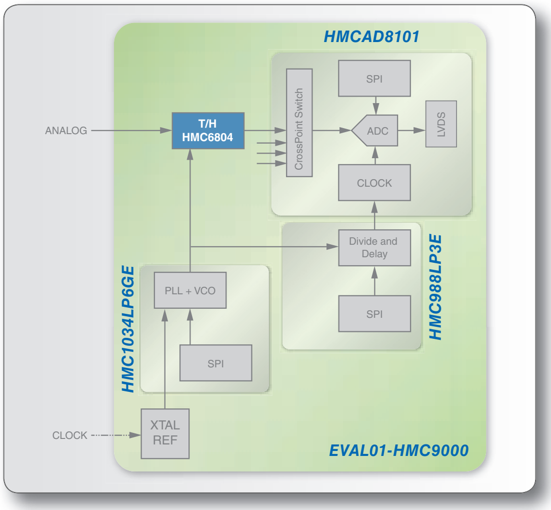


Features

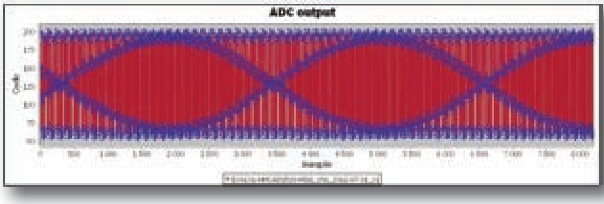
- *Industry's Best Ultra High Frequency Wideband Performance*
- *Proprietary Clock & Delay Control*
- *Robust & Optimized PCB Design & Layout*
- *Path to Improve Performance Through MCM or Monolithic*
- *Eval Kit with EasySuite™ Software*

Performance Examples

- *18 GHz Input Bandwidth*
- *1 GSPS Sampling Speed*
- *Instantaneous Bandwidth to 500 MHz*
- *1 GSPS, 1 Vp-p:*
  - *>50 dB SFDR up to 7 GHz*
  - *>40 dB SNR up to 9 GHz*
- *Direct Eye Diagram Capture up to 26 Gbps*



MGQ output with 16 Gbps BERT Test Pattern input



Ideal for High Speed Data Acquisition Systems

- *High End Test & Measurement Bit Error Rate Testers (BERT), Real Time Oscilloscopes*
- *Pulse Detection Systems Pulse Doppler Radars*
- *High Speed Signal Capture*
- *Operates at Input Frequencies Much Greater Than Sample Rate to Provide Sub Sampling, Frequency Down Conversion*

Hittite
MICROWAVE CORPORATION

2 Elizabeth Drive • Chelmsford, MA 01824
978-250-3343 tel • 978-250-3373 fax • sales@hittite.com

Visit Us: www.hittite.com
Contact Us: adc@hittite.com

Receive the latest product releases - click on "My Subscription"

Ultra Low Noise Amplifiers Improve Cell Coverage and Reduce Costs

Mobile data communication utilization is increasing rapidly, outpacing voice communication utilization due to the increasing number of mobile data consumers. New radio access networks (RAN) are currently being developed and tested to accommodate this growth in data capacity and mobile data users. For instance, long term evolution (LTE) RANs are now being tested and deployed globally. This raises the corresponding demands on radio transceiver performance, such as a lower noise figure (NF), a high input intercept point of second/third order (IIP2/IIP3) and operation over a wider bandwidth (BW). Better immunity against large unwanted signals is also desired.

Yet a cellular base transceiver system (BTS) can be deployed in such a way that the total number of BTSs in a given region can be reduced, while still maintaining optimal cell coverage. From an operator perspective, this yields opportunities to reduce CAPEX and OPEX.

A low NF is not the only RF parameter that matters for an LNA. The number of interference signals increases when the number of users in one cell is increased. To cope with high levels of interfering signal levels, the linearity of the LNA needs to be increased while maintaining the lowest possible NF. Finally, the NF and linearity should be flat over frequency to support wideband RANs.

NF LINK TO CELL DISTANCE

In order to link the LNA's NF to cell distance, some intermediate steps have to be made first. Two classical formulas are used, one for the receiver sensitivity and the other for the propagation model. The receiver sensitivity P_{sens} is expressed as:

$$P_{sens} = kT \cdot B \cdot F_{sys} \cdot P_G \cdot \frac{E_b}{N_o} \quad (1)$$

where k is Boltzmann's constant, T is the device temperature, B is the signal bandwidth (in case of UMTS 3.84 MHz), F_{sys} is the system noise factor, P_G is the processing gain (in case of WCDMA), and E_b/N_o is the bit energy to noise energy ratio.

The radio link budget assumes a minimum signal level to be received at the cell edge, usually expressed in terms of a maximum allowable path loss together with a link margin to provide a specified level of Quality of Service (QoS). A statistical analysis of the radio signal measurements exposes that the path loss (PL) at any particular location between the base station and mobile stations at any distance (d) can be expressed as a random variable, which follows a log normal distribution around the median path loss value. The propagation model that is used here is the COST Okumura-Hata model:

$$PL = 46.3 + 33.9\log_{10} f_c - 13.82\log_{10} h_B - a(h_R) + \left[44.9 - 6.55\log_{10} h_B\right]\log_{10} d + C \quad (2)$$

And in the case of urban areas:

$$a(h_R) = (1.1\log_{10} f_c - 0.7)h_R - 1.56\log_{10} f_c - 0.8$$

$$C = \begin{cases} 0 \text{ dB for medium cities and urban areas} \\ 3 \text{ dB for metropolitan areas} \end{cases}$$

with $1500 \text{ MHz} < f_c \le 2000 \text{ MHz}, 30 \text{ m} < h_B \le 200 \text{ m}, 1 < h_R \le 10 \text{ m and } 1 \text{ km} < d \le 20 \text{ km}$

where PL is the median path loss (dB), f_c is the radio frequency (MHz), h_B is the base station antenna effective height (m), d is the link distance (km), h_R is the mobile station antenna effective height (m) and $a(h_R)$ corresponds to the mobile station antenna height correction

Paul Mattheijssen
NXP Semiconductors, Eindhoven, The Netherlands

factor (dB). In suburban areas, 8 dB standard deviation is subtracted to deal with shadowing. The total medium path loss (PL) is obtained from the total link budget as shown in ***Appendix 1*** (view online at mwjournal.com/NXPappendix).

In addition, other parameters have to be included in the link budget. These are:

Soft hand over (SHO) gain, which is gain against slow fading (log normal fading) by reducing log normal fading margin. Soft hand over is the ability to exploit the macro diversity between different Node Bs. All cellular systems use multi-antenna diversity at the base station receiver and transmit antenna diversity at the base station transmitter. However, these 'micro diversity' techniques are mainly aimed at mitigating the effects of multipath fading and have very little impact on the larger scale like shadow fading.

If a mobile device can establish simultaneous links to different Node Bs, then, given the spatial separation of the Node Bs, each link is likely to experience a different shadow fading characteristic. By combining the information received on each individual link, the effects of shadow fading can be mitigated to some degree and this is termed macro diversity.

Uplink noise rise: There is a trade off between intended uplink coverage and uplink total received interference power. The total received power increases due to the addition of a user in the cell and depends heavily on the uplink noise rise (NR). This is defined as the ratio of total received interference power to background noise power, NR = C/N. It represents the direct relationship between total interference power increase and current noise increase, as opposed to current total received interference power. This is the reason why uplink noise has to be included in the link budget. Noise rise is also often described by means of the cell load η: 10 Log (1/(1 - η)). In this article, a cell load of 0.7 (or 5.23 dB) is used.

Log-normal fade margin: Slow fading is caused by events such as shadowing, where a large or tall obstruction such as a hill or a tall building obscures the main signal path between the transmitter and the receiver. The amplitude change caused by shadowing is often modelled using a log-normal distribution with a standard deviation according to the log-distance path loss model. In this example, a standard deviation of 5 dB is used with a confidence probability of 90 percent.

Voice communication is the most critical consideration in cell planning, due to the fact that no retransmission is allowed compared to data transmission. For this reason, the link budget is based on voice communication. The lowest voice data rate using adaptive multi-rate audio speech (AMR) codec is 12.2 kbps. In UMTS, the chip rate is 3.84 MChips/s, which results in a spreading gain or processing gain of 25 dB.

The total base station transmission power is chosen to be 40 dBm or 10 W into 50 Ω, measured at the output of the final stage amplifier. The output power level is attenuated by cable and connector losses before it arrives at the antenna connector. The 40 dBm power is conducted power and needs to be converted to radiated power or effective isotropic radiated power (EIRP). An isotropic radiator radiates power equally in all directions. However, a perfect isotropic radiator is only theoretical. All realizable antennas will concentrate the power in a certain direction. For instance, a half wave dipole has an antenna gain of 2.15 dBi. In this article, the antenna gain of the base station is assumed to be 18 dBi, which gives a total EIRP of 55.5 dBm or 355 W radiated power.

The radiated power is further attenuated by free space loss and absorption by materials like trees, concrete buildings, etc. Moreover, not only attenuation takes place but also reflection, refraction and diffraction. For diffraction, an additional margin, called fading margin, should be included in the link budget and here a 5.1 dB lognormal fading margin is assumed.

At the UE side, the antenna receives the multiple replicas of the wanted and unwanted signals. The radiated power received at the antenna is converted into conducted power where an antenna gain of 0 dBi is assumed. In addition, an extra body loss of 3 dB should be accounted for in the link budget. This reflects the fact that antenna gain is measured in free space, whereas in practice the handheld device is close to the human head, which reduces the antenna gain.

Via the duplex filter, the received signal enters the input of the LNA, after which it will be further processed toward the base band. This concludes the downlink Node B (transmit) to UE (receive). In fact, the return path UE to node B is of greater importance for a base station.

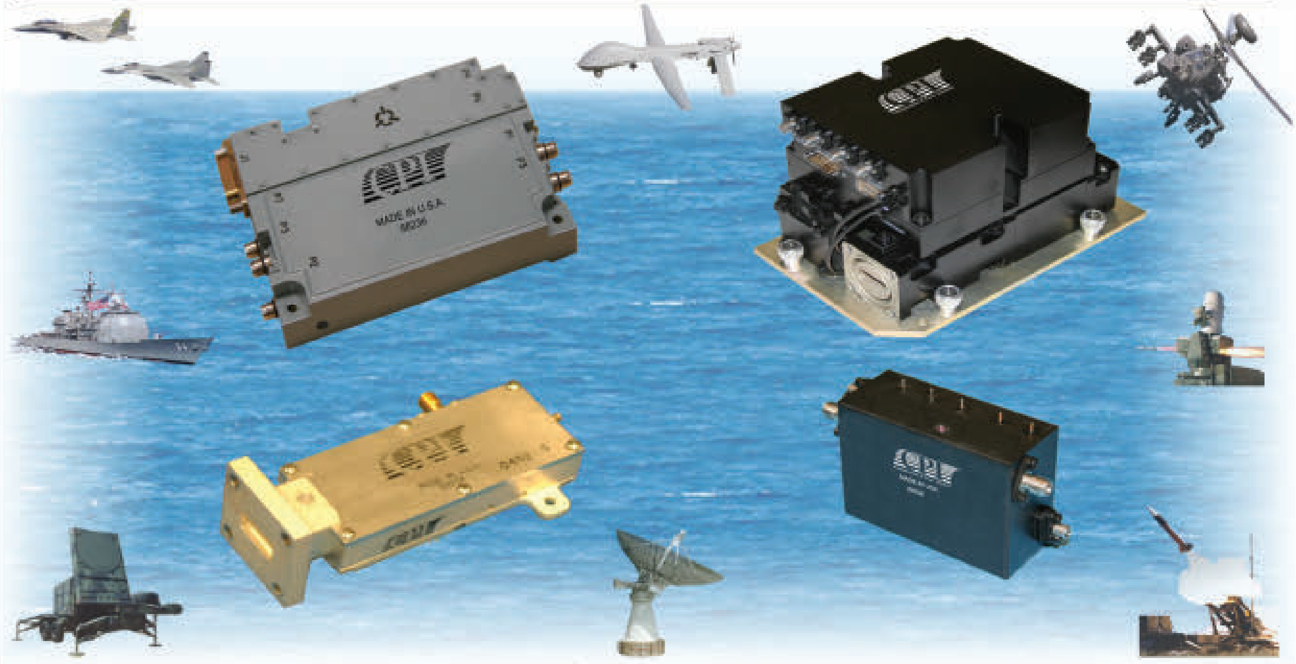
In the uplink from transmitting UE to receiving Node B, the maximum transmit power at the UE is limited, due to battery operation lifetime. Here, a conducted power of 21 dBm or 126 mW into a 50 V termination is assumed. Likewise for the downlink, the antenna gain is set to 0 dBi and a body loss of 3 dB is assumed. The conducted power is converted to EIRP at the UE antenna and equals 21 dBm. It is assumed that the radio channel is equal for the downlink and the uplink.

At Node B, the receive antenna gain is again 18 dBi. Additional losses (antenna connector, cable and duplex filter) should be subtracted from the received conducted power. For the sake of simplicity, diversity gain is not used in this link budget calculation. After the receive antenna, connector and cable losses, the received signal arrives at the input of the duplex filter. This filter has an insertion loss of 0.6 dB. To meet the receiver sensitivity level, the total front end noise figure should not exceed 3.1 dB.

This 3.1 dB can be decomposed into several contributions, duplex filter losses (0.6 dB), baseband processing noise (0.5 dB) and front end noise. The front end noise includes ADC noise and, given the duplex filter noise and baseband noise, the overall front end noise figure (NF) is 1.9 dB, assuming that the LNA contributes most of it and is chosen to be 0.6 dB. Knowing the total system noise figure NF_{sys}, the receiver sensitivity can then be calculated. Given the thermal noise density and the total system noise, the total noise density can be calculated as –170.7 dBm/Hz. Next the minimum signal strength, or sensitivity level, for a given bit error rate can be calculated.

This level is defined by the required E_b/N_o, the bit energy divided by the noise energy, which is often provided in the standard and depends heavily on the radio channel propagation conditions. In this article, using a voice call at 12.2 kbps and a pedestrian channel the E_b/N_o is specified as 11.9 dB. Adding the total noise density, the required E_b/N_o and processing gain and converting from power density to power

Integrated Microwave Assemblies



Advanced Technology - Extensive Experience - Superior Performance

CPI
Communications & Power Industries

Communications & Power Industries' Beverly Microwave Division (BMD) offers product technology that includes Integrated Microwave Assemblies and Control Components. BMD's broad experience and extensive capabilities in the areas of high power microwave component design for military and non-military radar, satellite, communications, and EW systems makes it uniquely suited to design and manufacture a wide range of components and multi-function assemblies in small, lightweight packages. Coupling that with our experience in other transmission lines and technologies gives us a technical capability that is unparalleled in the microwave industry.

* Multi-function components
* RF front ends
* Switches & attenuators
* High level assemblies & modules
* Design capability up to 40 GHz
* Power handling to 1 MW+ peak
* Integral driver & associated electronics
* The industry's most extensive high power test facility

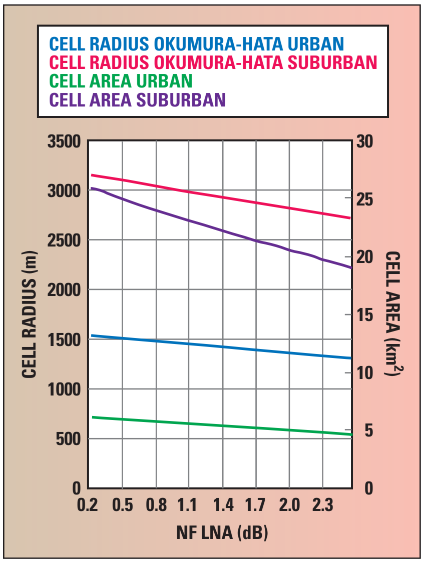
Communications & Power Industries
Beverly Microwave Division

150 Sohier Road
Beverly, MA 01915
Phone: (978) 922-6000
Fax: (978) 922-2736

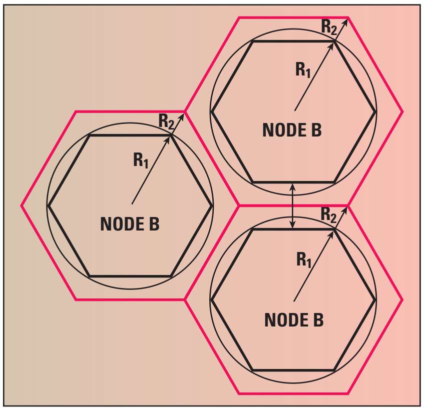
marketing@bmd.cpii.com
www.cpii.com/bmd

level by adding the bandwidth logarithmically, the receiver sensitivity is obtained (–112 dBm). Finally, after inclusion of all of the aforementioned effects, the total path loss (PL) [dB] can be calculated as:

PL = EIRP Tx power + Rx antenna gain - body loss - noise rise + Rx diversity gain - cable/connector loss - receiver sensitivity + SHO gain (dB).



▲ *Fig. 1 Cell radius and cell area as a function of LNA NF.*

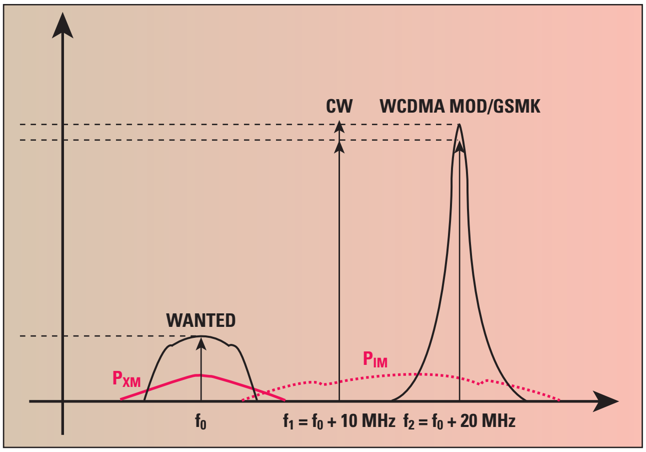


▲ *Fig. 2 Cell coverage increase by lowering LNA NF.*

Knowing the total path loss (= median path loss) from the link budget and the path loss channel model from Okumura-Hata path loss model for urban and suburban areas, the cell radius can then be calculated. In the case of the pedestrian channel, the cell radius is assumed to be 1.3 km for urban areas and 2.6 km for suburban areas. Suppose that the shape of a cell is a regular hexagon with a cell radius of 1.3 km or 2.6 km, then in the case of an urban area the covered area is 4.4 km^2 and 17.6 km^2, respectively. If the NF of the LNA is swept from 0.2 to 2 dB, the cell radius gain and cell area gain can be plotted as shown in ***Figure 1***. Reducing the NF of the LNA by a factor of 2 increases the cell area by more than 7 percent. Therefore, the usage of an LNA with an NF of 0.4 dB instead of having an NF of 2.0 dB increases the operator's coverage by 26.5 percent. ***Figure 2*** illustrates the cell coverage improvement achieved by lowering the LNA's NF.

CROSS AND INTERMODULATION CHARACTERISTICS

There are two basic nonlinear distortion mechanisms, one is the intermodulation and the other is the cross-modulation. Intermodulation may produce an additional amount of noise in the wanted frequency channel, called PIM, (see ***Figure 3***). The cross-modulation characteristics are a measure of the immunity of the base station receiver against interferers that produce a spurious response within the wanted assigned channel frequency. This specification sets the cascaded input referred third-order intercept point (IIP3) of the base station receiver. Cross-modulation distortion is the most significant distortion mechanism in WCDMA receivers, where the modulated transmitter signal in the receiver path cross-modulates with a close-in jammer to produce in-band distortion.



▲ *Fig. 3 Intermodulation requirement for WCDMA wide area base station.*

Normally the static reference performance of the wanted signal is defined 3 dB above the reference sensitivity level. Two interfering signals with specific cross-modulation performance requirements are added. Figure 3 shows the intermodulation and cross-modulation requirements in the case of a WCDMA wide area base station non-narrow band cross-modulation. The red line (P_{XM}) represents the result of cross-modulation from the CW tone with the WCDMA modulated signal and falls in the wanted frequency.

In order to calculate inter-modulation requirements, two more parameters are needed: the required E_b/N_o to meet the reference BER and the maximum allowed receiver desensitization X. The reference BER for voice speech is E_b/N_o = 8.3 dB and the power levels of the two interferer signals are for P_{cw} = –48 dBm and for the P_{wcdma} = –48 dBm/3.84 MHz. Accordingly, the IIP3 can be calculated using the equation:

$$IIP3 = P + \frac{P - \left(P_{ref} - \frac{E_b}{N_o} + 10\log 10\left(10^{\frac{X}{10}} - 1\right)\right)}{2} \quad (3)$$

where $P = P_{cw} = P_{WCDMA}$ are the interference power levels, P_{ref} is the reference sensitivity level, E_b/N_o is the level to meet the reference BER and X is the receiver desensitization factor. Where X is set to 3 dB, the cross-modulation noise (P_{XM}) is equal to the thermal noise floor (N_o) and the receiver is desensitized by 3 dB, thus P_{ref} is increased from –115 dBm to –112 dBm. In the 3GPP standard, a 3 dB receiver desensitization is specified.

However, since there are more distortion components that will desensitize, the receiver base station manufacturers apply a lower value. Here, a receiver desensitization of X = 3 dB is taken, due to intermodulation specifications according to the 3GPP standard. ***Table 1*** shows the IIP2 and IIP3 numbers for WCDMA wide area base station.

BLOCKING CHARACTERISTICS

The blocking characteristics are a measure of the receiver's ability to receive a wanted signal at its assigned frequency channel in the presence of an unwanted interferer on frequencies other than those of the adjacent channels. Distinction is made between adjacent channel blocker, in-band blockers (IBB) and out-of-band blockers

MICROWAVE PYROLYSIS

The most important thing we build is trust

Batch reactor:

The Cobham RMP2450B microwave reactor system allows granular solids to be simultaneously heated and stirred under controlled atmospheric conditions. The equipment enables accurate microwave measurements to be obtained and these can be automatically stored together with the reaction temperatures, thus providing data that can be used for further analysis.

Pyrolysis reaction temperatures of up to 900ºC

Temperatures are monitored using calibrated microwave choked infrared sensors. Homogeneous reaction conditions throughout the large multimode cavity are achieved.

Leakage levels in all possible operating conditions are maintained within the limits set by the national safety standard thanks to our unique choke design.

Easy coupling to a vacuum pump for the recovery of volatile solvents or organics. The quartz glass reaction vessel has a capacity of 1200ml.

Ideal for proof of principle and feasibility studies

The Cobham batch reactor provides all the efficiency benefits of a multi mode cavity with the uniform energy distribution and continuity of the reaction process associated with a single mode cavity design.

Continuous feed system:

We have successfully completed a fully operational continuous feed pyrolysis system in 2012

The continuous feed system is currently being used to recover value from waste tyre rubber in the form of carbon char, oil and gas. At Cobham Microwave we know microwave pyrolysis is key to a more efficient and environmentally friendly recycling industry.

(The development of this equipment was assisted through funding by the Technology Strategy Board)

For further information please contact:

Cobham Microwave
Stocks Lane, Bracklesham Bay
Chichester, West Sussex, UK
Tel: +44 (0) 1243 670711
Email: microwave.uksales@cobham.com

TABLE I

IIP2 AND IIP3 FOR WCDMA CROSS-MODULATION CASES FOR WIDE AREA BASE STATION

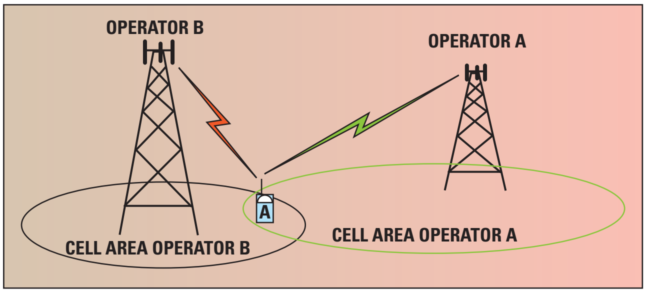
All	Pref (dBm)	PCW (dBm)	PMOD (dBm)	PW (dBm)	E_b/N_o (dB)	Rate	Max Rx Dense(dB)	IIP3 (dBm)	IIP2 (dBm)
Wide Area BS	–115	–48	–48	–115	8.3	12.2 kbps	3	–10.34	27.320624
Band II, III, IV, V, VII, X, XII, XIII, XIV									
Wide Area BTS	–115	–47	–47	–115	8.3		3	–8.84	29.320624

(OOB). This can better be explained by referring to ***Figure 4***. When node B from operator B is receiving a strong (IBB) signal from a mobile device linked to operator A, but working in operator B adjacent carrier, then node B from operator B can be blocked. Operators have to deal with this so-called near-far problem. The signal strength of the blocking signal depends on many aspects such as cell size and position. A worst case situation will occur when the sites of operator B are allocated at the cell borders of operator A.

ADJACENT CHANNEL BLOCKER

In the test specification of the 3GPP standard, the adjacent channel selectivity (ACS) is a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an adjacent channel signal at a given frequency offset from the center frequency of the assigned (wanted) channel. ACS is the ratio of the receiver filter attenuation on the assigned channel frequency to the receiver filter attenuation on the adjacent channel(s). The adjacent channel blocker can be linked to adjacent channel leakage ratio (ACLR) by the following empirical formula:

$$\text{ACLR} = 2(P \pm \text{IIP3}) - 20.75 + 1.6\xi \quad (4)$$



▲ *Fig. 4 Graphical blocking description in case of two operators working in the same area.*

where P is the blocking power, IIP3 is the input inter-modulation of third order, the 20.75 is a constant that depends on CCDF statistics of the WCDMA signal, and j is the peak to average ratio (PAPR). Note that this formula is only valid in cases where an adjacent channel has only a single carrier. ACLR itself can be written as PIM3-P (note that ACLR results in a negative dBc number). Including the receiver desensization factor X, the IIP3 can be expressed as:

$$\text{IIP3} = P + \frac{P - \left(P_{ref} - \frac{E_b}{N_o} + 10\text{Log}10\left(10^{\frac{X}{10}} - 1\right) + 20.75 - 1.6\xi\right)}{2} \quad (5)$$

The PAPR factor j is set to 11 dB (worst case). For a wide area base station, the interfering signal mean power level P is –52 dBm at a frequency offset of 5 MHz (the adjacent channel). The reference sensitivity level mean power is –115 dBm (for voice rate of 12.2 kbps). ***Figure 5*** shows the blocking characteristics for WCDMA.

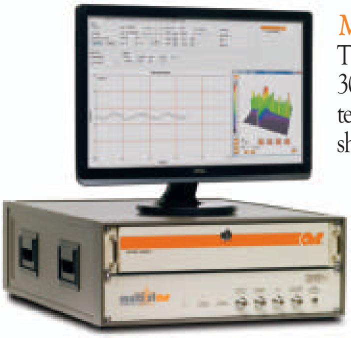
Substituting the values in Equation 5 gives the IIP3 due to adjacent channel blocking as –6.61 dBm.

IN-BAND BLOCKERS

In-band blocking characteristics are a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer on frequencies other than those of the adjacent channels (alternate channel). This is shown in ***Figure 6*** as F_0+10 MHz – since these interferers are beyond 5 MHz,

When Good Enough Is Not Good Enough

It's a tough, competitive world. If you let your guard down for a second, your competition could knock you out of the game. So you've got to keep finding ways to get better, faster, more accurate. That's the way we think at AR, and that's why our customers welcome our new products and new technologies. We can help you gain a competitive edge with innovations like the following:



MultiStar Precision DSP Receiver

This EMI receiver accurately performs over 30,000 CISPR detections at once to reduce test time from days to minutes and insures that you detect short duration disturbances!

MultiStar Multi-Tone Tester

This incredible system cuts RF immunity testing from days down to hours by testing multiple frequencies simultaneously. It saves time & money, and helps get your product to market faster.

1.0 to 2.5 GHz Solid State Amplifiers

This amplifier family provides an alternative to TWTA's and offers better harmonics, less noise and superior reliability.

Dual Band Amplifiers

For the first time you can go from 0.7 to 18 GHz with the reliability of solid state. You not only have new freedom, you've got a two-amp package that costs less, weighs less, and takes up less space than two separate amplifiers.

Traveling Wave Tube Amplifiers

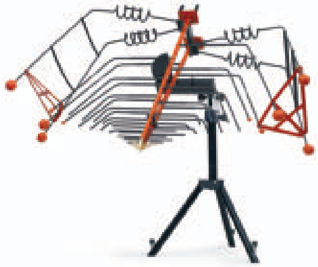
We may not have invented TWTAs, but we definitely perfected them. Our extensive line of TWTAs provide higher power up to 40 GHz. Reliable power, compact size. We offer CW or pulse designs.

Integrated Test Systems

AR can provide an all-in-one test system for any EMC application from DC to 50 GHz. Everything you need is right at your fingertips. Our systems make testing easy, accurate, efficient and affordable.

Laser-Powered E-Field Probes

Never needs batteries. Most continuous coverage from 5 kHz to 60 GHz and up to 1000 V/m field strength. With outstanding accuracy, linearity and bandwidth.



Radiant Arrow Bent Element Antennas

We bent the rules and advanced the science of log periodic antennas. Our bent element antennas are up to 75% smaller, lighter, and more compact to fit in smaller chambers.

When "good enough" isn't good enough for you,
visit www.arworld.us/omni or call us at 215-723-8181.

ISO 9001:2008 Certified

rf/microwave instrumentation

Other ar divisions: modular rf • receiver systems • ar europe

USA 215-723-8181. For an applications engineer, call 800-933-8181.
In Europe, call ar United Kingdom 441-908-282766 • ar France 33-1-47-91-75-30 • ar Benelux 31-172-423-000

www.arworld.us

the ACLR requirement is not of interest. It is assumed that intermodulation is responsible for the distortion.

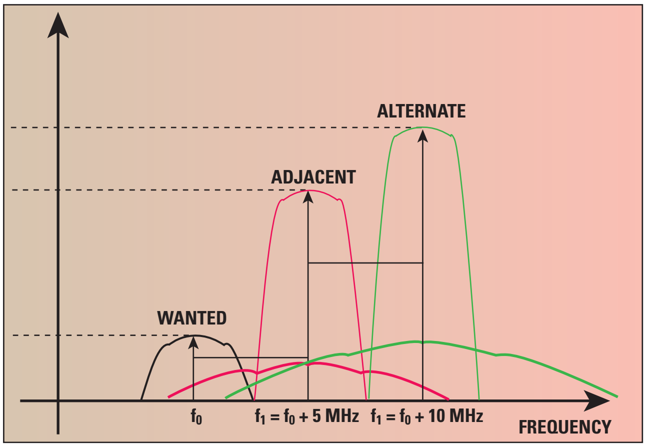
The center frequency of the interfering signal (band I) is between 1920 and 1980 MHz. For a wide area base station, the interfering signal mean power is –40 dBm, where the static reference performance is met with –115 dBm wanted signal mean power. Equation 5 is not applicable for alternate channels, therefore Equation 3 will be used here. Substituting the power values and the receiver desensization factor X of 0.1 dB, the required IIP3 due to alternate channel blocking equals 9.81 dBm.

OUT-OF-BAND BLOCKERS

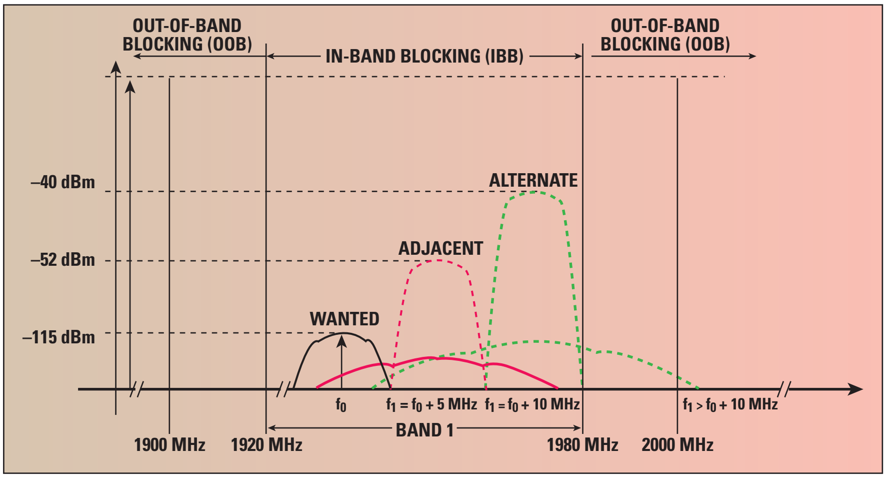
Referring to 3GPP band I blocking performance, there is also a requirement for out-of-band interference from 1900 to 1920 MHz and 1980 to 2000 MHz bands. These frequency ranges are just outside the wanted receive band from 1920 to 1980 MHz. Using wide area base station requirements, the interfering signal mean power is –40 dBm in this OOB case (1900 to 1920 MHz and 1980 to 2000 MHz). The static reference performance is met with –115 dBm wanted signal mean power. This results in the same IIP3 as in the IBB case 9.81 dBm since the types of blocking signals are the same.

Finally there is a requirement for 1 to 1900 MHz and 2000 to 12750 MHz, where the interferer is a CW having a power level of –15 dBm. The frequency offset is 20 MHz away from the Band I frequency edges. It is assumed that this part of OOB can be partly filtered. For instance, suppose that the interferer can be attenuated by 30 dB worst case (typical 40 dB attenuation). In this case the IIP3 equals 2.3 dBm when dominated by intermodulation.

More important is the Tx (2110 to 2170 MHz) leakage into the receive band (1920 to 1980 MHz). In the case of a FDD system, the Tx-Rx separation is 190 MHz and a commercial available duplex filter has 40 dB attenuation. Suppose that the average transmit power is 49 dBm/3.84 MHz (80 W/3.84 MHz in 50 V) then the Tx signal that leaks into the Rx band is 9 dBm/3.84 MHz. The requirement for a wide area base station that limits spurious emissions for protection of the base station receiver is -96 dBm measured in 100 kHz, or –80 dBm/3.84 MHz. Fortunately the Tx and Rx time slots have a certain delay so that during the Rx slot, the Tx leaked signal is sufficiently ramped down.

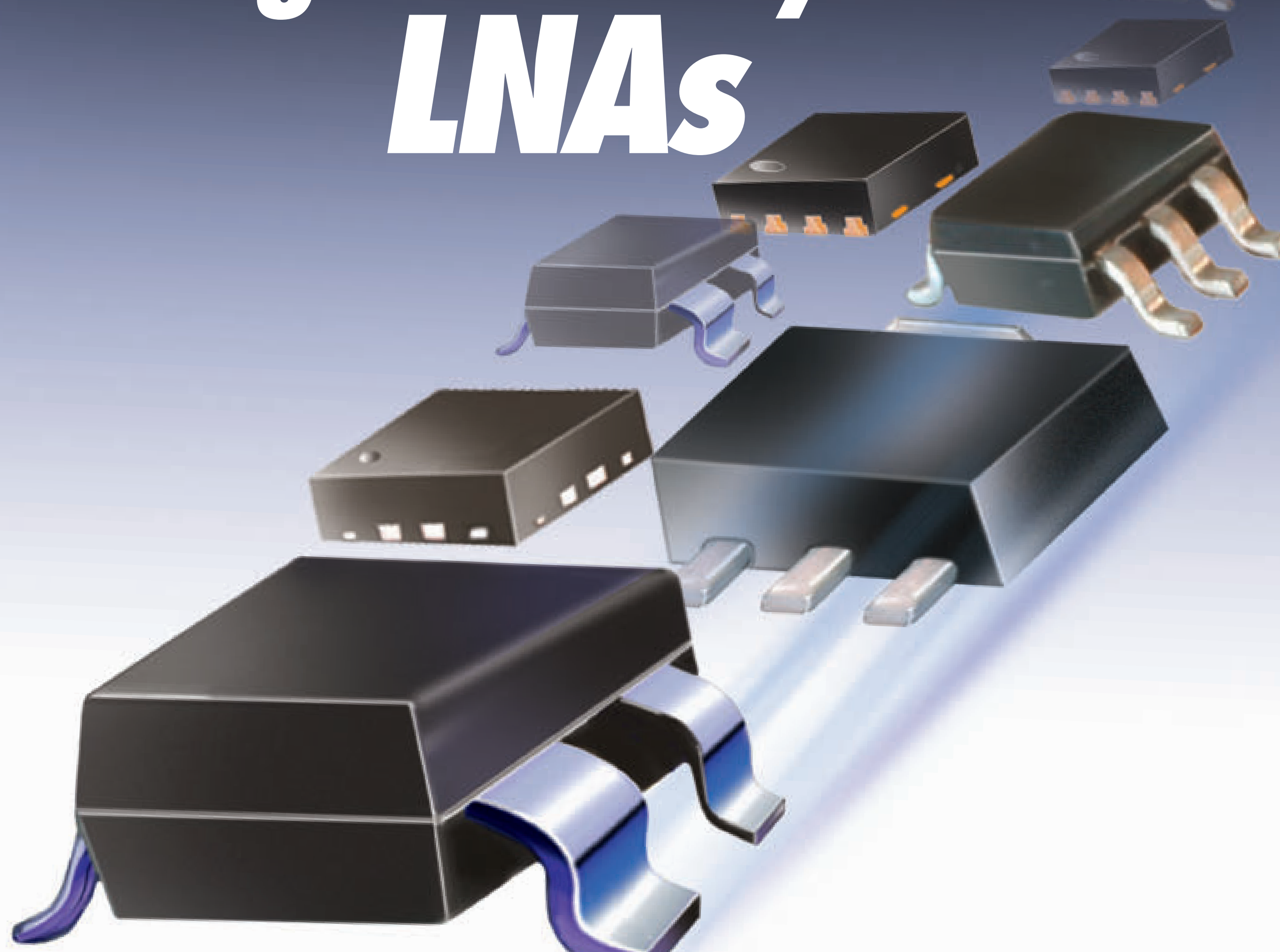


▲ *Fig. 5 Blocking WCDMA characteristics (adjacent and alternate channels).*



▲ *Fig. 6 In-band adjacent and alternate channel WCDMA blockers.*

High Linearity LNAs



NF as low as 0.5 dB • IP3 up to 43 dBm • DC current 20 mA and up from $1.49 ea. (qty. 20)

Pick your parameters, and meet your needs at Mini-Circuits! With over 20 low noise/high linearity amplifier models to choose from, you'll likely find the output power, gain, DC current, and broad bandwidths required to upgrade almost any 3-to-5V circuit—from cellular, ISM, and PMR to wireless LANs, military communications, instrumentation, satellite links, and P2P—and all at prices that preserve your bottom line!

Our catalog models are in stock and ready to ship, so why wait? Go to minicircuits.com for all the details, from data sheets, performance curves, and S-parameters to material declarations, technical notes, and small-quantity reels—as few as 20 pieces, with full leaders and trailers. Place an order today, and see what these tiny, high-performance amplifiers can do for your application, as soon as tomorrow! *RoHS compliant*

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

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

Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

YONI2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

506 rev C

TABLE II

IIP3 DERIVED REQUIREMENT FROM A STANDARD SUMMARY TABLE INCLUDING GSM

GSM IIP3 Due to Blocking				
	GSM400, TGSM810, P-, E-, RGSM900		*DCS1800 & PCS1900*	*GSM900, EGSM900 BTS*
Inband	*IIP3 BTS Except MC*	*Multi Carrier BTS*	*BTS incl. Multi Carrier BTS*	
600 kHz $\leqq \|f-f_0\| <$ 800 kHz	16.01	2.51	2.51	10.01
800 kHz $\leqq \|f-f_0\| <$ 1.6 MHz	31.01	26.64	17.51	–4.99
1.6 MHz $\leqq \|f-f_0\| <$ 3 MHz	31.01	26.64	17.51	–4.99
3 MHz $\leqq \|f-f_0\|$	35.51	26.64	17.51	–4.99
Out-of-Band				
(a)	7.01	7.01	–4.99	7.01
(d)	7.01	7.01	–4.99	7.01
UMTS IIP3 Due to Blocking				
	1920-1980 MHz	*1900-1920 MHz 1980-2000 MHz*		*1-1900 MHz 2000-12750 MHz*
	1.66	1.66		–5.84
IIP3 Due to X-Modulation			*IIP3 Due to ACS Blocking*	
GSM900 Normal BTS	*UMTS Wide Area BTS*		*GSM900 Normal BTS*	*UMTS Wide Area BTS*
–9.49	–10.34		–23.34	–14.76

Table 2 shows the IIP3 derived requirement summary for GSM and WCDMA. It can be concluded that GSM sets the demanding IIP3 requirements. Note that these values are obtained from the values written in the GSM and WCDMA standard (3GPP). In the case of single carrier GSM, a sharp bandpass filter is required to attenuate the blocking signals, while for multicarrier GSM, a band pass filter is only applied where multiple carriers are passed through.

According to Table 2, using the blocking requirement from R-GSM MC BTS standard results in an IIP3 of 26.64 dBm and includes relaxation for multicarrier GSM. But the likelihood that a blocker has a level beyond the power level is limited. Today's LNAs achieve an IIP3 between 17 and 19 dBm at a fixed gain of 18 dB.

REDUCING BASE STATION NUMBERS

Besides the improvement in cell coverage due to low NF, there is an additional financial benefit for the operators. Take for example two LNAs with two different noise figures of 0.9 and 1.2 dB. Given the LNAs' NFs, the cell size is known and the area of the country – in this case the Netherlands with an area of 41,526 km^2. Assume also that there are more urban base stations than suburban base stations. In this calculation, the distribution is taken to be 70 percent, 30 percent.

The annual costs for one base station are as follows. Assume one base station consumes 800 W and the price for electricity is €0.20/kWh, then the price for one year is €1397.76. Further assumptions are O&M €3000 per unit and average site lease costs of €5000 per year.

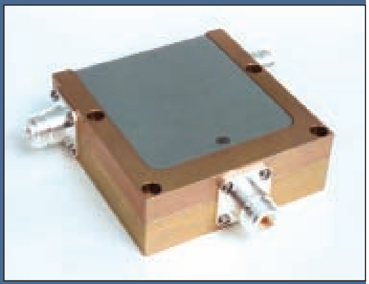
Initial costs include equipment purchase and site build out, including installation, which are €40,000 and €80,000 per unit. Adding all costs together and working them out across the Netherlands gives a total cost savings of €34.3 million, which is significant. If divided among the number of operators, this represents substantial savings per operator. In terms of the number of base stations, the savings is 4.4 percent and CAPEX and OPEX is reduced by 4.5 percent.

CONCLUSION

This article has shown that the noise figures of LNAs can be linked to the distance of the cell coverage via link budget calculations. On the other hand, the number of interference signals increases when the number of users in one cell is increased. To cope with high levels of interfering signal levels, the linearity of the LNA needs to be increased while maintaining the lowest possible NF. More important for network operators, lowering the LNA NF yields savings in CAPEX and OPEX (4.5 percent). ■

HIGH POWER

100 MHz to 20 GHz

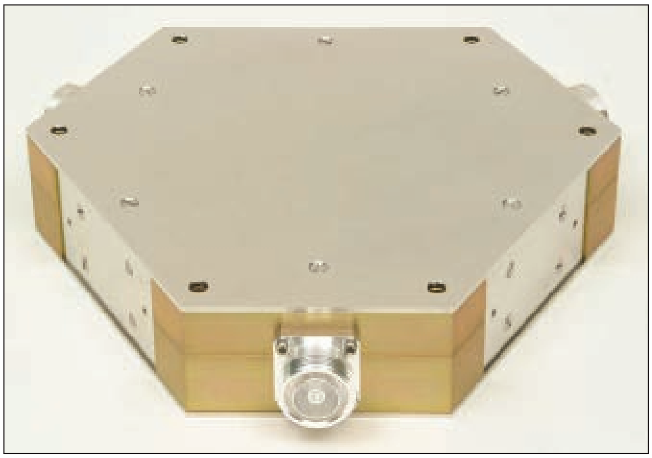


For Military / Radar Applications.

Isolators/Circulators

As one of the leading suppliers of ferrite components in the industry, UTE Microwave has pioneered innovative designs, quality craftsmanship and exceptionally high quality products. Custom designs, standards...many of them off-the-shelf, are the result of over 35 years of experience in the industry. UTE Microwave continues this tradition with new products for ever changing applications. Our broad line of HIGH POWER, low loss circulators and isolators spans the spectrum from below 100 MHz in coax/stripline units to waveguide devices at 18 GHz for both peak and average powers.

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



A new HIGH POWER Circulator suitable for FM Broadcast, Scientific and Medical applications is now available. The unit provides 10 MHz bandwidth in the 85–110 MHz spectrum.

Specifications are 20 dB min. isolation, 0.3 dB max. loss and 1.25 max. VSWR. Operating power is 1 kW average and 25 kW peak. The 8-1/2" hex x 2" thick unit operates over a 15°–50° C temperature range. DIN 7/16 connectors are standard. Other units are available at higher frequencies.

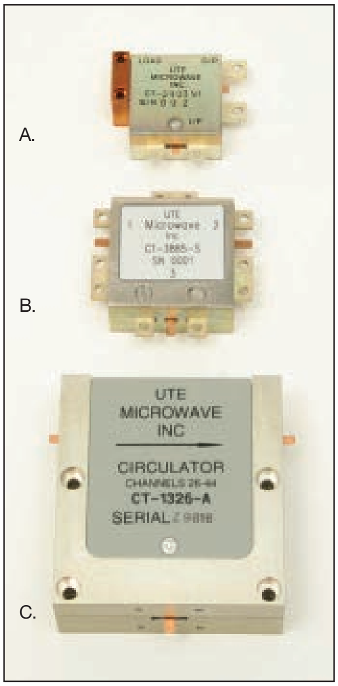
HIGH POWER Drop-in Series

A broad line of low loss HIGH POWER Drop-in circulators are available from VHF to Ku band including Kilowatt average power levels at VHF thru S band. L and S band radar are a specialty. A few of these are shown here.

A) 2.7–3.1 GHZ 1 kW pk, 100 W av

B) 1.2–1.4 GHZ 3 kW pk, 300 W av

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



Our "POWER-LINE" serves the COMMUNICATIONS, TELECOM, MEDICAL, SCIENTIFIC, TV, PCS and INDUSTRIAL markets.

The following models are examples of our High Power units

Model No.	Power	Connectors	Freq. Range
CT-1542-D	10 Kw Pk 1 Kw Av	DIN 7/16	420–470 MHz
CT-2608-S	3 Kw Pk 300 W Av	"Drop-in"	1.2–1.4 GHz
CT-3877-S	2.5 Kw Pk 250 W Av	"Drop-in"	2.7–3.1 GHz
CT-3838-N	5 Kw Pk 500 W Av	N Conn.	2.7–3.1 GHz
CT-1645-N	250 W Satcom	N Conn.	240–320 MHz
CT-1739-D	20 Kw Pk 1 Kw Av	DIN 7/16	128 MHz Medical

FEATURES:

- Power levels to 5 KW CW, 75 KW Pk.
- Low Intermod Units
- Low Loss Options
- Extended Octave Bandwidths
- Power Monitors and DC Blocks
- Iso Filter-Monitor Assemblies

Broadband Units • Common Band Devices • High Isolation Units • Multiport Devices • Drop-In Devices • Wireless/PCN Devices • High-Power Industrial/Medical Iso Adaptors Waveguide Junctions • High-Power TV Units • VHF and UHF Devices

sales@utemicrowave.com

UTE MICROWAVE INC.
3500 Sunset Ave., Asbury Park, NJ 07712
Tel: 732-922-1009 Fax: 732-922-1848
E-mail: info@utemicrowave.com

Contact us for more information on our extensive product line and current catalog. We accept Visa, MC, Amex

Decades of Innovation: Past, Present and Future

Robert Stephens, President of Aeroflex / Weinschel, talks about the RF/microwave control components market, the evolution of the technology to support today's systems and test instrumentation and the company's 60 year milestone.

Executive Interviews

Aeroflex / Weinschel is celebrating 60 years of operations since founder Dr. Bruno Weinschel set up shop in 1952 manufacturing passive microwave components, including the world's first commercial coaxial attenuators. At the time, the technology to produce and measure precise passive microwave components was in its infancy. Dr. Weinschel played a key role in advancing the early state of attenuation-based technology and measurement equipment. Since then, the company has progressed with the times and demands of the markets it serves, enhancing the performance and capabilities of RF and passive microwave components into a broad range of products that includes fixed and programmable attenuators, commercial off-the-shelf and custom subsystems, and unique connector system solutions for a wide range of challenging test, simulation and RF distribution applications. The times may have changed but the company's longevity is a testament to the market demand for signal control products that have evolved to include a wide range of subsystem solutions far beyond that original attenuator technology.

Dr. Weinschel came to the United States as an eighteen-year-old genius with the equivalent of a Bachelor's degree in physics and a wealth of hands-on mechanical training. Studying under Nobel Prize winners Isidor Rabi and Enrico Fermi at Columbia University Graduate School, Dr. Weinschel was first exposed to microwave measurements when he was tasked with building a 1300 MHz source for investigating the magnetic moment of molecules. Accepting a job as a supervisory engineer at Bell Labs (1943-44), the German-born physicist found himself designing microwave test equipment side-by-side with American engineers possessing a minimal understanding of microwave theory. Dr. Weinschel's physics background proved invaluable in designing equipment for precise attenuation measurements and industry standards. As chief engineer at Industrial Instruments (1944-48), and then section chief at the National Bureau of Standards (1949-52), Dr. Weinschel convinced his management to let him work on coaxial attenuators, advancing the work he had started at Bell Labs. Developing attenuator technology for the Army's ordnance development, he was responsible for a classified contract working on techniques to measure the microwave reflections used to trigger proximity fuses. Dr. Weinschel's engineering passion and drive to improve the performance of his attenuator technology eventually led him to set up a pri-

Aeroflex / Weinschel
Frederick, MD

vate laboratory and to discover a market for precision attenuators. To avoid any perceived conflict of interest, he left the NBS to form Weinschel Engineering and continue developing the technology that is so critical to today's RF and microwave signal control and measurement systems. Dr. Weinschel received the National Medal of Science under President Regan. He also served as IEEE president in 1986 and the chairman of the Committee on U.S. Competitiveness (1988) for the IEEE.

Thriving through multiple ownership and name changes, including Lucas Industries PLC and Lucas Weinschel (1986), Sierra Networks and Sierra Weinschel (1995), MCE Technologies Inc. and Weinschel Corporation (1995), and the Aeroflex purchase of MCE / Weinschel which created the current Aeroflex / Weinschel (2003), the company has emerged as an industry benchmark in quality products and service. "The company formed as Weinschel Engineering, Co. in 1952, has changed ownership seven times, having successfully transitioned from a privately held company, to a division of a foreign-owned corporation, to a division of a publicly traded company. The company has managed to survive multiple recessions, various war-driven economies and national budget-constrained times, and through it all, remained a market leader, continuing to re-invent itself with new products that provide solutions to today's market needs," says Robert L. Stephens, Aeroflex / Weinschel president and general manager.

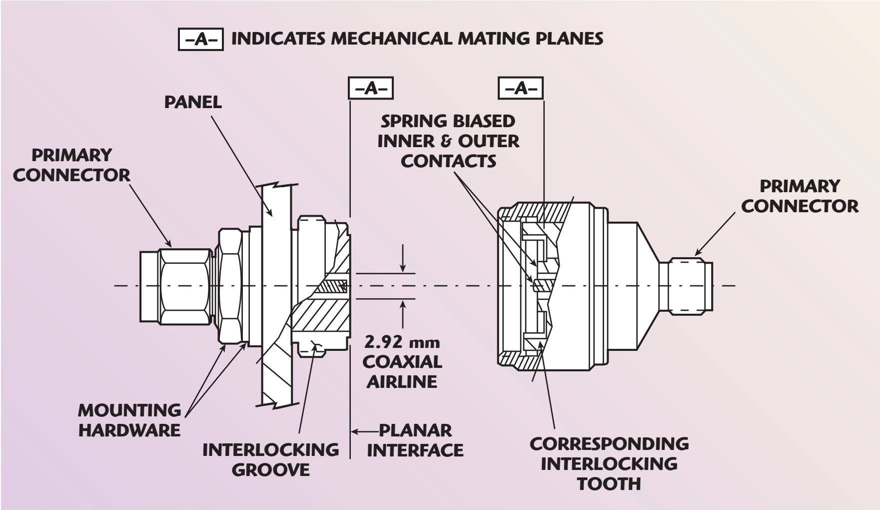
In the early 70s Dr. Weinschel saw the demand for fixed RF attenuators grow rather fast, beyond the test and measurement applications of the laboratory. He wanted to improve on the RF connector design. At the time the insulators and center contacts were pressed into a jack or plug body and held together with epoxy, injected from a side hole. This made the connectors inherently leaky to RF waves. Dr. Weinschel wanted to address this leakage problem while moving to higher volume manufacturing, so he invested heavily in injection mold machines from Germany.

Every connector type, either SMA or type N, needed a complicated mold fixture to get the desired final connector, with the support insulator, the center contact and the jack/plug body all neatly molded in one piece without the need for any epoxy. Weinschel was the first company to supply Injection molded RF connectors into its commercial product line. Today the same process has been extended beyond SMA and type N connectors. Type SMK (2.92mm) and 2.4mm connectors are also molded in a multi-cavity mold. Injection molded connectors are rugged and reliable, have a consistent pin recession and offer the lowest RF leakage.

In conjunction with the attenuator development and other resistive base components, the need arose to make accurate insertion loss measurements. This need resulted in the development of precision measurement and calibration instruments. These instruments were originally designed for their own use, but the demand for this type of equipment by other laboratories was so great that Weinschel decided to make their calibration instruments available industry wide. This effort produced several products such as attenuator calibrators (BA-5 & VM-3), differential null detectors, double stub tuners, AF-substitution attenuators, modulated RF sources and other test and calibration of instruments. Weinschel's engineering and calibration staff has received over 40 patents and had over 70 technical articles published. This innovation has aided in their development of precision measurement and calibration equipment. In November 1997, this instrument line was sold to Tegam where they still manufacture these products today.

Look no further than its list of patents, past and present, which set the foundation for Weinschel's technical history. Its patents in attenuation measurements and design, connectors, detectors, frequency control, impedance measurement, power measurement, RF sources, step attenuators and tuners paved the way for the company's current business strategy. The evolution and success of Weinschel lies in its ability to adapt to changing market conditions and customer demands while simultaneously maintaining the core technologies, product development, processes and procedures. Innovation at Aeroflex / Weinschel is reflected in its ever-expanding


Big and Small,
we have 'em all
Almost any Waveguide to almost any Coax Connector
WG Materials : Aluminum, Copper, Brass
Connectors : 1.92mm ...SMA....
TNC....N...7/16
Spectrum
Elektrotechnik GmbH
when Quality is needed
80905 Munich, Germany
P.O. Box 450533
Telephone: +49-89-3548-040
Facsimile: +49-89-3548-0490
WWW.SPECTRUM-ET.COM
Email: Sales@Spectrum-et.com
WG-Big&SmallE5



▲ *Fig. 1 Cross section of Planar Crown® Universal Connector System.*

line of RF and microwave components and subsystems. From the company's very first DC to 1 GHz tee attenuator came the technology that fostered the design of the industry's very first 500 W, DC to 10 GHz and 20 W, DC to 40 GHz attenuators, to name just two. These planar distributed resistor elements, form the basis for most all attenuators manufactured today from DC to 65 GHz.

Aeroflex / Weinschel utilizes both a thick film process, for DC to 3 GHz programmable attenuators, and a thin film process for the development of its resistors. The company utilizes a proprietary chemical vapor deposition (CVD) where a tin oxide (SnO) film doped with antimony (Sb) is sprayed onto a ceramic and the deposition takes place at a very high temperature. This technology and process gives Aeroflex / Weinschel's thin film products extreme ruggedness and high power handling capability at very high surface temperatures. Doping the film with Antimony results in an industry standard setting attenuator performance with low power and temperature coefficients, long term stability and endurance under high power. It also allows Weinschel to offer a wide variety of low intermodulation (IM) attenuators and terminations. Today Aeroflex / Weinschel offers the broadest frequency and power handling performance envelope in the industry.

In the late 70s Weinschel obtained a patent on a 2 GHz relay based programmable attenuators. They used relays from Teledyne and were built on alumina with thick-film circuitry providing a patented scheme for tuning each individual attenuator. The result was a flat frequency response over DC to 2 GHz, quite unmatched in those early days. This attenuator formed the foundation of today's long list of programmable attenuator products spanning from DC to 6 GHz to DC to 26.5 GHz. The various programmables use either microstrip or edge-line as the transmission medium. Electromechanical relays, Edge line Reed Switches, PIN diodes, FETs or MMICs provide the programmability and the switching function, depending on the application.

As customer demand for faster switching speed within the telecommunications industry increased during the mid 90s, mainly for simulation and handover testing of mobile phones, Weinschel saw the need to develop its own line of solid-state GaAs and PIN switched programmable attenuators for its own attenuation matrices. New requirements from end-users to reduce cost and provide portability has produced a line of MMIC switched digital attenuators that are low profile and operate to 6 GHz up to 95 dB. Control for these devices was also an important consideration, which led Aeroflex / Weinschel to incorporate both built-in TTL and USB 2.0 interfaces. This device is programmed to auto select the type of control that is connected to the device. Included attenuation control center software makes it even easier to operate whether the device is in a bench or field application. In a majority of its

software included

This tiny peak power sensor will make a giant impact on your productivity.

In your job, there's no time for downtime. And there's less tolerance for error. That's why we created Agilent U2020 X-Series USB peak power sensors. They're the world's fastest USB power sensors, so you'll spend less time in testing. Plus you'll save cost and complexity with built-in trigger in/out. Now you'll always be ready to achieve your peak performance.

U2020 X-Series Peak Power Sensors
3,500 readings/sec measurement speed
2 models: up to 40 GHz
–30 to +20 dBm peak power range
Internal zero and calibration

Scan the QR code or visit goo.gl/AcGQv to see a video demo

Agilent and our Distributor Network
Right Instrument.
Right Expertise.
Delivered Right Now.

Buy from an Authorized Distributor
www.agilent.com/find/distributors

Make faster and more accurate pulse measurements. Download our app note at
www.agilent.com/find/USBpowersensor

Anticipate ___Accelerate ___Achieve

Agilent Technologies

wide product line, including high-reliability products, Weinschel does not use any solder, either to launch onto the substrate or for RF grounding. Every product has a unique gold-plated spring mechanism to provide RF and thermal grounding. Each product also has a spring loaded connector end launch onto the RF circuitry. These two features make the products virtually immune to mechanical shocks and thermal extremes, a very important requirement of high-reliability products being launched into space.

Industry demand for high performance connectors led Weinschel to develop an innovative specialized planar connector systems. The Planar Crown® Universal Connector System, which is comprised of two connector halves/subassemblies, has a common mating interface referred to as the Planar Interface (see ***Figure 1***). The first connector half is called the Planar Bulkhead which readily mounts into instrument front panels, components and cables. One end of this bulkhead has a 2.92mm (SMK) male/female primary connector. The other end has a combination of grooves, external threads and a coaxial Planar Interface with a 2.92mm (SMK) airline geometry. The bulkhead operates mode free beyond 40 GHz. The second, replaceable connector half, called the Planar Crown, has corresponding projections which interlock with slots on the bulkhead and a coupling nut which secures the two connector halves, resulting in a non-rotational, torque independent electrical connection.

The spring biased inner and outer contacts eliminate the need for specifying proof torque and no tools are required to mate or unmate the connection. The primary end of the Planar Crown is offered in a variety of primary coaxial connector configurations such as SMA, Type N, GPC-7, TNC, 3.5mm, 2.92mm (SMK) and 2.4mm (under development), thus providing an extremely versatile connector system wherein a connector can be replaced in a matter of seconds.

The Planar Blind-mate Connector Series was designed for threadless connector mating that is useful when mating an array of connectors from one RF module to another in seconds. This design provides a "forgiving" mechanical interface that can permit a 0.02 mis-alignment. These connectors offer DC to 40 GHz operation, a contact life of 1.0 m cycles and a repeatability of 0.05 dB typical per connection. Other features of this connector series include pressurized and unpressurized designs, SMA and SMB connector options and a space saving and rugged construction.

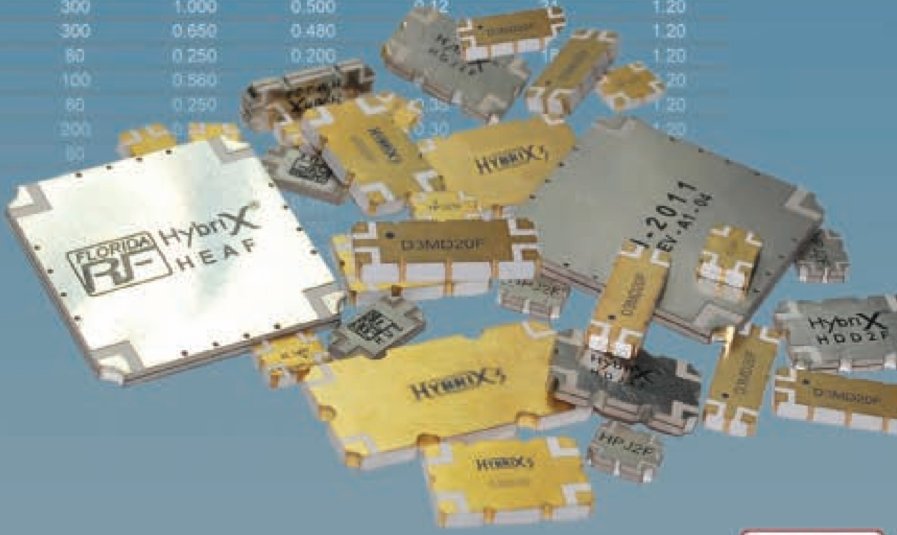
Today Aeroflex / Weinschel builds products for a host of customers, including leading aerospace and defense contractors, commercial wireless network providers and test equipment manufacturers. The company's subsystem development activity focuses on custom products employed in telecommunications, radar and CNI, satellite and ground communication systems, base station and mobile unit software conformance verification, signal analysis, cable modem and VoIP testing, production test systems and precision microwave related test instruments. These custom subsystems include attenuator and switch matrices and RF distribution systems.

Weinschel's subsystem group has developed a modular approach, trademarked "SmartStep®," that utilizes a single controller that provides control of digital and programmable attenuators, switches and other devices using various industry standard communications interfaces (GPIB/IEEE-488, RS-232, RS-422, RS-485) to the serial Driver Interface Bus. New designs will include a USB 2.0 Full-Speed configuration, which is 12 Mbps and is compatible with 1.0 (1.5 Mbps) and 1.1 (12.5 Mbps) speeds. The Device Interface Bus (DIB) is a system for connecting a number of relatively low-speed I/O devices to a host, providing a simple, uniform and inexpensive way to control a variety of devices via a single port. The DIB is based on the two-wire serial bus and several software protocol layers that allow the controller to address up to 125 peripheral devices with serial data rates of up to 100 kHz. The DIB is also used to supply DC power to the devices, resulting in a simple, low-cost interconnection system. The future requirements placed on RF and microwave signal control circuitry by the industry will spirit innovation that started with Bruno Weinschel and the company that bears his name. ■

Couplers from 50 MHz to 18 GHz

0805 Package Now Available

Part #	Frequency	Power	Length	Width	I.L.	Isol.	VSWR
DN05W20F	15000-18500	50	0.175	0.175	0.60	32	1.60
HN05W03F	15000-18500	50	0.175	0.175	0.70	18	1.50
HUU2F	5000-6000	25	0.400	0.200	0.22	25	1.18
D3PR20F	3400-3600	80	0.250	0.200	0.22	40	1.20
HPR2F	3000-4500	60	0.250	0.200	0.18	24	1.15
HPQ2F	2700-3200	50	0.250	0.200	0.18	23	1.15
HPP2F	2300-2700	35	0.250	0.200	0.21	23	1.23
HMP2F	2300-2700	80	0.560	0.200	0.11	23	1.17
D3DP30F	2300-2700	200	0.560	0.350	0.20	48	1.20
HVR3F	**3300-3700**	**5**	**0.080**	**0.050**	**.30**	**20**	**1.20**
HVP3F	**2300-2700**	**5**	**0.080**	**0.050**	**.35**	**24**	**1.20**
HVL3F	**2000-2300**	**5**	**0.080**	**0.050**	**.35**	**24**	**1.20**
HVJ3F	**1700-2000**	**5**	**0.080**	**0.050**	**.35**	**24**	**1.20**
HVV3F	**700-1000**	**5**	**0.080**	**0.050**	**.60**	**17**	**1.26**
HDDF	811-1000	200	0.560	0.350	0.15	26	1.15
HDD2F	811-1000	200	0.560	0.350	0.15	26	1.15
WH0825F	800-2800	150	2.200	0.500	0.48	16	1.38
HDV2F	700-1000	200	0.560	0.350	0.24	24	1.21
D3PV30F	700-1000	200	0.250	0.200	0.10	50	1.15
HDT2F	690-910	200	0.560	0.350	0.25	23	1.17
HLB2F	470-870	500	1.340	0.670	0.12	20	1.20
HSBF	470-860	200	0.650	0.480	0.25	19	1.30
HEAF	150-175	200	1.000	1.000	0.20	20	1.17
HE128MF	123-133	300	1.000	1.000	0.23	28	1.10
HG064M2F	048-084	300	2.000	1.500	0.20	20	1.20
HD128M3F	123-133	10	0.560	0.350	0.80	20	1.35
HAA3F	180-210	200	1.000	0.500	0.30	20	1.20
HLA3F	180-210	300	1.034	0.670	0.30	20	1.20
D3AA30F	180-210	200	1.000	0.500	0.30	48	1.20
HDC3F	380-520	200	0.560	0.350	0.30	20	1.20
HSC3F	400-500	200	0.650	0.480	0.25	20	1.20
HDB3F	470-860	200	0.560	0.350	0.30	20	1.20
HLB3F	470-860	500	1.340	0.670	0.30	18	1.30
W3H0526F	500-2600	100	1.772	0.394	0.50	18	1.30
HPT3F	620-900	150	0.250	0.200	0.18	23	1.15
W3H0830F	800-3000	100	1.969	0.394	0.50	18	1.30
HDD3F	815-960	200	0.560	0.350	0.15	23	1.20
HAD3F	815-960	300	1.000	0.500	0.12	[illegible]	1.20
HSD3F	815-960	300	0.650	0.480	[illegible]	[illegible]	1.20
HPD3F	815-960	80	0.250	0.200	[illegible]	[illegible]	1.20
HMD3F	815-960	100	0.560	[illegible]	[illegible]	[illegible]	[illegible]
HPF3F	950-1100	80	0.250	[illegible]	[illegible]	[illegible]	1.20
HDE3F	1000-2000	200	[illegible]	[illegible]	0.30	[illegible]	1.20
HPG3F	1200-1700	80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HDJ3F	1700-2000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HAJ3F	1700-2000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



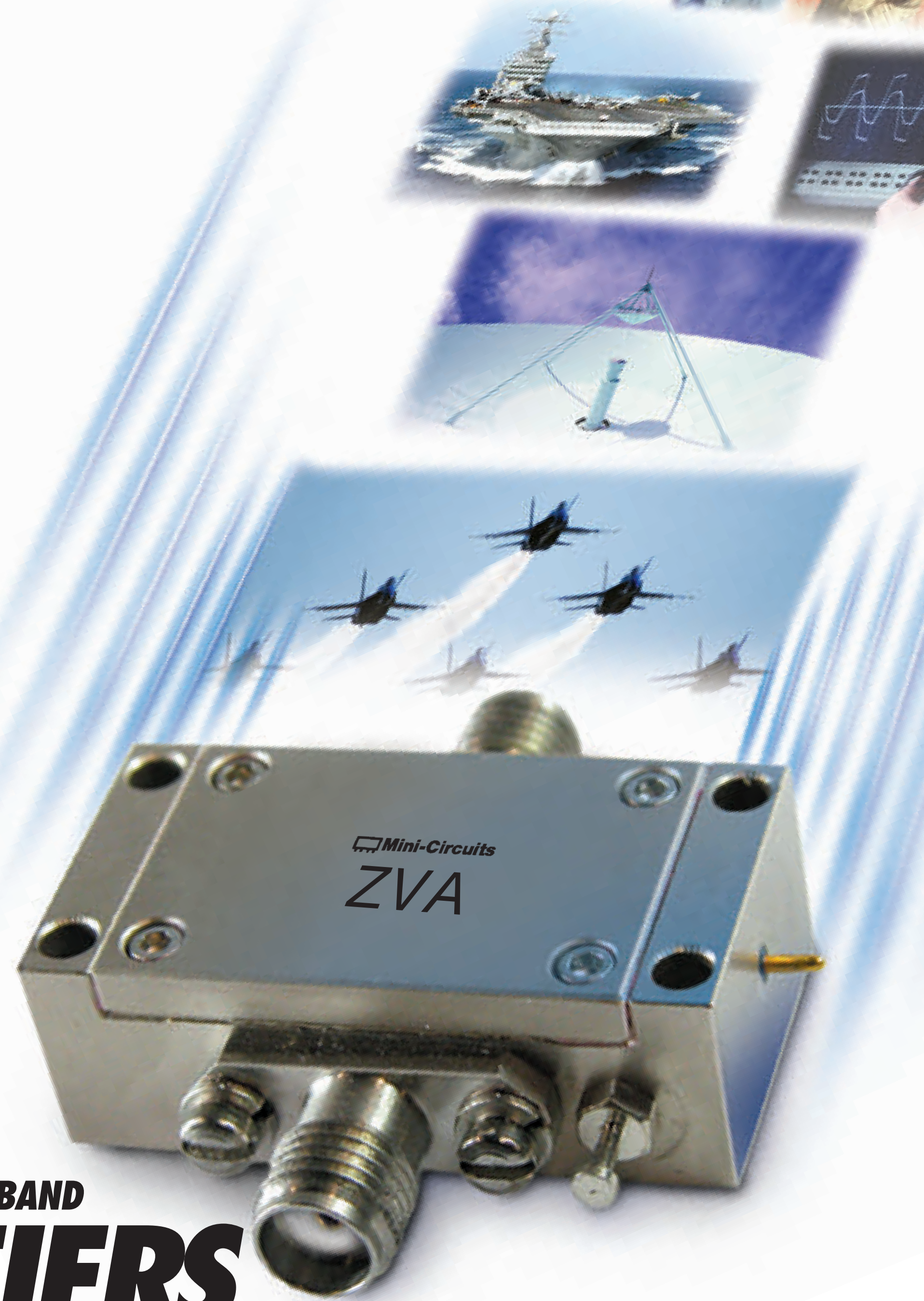
+1 772-286-9300 or 800-544-5594

www.emc-rflabs.com | sales@emc-rflabs.com

FLORIDA RF Labs

Editorial Index

Editorial Index



SUPER ULTRA WIDEBAND

AMPLIFIERS

up to +27 dBm output... 0.1 to 21 GHz

from $845 *ea.*

Ultra wide coverage and super flat gain make our ZVA family ideal for ECM, instrumentation, and test systems. With an output power up to 0.5 Watts, they're simply some of the most usable amplifiers you'll find, for a wide range of applications and architectures!

All of our ZVA models are unconditionally stable, ruggedly constructed, and able to withstand open or short circuits at full output. For more details, from data sheets to environmental ratings, pricing, and real-time availability, just go to minicircuits.com!

All models IN STOCK!

RoHS compliant

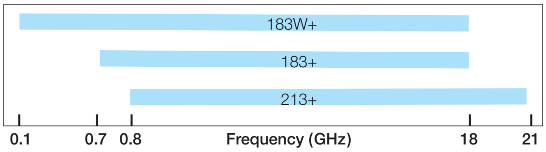
Mini-Circuits…we're redefining what VALUE is all about!

Electrical Specifications (-55 to +85°C base plate temperature)

Model	Frequency (GHz)	Gain (dB)	P1dB (dBm)	IP3 (dBm)	NF (dB)	Price $ * (Qty. 1-9)
NEW ZVA-183WX+	0.1-18	28±3	27	35	4.0	1345.00
ZVA-183X+	0.7-18	26±1	24	33	3.0	845.00
ZVA-213X+	0.8-21	25±2	24	33	3.0	945.00

* Heat sink must be provided to limit base plate temperature. To order with heat sink, remove "X" from model number and add $50 to price.

Wideband Performance



Mini-Circuits®
ISO 9001 ISO 14001 AS 9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yoni2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

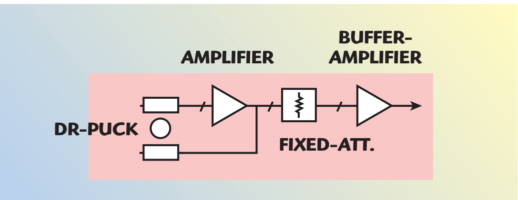
440 rev M

Editorial Index

Ultra-Low Noise Dielectric Resonator Oscillator

When high data-rates have to be transferred, as with M-QAM modulation in LTE, LMDS, fixed frequency point-to-point digital radio and satellite-links, these systems need low phase noise signal sources either free running or phase-locked. RADAR systems and Research Laboratories also require ultra-low noise sources to generate ultra-low noise carrier signals.

A wide range of military, industrial, medical, test and measurement markets demand these very stable frequency sources with enhanced phase noise performance and low thermal drift. A popular solution in the range of 3 to 18 GHz frequency spectrum is the dielectric resonator oscillator (DRO), recognized for its superiority in ultimate noise floor and spectrum purity when compared to other competing solutions such as multiplied lower frequency fundamental sources.



▲ *Fig. 1 DRO block diagram.*

Synergy Microwave is introducing a new generation of small, ultra low noise DROs to address these market needs. The free running CDRO1000-8 from SMC has mechanical and electrical frequency tuning designed to give the best phase-noise performance for a 10 GHz DRO to serve these markets.

The circuit in ***Figure 1*** shows a typical block diagram of the DRO. The design challenge was to develop the lowest phase noise DRO, while minimizing costs through highly repeatable production builds. Such consistency in design and manufacturing could only be achieved through solid circuit simulation, by employing the latest state-of-the-art CAE tools such as ANSYS HFSS and Agilent-EEsof ADS/Momentum. The complete DRO design has been exercised and optimized using circuit and EM co-simulation (see ***Figure 2***). This approach enabled us to achieve a high loaded figure of merit (Q_L) for the dielectric resonator arrange-

Synergy Microwave
Paterson, NJ

Radio Wireless Week

20 - 23 JANUARY 2013, AUSTIN, TX, USA

IEEE | MTT-S | IEEE COMMUNICATIONS SOCIETY

http://www.radiowirelessweek.org/

Register Now! http://www.radiowirelessweek.org/

Start The New Year With A Week of Wireless 20-23 January 2013 in Austin, TX

Join us in Austin, Texas for the 2013 IEEE Radio and Wireless Week (RWW). In addition to the Radio and Wireless Symposium (RWS) and IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF), three topical conferences held in parallel provide more focused sessions in the areas of RF Power Amplifiers (PAWR2013), Biomedical Wireless Technologies and Sensing Systems (BioWireleSS2013), and Wireless Sensors and Sensor Networks (WiSNet2013). Those five related conferences focus on the intersection between radio systems and wireless technology, creating a unique forum for engineers to discuss hardware design and system performance of state-of-the-art wireless systems and their end-use applications. The conference targets to bridge the gap between digital and RF and hardware and software. This multidisciplinary IEEE event will offer the latest information on wireless communications and networking, associated enabling technologies, and emerging new services and applications.

RWW 2013 Highlights

35 Technical Oral Sessions - Mon-Wed, 21-23, Jan., 2013
Interactive Poster Sessions - Mon/Wed, 21,23, Jan., 2013
Student Paper Competition Finals - Mon, 21 Jan., 2013
Demo Sessions - Tue, 22 Jan., 2013
Workshops - Sunday afternoon, 20 Jan., 2013
- "Machine-To-Machine (M2M) Communication: A Path Towards the Internet of Things (IOT)"
- "Metamaterials in communications and sensing: reality or fiction?"
- "Towards THz Communications Systems and Applications"
- "Software Defined Radio: Recent Advancements in Hardware and Software"

Panel Sessions, Sun-Mon, 20-21 Jan., 2013
- "Tunable and Reconfigurable Radio Frontends"
- "Wireless Personal Area Networks "
- "Should Design Engineers Really Care About Software Piracy?"
- "Base Station Design Breakthrough Opportunities"

Two RWS/SiRF Joint Sessions
- "THz Communications: Circuits to Networks"
- "Power Amplifiers and Transmitter Modules"

Three Focus Sessions
- "Wireless Power"
- "Wireless Enabled Automotive and Vehicular Applications"
- "Advances in Micro & Millimeter-Wave Biosensing & Interaction"

Exhibits – Mon-Tue, 21-22, Jan., 2013

Joint RWW/SiRF Plenary Session

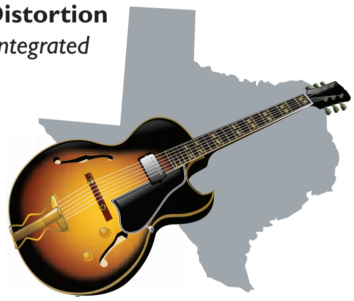
Tue, 22 Jan., 2013

System Approach to RF and Microwave Design
Dr. James Truchard, *CEO of National Instruments*

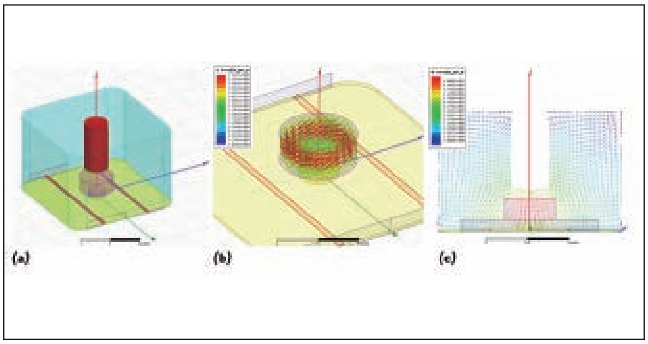
Distinguished Lecturer Talks

Mon, 21 Jan., 2013

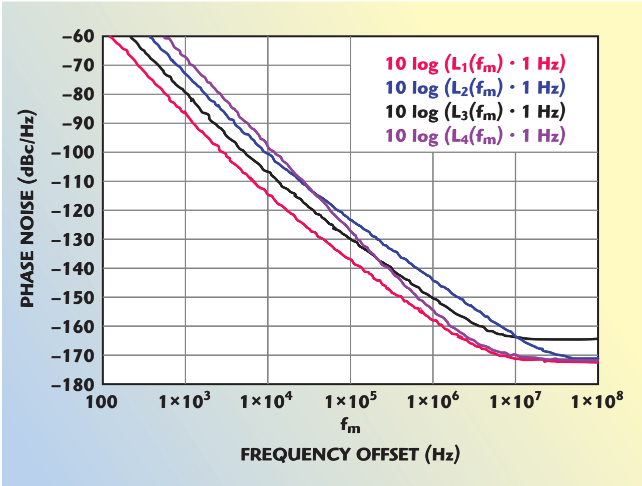
Implantable Wireless Medical Devices and Systems
Dr. J.C. Chiao (MTT-S), *University of Texas at Arlington*
Wideband and Low-Loss Metamaterial Antennas and Arrays with Tunable Radiation Patterns and Directions for Wireless and Radio Applications
Dr. J. Le-Wei Li (APS), *University of Chengdu, China*
What's New in Digital Pre-Distortion
Dr. John Wood (MTT-S), *Maxim Integrated*



HTTP://WWW.RADIOWIRELESSWEEK.ORG



▲ *Fig. 2 Four-port dielectrical resonator model (a), E-Field vector plot within the DR at resonance (b) and H-Field vector plot in YZ-plane (c).*



▲ *Fig. 3 The impact of possible impairments on the phase noise performance.*

ment in conjunction with the oscillator core which is one of the preconditions for achieving lowest phase noise. The oscillator's main active device has been selected carefully with respect to noise figure and flicker noise, with optimum bias level conditions.

Figure 3 illustrates the impact of possible impairments on the phase noise performance. The red trace identifies the measured phase noise performance of Synergy's new 10 GHz model number CDRO1000-8. The blue trace corresponds to a lower Q_L with identical oscillator core noise properties. The black and magenta traces correspond to identical Q_L but significantly higher effective noise figure or flicker corner frequency when the active device is not selected or biased optimally. A combination of these impairments together with nonlinear noise effects account for the much higher phase noise performance found in many competing DRO designs.

The CDRO1000-8 has a typical noise floor of –166 dBc/Hz which approaches state of the art performance. The measured phase noise reaches –111 dBc/Hz at 10 kHz offset as indicated in ***Figure 4***. Mechanical and electrical tuning are available for frequency adjustment and phase locking. The frequency is factory set to 10 GHz and can be mechanically varied by approximately ± 50 MHz. The electrical tuning port varies the center frequency by ±1 MHz with a tuning voltage of 1 to 15 V DC to compensate for frequency drift in phase locked systems. The temperature stability is typically specified at 80 ppm.

The oscillator supply voltage can vary between +7 to +10 V and the internal voltage regulation gives high immunity to power supply noise. The supply-current is typically 50 mA and the temperature range is specified from –25° to +70°C. The output-power exceeds +8 dBm. The actual package size is approximately 3.1" × 1.34" × 0.788", including mounting flaps.

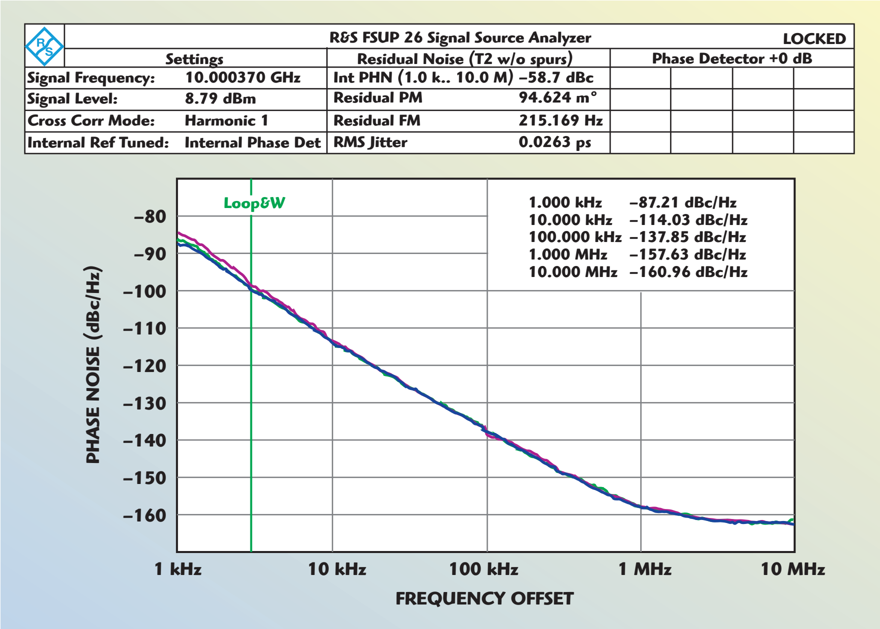


Fig. 4 Measured phase noise of CDRO1000-8.

Similar to crystal oscillators, DROs tend to be prone to vibrational noise since the dielectric resonator itself cannot be secured mechanically. Therefore vibrations must effectively be damped by other means before they reach the dielectric resonator. The CDRO1000-8 is designed with rugged construction to minimize vibration noise and microphonic effects to prevent unwanted modulation.

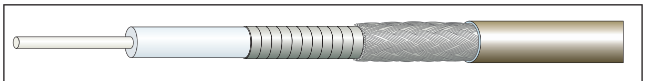
Its excellent phase noise performance makes this DRO well suited for low-jitter communication systems, reference oscillators for phase noise measurement, RADAR systems, SDH/SONET, cable TV, SATCOM systems, aeronautical equipment, digital radios (QAM) and laboratory frequency references. Custom frequencies and packages (hermetic) can be developed on request.

Synergy Microwave,
Paterson, NJ
www.synergymwave.com,
info@synergymwave.com.

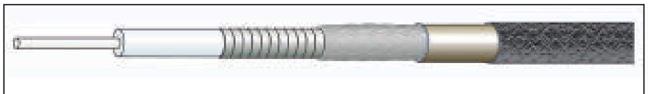
Low Loss Cable Family is Extended

The SUCOFLEX 404 and 404D cable assemblies were launched in summer 2011 and the next step in the roadmap of the SUCOFLEX 400 cable family comes with the introduction of the new 18 GHz cable assembly versions of the SUCOFLEX 406 and 406D, which cover the upper limit of the diameters for very low loss cables in this class. Following the tradition of the new SUCOFLEX 400 cable family strategy, the company aims to continue to set new standards for microwave cable assemblies, particularly in markets like test and measurement, space and defence and instrumentation.

In all these applications, minimal electrical losses, as well as a high level of phase stability in a broad temperature range, are vital. Following a period of intensive development, the SUCOFLEX 406 and 406D meet these extremely high requirements. A new dielectric process technology, similar to the SUCOFLEX 404, significantly improves the electrical properties of the product. Further highlights are its excellent return loss properties and the good phase stability versus bending.



▲ *Fig. 1 The SUCOFLEX 406 is 8.35 mm in diameter.*



▲ *Fig. 2 The SUCOFLEX 406D is 8.70 mm in diameter.*

LOW INSERTION LOSS

The construction of the SUCOFLEX 406 and 406D (shown in ***Figures 1*** and ***2***, respectively) is a solid silver-plated copper wire center conductor, encased by an extruded and expanded ultra low density PTFE dielectric. Responsible for the shielding is a wrapped silver-plated copper tape, covered by a silver-plated copper braid. The cable is jacketed with Fluorinated Ethylene Propylene (FEP). For the 406D, an impregnated aramid yarn is used as a ruggedization for higher mechanical strength.

In particular, the extruded and extended ultra low density PTFE dielectric is responsible for the loss performance of SUCOFLEX 400 products. With a dielectric constant of $\varepsilon_r = 1.26$, the SUCOFLEX 406 is claimed to deliver the lowest insertion loss currently available in its class.

Another highlight is the CW power capability that has been increased together with a

HUBER+SUHNER AG
Herisau, Switzerland

very significant improvement in phase stability versus temperature (shown in *Table 1*). This is a great advantage in applications such as phased array antenna systems and also helps to simplify the adjustment of radars.

The new SUCOFLEX 406 cable assemblies have been specifically developed for defence ground systems, as well as for space measurement and instrumentation applications. In this market, low loss, high phase stability versus temperature/bending and mechanical stability is the key to success.

APPLICATIONS

The SUCOFLEX 406/406D cable assembly is suitable for different applications. In defense technology, its main use is in tactical and strategic communications, electronic warfare and radar systems. Phase-matched cable assemblies are often required for radar applications. Complete sets of phase-matched, time-delay-matched or amplitude-matched SUCOFLEX 406 cable assemblies are available. Also, the special characteristics of the new cable assembly family are likely to make it the preferred solution for all industrial applications where lowest loss is crucial for customer specific installations.

ROLL-OUT

The roll-out of SUCOFLEX 406 and 406D products for selected markets will start with straight male N and TNCA connectors, which will be available by the beginning of 2013. The SUCOFLEX 406/406D including TNCA straight male connector is suitable for 18 GHz and covers MIL-STD-348/313-3. During the course of 2013, the SUCOFLEX 400 product portfolio connector range will be extended and followed by additional thinner cable versions with the lowest losses for frequencies up to 40 GHz, as well as additional connectors, jackets and armor versions for all kinds of applications.

The continuously growing SUCOFLEX 400 family builds on a similar design as the familiar SUCOFLEX 100 products, which have proved their reliability and stability for a wide range of applications for more than 25 years. The connectors have been tuned to the cable in order to preserve the excellent return loss (VSWR) characteristics for the assembly. Current and future RF-systems for defense, space and other industrial applications must comply with the highest requirements; consequently it is essential for the connector components to meet the highest standards.

HUBER+SUHNER AG,
Herisau, Switzerland
+41 71 353 4111,
info@hubersuhner.com,
www.hubersuhner.com.

TABLE I

CABLE CHARACTERISTICS FOR SUCOFLEX 406

Impedance	50 ± 1 Ω
Operating Frequency	18 GHz
Capacitance	72.4 ± 1.9 pF/m
Velocity of Propagation	89%
Signal Delay	3.74 ns/m (1.14 ns/ft)
Phase Stability vs. Temperature	< 1000 ppm
Phase Stability vs. Bending, 360°, Radius 50 mm	max. 1.5 °/GHz
Insertion Loss Stability vs. Bending	< 0.1 dB
Screening Effectiveness up to 18 GHz	> 90 dB
Attenuation Coefficients: a: 0.1200 b: 0.0080*	max. 0.66 dB/m @ 18 GHz
Weight (406/406D)	145 gr/m/155 gr/m
Minimum Bending Radius (406)	> 30 mm
Minimum Bending Radius (406D)	> 80 mm
Operating Temperature	-55° to +125°C
RoHS (2002/95/EC)	compliant

Improving Ultra-Low Cryogenic Temperature Measurements

Noise and uncertainty are the enemies of temperature measurement accuracy, resolution and speed. In the science of cryogenic temperature measurement and control, there are unique challenges in addressing the many sources of potential error. Because the allowable excitation power for the sensors becomes diminishingly small as the temperatures being measured approach absolute zero, the signal levels being measured from those sensors are extremely low. Thus, elimination of noise becomes a critical factor in overall measurement quality.

Recent noise-reducing circuit improvements to cryogenic temperature controllers are improving their overall measurement capability. Among these improvements are improved heater output circuits that generate lower noise and better layout and isolation of the critical input circuits so they pick up less noise.

The newest cryogenic temperature controllers, such as the Model 350 developed by Westerville, OH-based Lake Shore Cryotronics, actually enable ultra-low temperature platform users and OEMs to achieve a new level of quality in measurement and control without requiring the use of more sophisticated AC resistance bridge instruments. This is achieved by reducing input noise by almost a factor of two over previous controllers and limiting the impact of environmental noise. The result is the ability to operate at excitation powers that are nine times lower than before, with a comparable reduction in measurement self-heating errors and an improvement in resolution, speed and overall control stability.

Another significant innovation is the adaption of specialized noise reduction input circuitry from AC resistance bridges. This technology has enabled these premium instruments to provide accurate measurement and control down to 20 mK and below by preventing external noise power from creating self-heating in the sensor. In real-world ultra-low temperature (ULT) installations, it is impossible to eliminate all of the noise induced in the sensor's input wiring from external sources. Rather than asking researchers to continually fight these effects with grounding and shielding schemes that will always be somewhat imperfect, the instrument's noise reduction circuitry cancels this noise internally. ***Figure 1*** shows the general design of differential current source circuitry (US Patent 6,501,225) developed specifically for noise reduction in an AC resistance bridge.

Lake Shore Cryotronics
Westerville, OH

Integration of this and other circuit improvements into modestly-priced next generation controllers enables them to measure and control temperatures down to 100 mK using sensor excitation current levels of as little as 10 nA, with resolution on the order of a few μK. This is quite suitable for pumped Helium-3 (He-3) refrigerators and similar ULT platforms. Reduced excitation current increases measurement accuracy by reducing errors due to self-heating. Better resolution means faster measurements, because a dependable result can be achieved with less averaging – and faster measurements enable faster response and better overall control stability for more consistent temperature management at the extremes.

Lake Shore Cryotronics incorporated a variety of such electronic enhancements into its new Model 350 cryogenic temperature controller. Extensive real-world validation testing was conducted at the company's in-house cryogenic sensor calibration facility that operates dilution refrigerators (DR) as part of an ultra-low temperature test-bed. ***Figure 2*** shows the calibration facility with DRs.

Comparisons were made between the new Model 350 controller and a previous design, the Model 340. Since the new controller is capable of lower excitation current settings than the earlier model, the older model's minimum current setting (30 nA) was used for the comparison. A Cernox™ CX-1010 sensor was selected with a 30 kΩ value

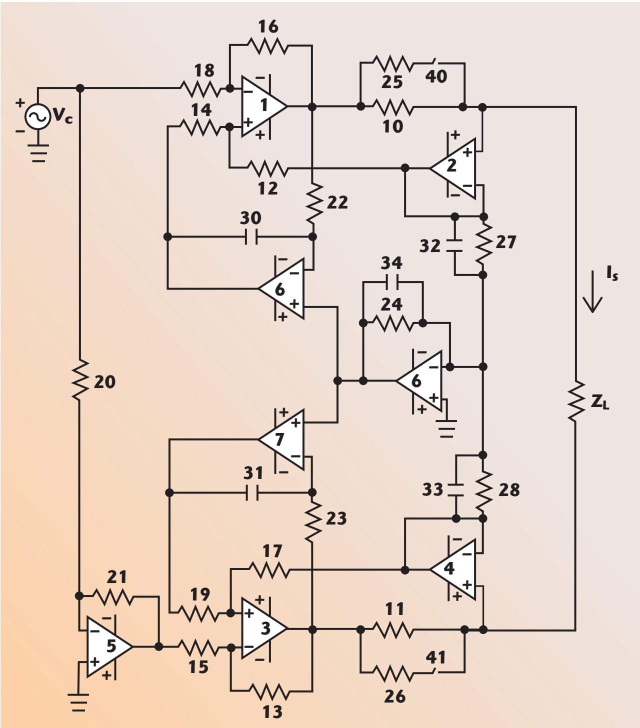


Fig. 1 Noise reduction circuitry design used in AC resistance bridges (US Patent 6,501,225).

TABLE I

SENSOR EXCITATION POWER VS. SELF-HEATING TEMPERATURE OFFSET FOR CERNOX™ CX-1010 SENSOR

Excitation Current/Voltage	*Sensor Resistance*	*Sensor Power*	*Self-heating Offset*
10 nA	30 kΩ	3 pW	6 mK at 100 mK
30 nA	30 kΩ	27 pW	54 mK at 100 mK

TABLE II

MEASURED NOISE

Baseline (at 100 mK)	*Sensor Power*	*Noise Measured/ Specification[1]*	*Noise[2]*	
Model 350 (10 nA)	3 pW	2.2 Ω/4.5 Ω	3.9 μK	
Comparison (at 100 mK)	***Sensor Power***	***Noise Measured/ Specification[1]***	***Noise[2]***	***Adjusted Noise[3]***
Model 350 (30 nA)	27 pW	0.7 Ω/1.3 Ω	1.3 μK	3.9 μK
Older Model 340 (30 nA)	27 pW	1.3 Ω/1.3 Ω	2.4 μK	7.2 μK

[1]RMS noise specification with 0.5 s filtering

[2]Temperature equivalence calculated from the typical sensitivity of a Cernox sensor at 100 mK (-558,110 Ω/k)

[3]Adjusted temperature converts measured noise to a 10 nA equivalent (noise × 3). Shows how the Model 340 would compare if it could operate at 10 nA. Note that although noise levels would be higher, self-heating errors would be reduced.

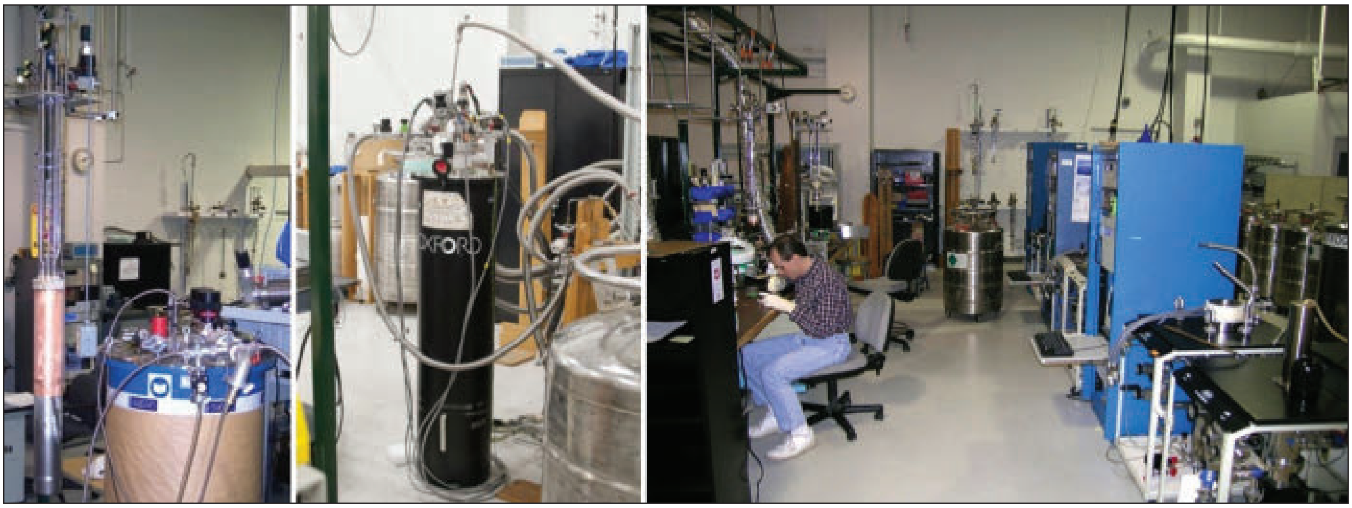
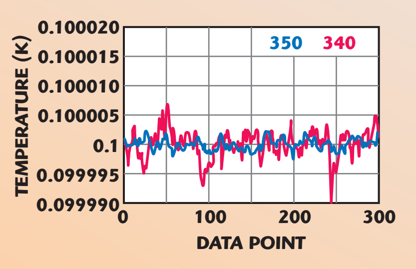


Fig. 2 Cryogenic sensor calibration facility.



▲ *Fig. 3 Sensor readings in test comparing Model 350 with older Model 340 (30 kΩ, 30 nA).*

at 100 mK, which was the target temperature for this test.

Table 1 shows the power and resulting self-heating offsets at excitation currents of 10 and 30 nA when using this sensor, illustrating the importance of excitation power and sensor selection. A typical Cernox CX-1010 sensor has a thermal resistance R_{TH} at 100 mK of about 2×10^9 K/W, and can have an electrical resistance R_e from 5 to 100 kΩ. Self-heating offset (ΔT_{SH}) depends on the excitation power P_S according to the equation $\Delta T_{SH} = P_S R_{TH} = I^2 R_e R_{TH}$.

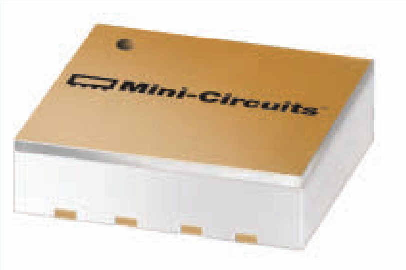
The new Model 350 is designed to work well with Cernox sensor resistances at 10 nA, with minimal self-heating. Under normal circumstances, this 10 nA current range would be used for measurement at 100 mK, and the resulting 6 mK offset is comparable to the total 5 mK uncertainty of a Cernox sensor. At the higher 30 nA excitation current, as was required in the comparison test, higher self-heating would be expected, but those effects would be consistent between the controllers. Lower sensor resistances could have been selected, but would have resulted in reduced sensitivity at the target temperature.

For this comparison, 300 data points were taken and the standard deviation was calculated to give an estimate of the typical RMS noise. The instruments were set to a 0.5 s filter with a sample rate of 10 Hz. This filter reduced the noise by about 2.24 (i.e., √5) for both the new Model 350 and the older model alike. ***Figure 3*** shows the measurements from the comparison test, and clearly shows the improved noise performance of the Model 350 over the previous Model 340 controller.

Table 2 summarizes the measured results and shows the actual noise measured versus each instrument's documented specifications. Noise measured (Ω) reflects the uncertainty in sensor resistance as measured by the instrument. The older Model 340 met its specification, while the Model 350 thoroughly beat its published specification – additional confirmation of the ability to successfully apply the new controller in extreme conditions.

Overall, the Model 350 demonstrated about half the input noise of its predecessor as a result of the updated circuitry. With this ability to use significantly lower excitation power, self-heating errors are reduced enabling higher measurement resolution speed and control stability.

Lake Shore Cryotronics,
Westerville, OH
(614) 891-2243,
www.lakeshore.com,
info@lakeshore.com.



Broadband Limiter

Mini-Circuits has developed an ultra-wide frequency power limiter. The CLM-83-2W+ is an RoHS-compliant limiter, which protects against ESD and input RF power surges, up to 1.6 W, across a very wide frequency range. Its internal diodes are bonded to a multilayer integrated LTCC substrate and then hermetically sealed under a controlled nitrogen atmosphere with gold plated covers and eutectic AuSn solder. The terminal finish on the tiny, low-profile case is Ni-Pd-Au.

These rugged, tiny limiters, only 0.12" × 0.12" × 0.045", provide excellent protection for low noise amplifiers and other sensitive equipment, especially in hostile environments where unwanted signals prevail, such as manufacturing sites, train tunnels and ECM and ECCM.

The CLM-83-2W+ key features include:

- Limiting abilities from +12 to +32 dBm to protect against very strong undesired signals to help prevent burn out of amplifiers and other highly sensitive components.
- Ultra wideband, from 30 to 8200 MHz, to protect against many different types of unwanted signals.
- Tiny surface mount, useful in crowded PCB boards where space is at a premium.
- Ceramic, hermetic, nitrogen filled construction, to protect against moisture, for long term reliability.
- A response time of 2 ns to react instantaneously to limit unwanted high level signals.
- A recovery time of 8 ns as a minimal downtime, after unwanted signals are removed, with quick restoration of standard operating levels.
- A low insertion loss, 0.5 dB typical, and a low VSWR, 1.2:1 typical, which provide minimal degradation of system performance, especially low noise amplifiers, where input loss is critical.

This limiter provides a low cost solution to protect expensive amplifiers or other sensitive applications.

VENDORVIEW

Mini-Circuits,
Brooklyn, NY
www.minicircuits.com.

BE SEEN IN '13!

2013 MICROWAVE JOURNAL EDITORIAL CALENDAR

Microwave Journal
Frequency Matters.

	EDITORIAL THEME	BONUS DISTRIBUTION
JAN	Radar and Antennas	DesignCon NATE (National Assoc. of Tower Erectors)
FEB	High Frequency Components, Boards and Systems	Mobile World Congress EDI CON (Electronic Design Innovation Conference) SATELLITE 2013
MAR	Test and Measurement	WAMICON
& SUPPLEMENT	Cables and Connectors	WAMICON CTIA Wireless IEEE MTT-S IMS
APR	Amplifiers and Oscillators	CTIA Wireless
MAY	IEEE MTT-S IMS Show Issue	IEEE MTT-S IMS
JUN	Semiconductors/ MMICs/RFICs	IEEE MTT-S IMS *Show Daily Sponsorship Opportunities*
JUL	RF & Microwave Software and Design	IEEE EMC
AUG	Satellite and Radio Communications	
& SUPPLEMENT	Military Microwaves	European Microwave Week MILCOM
SEP	European Microwave Week Show Issue	European Microwave Week AMTA 2013
OCT	Government and Military Electronics	Asia Pacific Microwave Conference MILCOM European Microwave Week *Show Daily Sponsorship Opportunities*
NOV	Passive and Control Components	
& SUPPLEMENT	Mobile Communications	Mobile World Congress 2014 CTIA Wireless 2014
DEC	Industrial, Scientific and Medical Applications	IEEE MTT-S Radio and Wireless Symposium

For more information, visit mwjournal.com/advertising

Web Update

Personalized Web Portal

VENDORVIEW

Agilent Technologies announced the launch of a new Web portal that allows customers to manage their relationship with Agilent and receive information personalized to their interests and the products they own. The myAgilent Web portal allows customers to register products to receive timely updates, including firmware updates, application notes, service notifications and related forum discussions; review product warranty and calibration status; view product order status; connect with peers in discussion forums; and track products of interest and get alerts for special offers.

Agilent Technologies Inc.
www.agilent.com/find/myAgilent

Centellax Online Store

Centellax announced that its line of microwave products, including ultra-broadband amplifier MMICs die, test equipment and military systems, frequency dividers and prescalers, and broadband amplifier modules, can now be ordered online from www.centellax.com. Customers can place orders at any time, through a secure online ordering gateway (128 bit SSL). Payment is made using American Express, MasterCard or Visa. Order minimum is $250.00 for online purchases. A Centellax customer service team member will contact you within one business day regarding your order status.

Centellax Inc.
www.centellax.com

Chinese Language Website

Emerson Network Power Connectivity Solutions launched its new Chinese language website on emersonconnectivity.com. The site went live in September and provides product and brand awareness throughout China, a target and rapidly developing market for the company. The new site provides users with a comprehensive overview of Emerson Connectivity Solutions, including product features, news and events, product search functionality, press releases, datasheets and installation instructions. Visitors to the site will also have immediate access to regional sales contacts and distributor firms within the region.

Emerson Network Power Connectivity Solutions
www.emersonconnectivity.com

New Website

Interference Technology launched its new website, which features a comprehensive EMC Buyers' Guide and a channel focused entirely on European content. In addition to the enhanced search functions for archived technical articles, the new website organizes news, articles, standards, and product information according to a dozen EMC technologies, from filters and ferrites to antennas and amplifiers, as well as related to specific EMC markets, such as automotive, military or telecom. This new layout according to product and market channels simplifies the search experience.

Interference Technology
www.interferencetechnology.com

RF Coaxial Connector Website

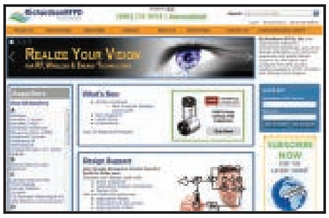
VENDORVIEW

San-tron announced major improvements to its website, including a faceted search empowered product finder which pulls from San-tron's extensive library of RF and microwave coaxial connectors and adapters and cable assemblies. The site also offers an expanded Knowledge Center and details on San-tron's latest SRX™ low PIM cable assemblies and adapters. The Knowledge Center offers a variety of videos, engineering tools and detailed documents to help visitors learn more about San-tron's products and how to incorporate them into their designs with optimum results.

San-tron Inc.
www.santron.com

Richardson RFPD Homepage

VENDORVIEW

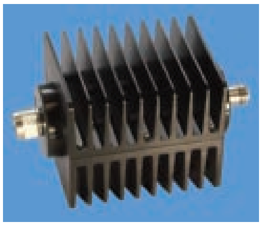


Richardson RFPD launched its redesigned website homepage. The new design offers more direct, one-click access to Richardson RFPD's portfolio of products and industry-leading suppliers, best-in-class design support, and purchase options. The new homepage includes a scrollable, linked list of suppliers; design support quick-links to block diagrams, application notes, white papers and more; new product and featured supplier highlights; and a Quick Buy form where customers can easily enter a part number to obtain a quote or buy a part.

Richardson RFPD Inc.
www.richardsonrfpd.com

Components

Fixed Attenuators



Aeroflex/Inmet's improved 100 W fixed attenuators are ideal solutions for high power PA testing, load simulation and many other test environments. Inmet's 6N100W-XX operates from DC to 6 GHz, has excellent attenuation accuracy (30 dB ± 1.5 dB) and a VSWR of less than 1.45:1. They are available in standard values of 3, 6, 10, 20, 30 and 40 dB and with Type N, SMA, 7/16 DIN or TNC connectors. Other dB values and custom connector configurations are available as options.

Aeroflex/Inmet,
www.aeroflex.com.

Phase Adjusters

The Coaxicom 3993 series of phase adjusters from Coaxial Components Corp. are designed to deliver a means of phase adjustment over frequency ranges up to 18 GHz. The 3993-1 SMA RF phase adjustable adapter has an adjustment range of 180° minimum and a maximum VSWR, with insertion loss of 1.30:1 and 0.42 dB, respectively. The 3993-2 and the 3993-3 are phase adjustable connectors with SMA plugs for direct solder to 0.141" and 0.086" semi-rigid cable or COAXICOM ULTRA-FLEX, respectively.

Coaxial Components Corp.,
www.coaxicom.com.

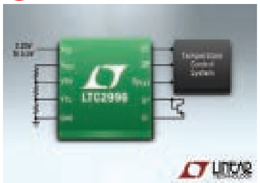
Hopping Filters

Lark Engineering offers a full line of low cost frequency agile filters (hopping filters) from 1.5 MHz to 1 GHz available in three surface mount housings (leadless). Tuning is voltage controlled or using an 8 bit parallel interface, allowing 254 tune words for frequency control. Lark's hopping filters are available with bandwidths from 4 to 20 percent with a 3 to 30 dB shape factor of 7:1. Applications include ground, shipboard and airborne environments.

Lark Engineering,
www.larkengineering.com.

Temperature Sensor

VENDORVIEW



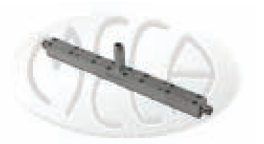
Linear Technology introduced the LTC2996 high accuracy temperature sensor for 2.25 to 5.5 V systems. The LTC2996 measures a remote diode's temperature with ±1°C accuracy and its own die temperature with ±2°C accuracy while rejecting errors due to noise and series resistance. The device provides a voltage-proportional-to-absolute-temperature (VPTAT) output, as well as individual under temperature and over temperature alert outputs, defined by user-adjustable thresholds. No code is required to configure the device. With a 200 µA quiescent current, the LTC2996 provides a precise, space-saving, micropower temperature monitoring solution.

Linear Technology Corp.,
www.linear.com.

Unequal Power Splitters

VENDORVIEW

MECA launched a line of unequal power splitters or tappers, developed to unevenly split high power signals for in-building DAS applications and designs.



The line consists of six models offering a 2, 3, 4, 6, 8, or 10:1 signal-split ratio, over 698 to 2700 MHz (cellular, PCS, AWS, and BRS/EBS frequencies) and feature low PIM ratings (better than -150 dBc), with ultra-low VSWR and minimal coupling variation over the entire frequency band. They handle high power levels of 300 W (CW) and have an operational temperature range of -55° to +85°C.

Microwave Electronic Components of America (MECA),
www.e-meca.com.

Conductor Cables

VENDORVIEW

Florida RF Labs has expanded its line of stranded center conductor cables Lab-Flex® S, a modified version of the Lab-Flex® high performance flexible cable assemblies. Lab-Flex S cables offer higher flexure rates and durability than solid center conductor designs. They have stainless steel connectors and employ a unique solder sleeve which provides the strongest cable to connector termination in the industry. With cable designs up to 65 GHz, there is a large selection of connector interfaces and configurations including: 1.85mm, 2.4mm, 2.92mm, SMA, TNC and Type N.

Florida RF Labs,
www.emc-rflabs.com.

Frequency Mixer

VENDORVIEW

Mini-Circuits introduced its high IP3 Level 23 (LO power +23 dBm) 3220 to 4500 MHz frequency mixer. The LAVI-452VH+ features very high IP3 (33 dBm typical), excellent L-R isolation (45 dB typical) and L-I isolation (40 dB typical), and high 1 dB compression (20 dBm typical). It has a shielded metal cover, is aqueous washable and is protected by U.S. Patent 6,807,407. It has an operating temperature of -45° to 85°C and a storage temperature of -55° to 100°C.

Mini-Circuits,
www.minicircuits.com.

Power Divider

VENDORVIEW

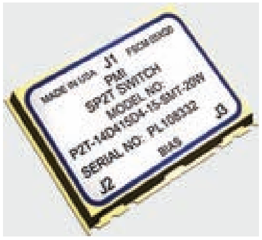
Narda Microwave-East introduced a high-power, two-way power divider that operates from 500 MHz to 2.5 GHz and handles up to 250 W CW input power (2 kW peak power). Model 2372A-2 has insertion loss of less than 0.6 dB, amplitude balance of ±0.25 dB or less, phase balance of ±5 deg., isolation of at least 13 dB from 500 to 700 MHz and 18 dB from 700 MHz to 2.5 GHz, and VSWR of less than 1.5:1. It measures 3.5" × 2.5" × 1".

Narda Microwave-East,
www.nardamicrowave.com/east.

Solid-State Switch

VENDORVIEW

PMI model P2T-14D415D4-15-SMT-20W is a driverless, 20 W, SP2T solid-state switch that is supplied in a compact package designed for surface mount applications.



This switch operates from 14.4 to 15.4 GHz and has an insertion loss of 1.2 dB maximum at +25°C. The Tx/Rx isolation is better than 10 dB and this switch can handle input power levels up to 20 W. The switch measures only 0.35" × 0.5" × 0.21". Other frequency ranges are available.

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

Hybrid Couplers

RFMW announced design and sales support for Florida RF 0805 hybrid couplers. These miniature couplers handle RF power up to 5 W CW and have greater thermal conductivity than comparably sized options. Standard applications include LNA circuits where a balanced topology using a hybrid coupler provides a higher intercept point than a single stage, offering increased sensitivity and therefore range. The hybrids can also be used in final stage amplifier circuits for pico cells and indoor repeaters. Five models cover the major commercial spectrum from 700 to 3700 MHz.

RFMW Ltd.,
www.rfmw.com.

New Products

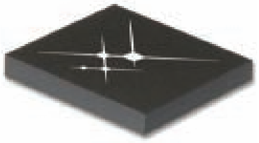
Hybrid Coupler

VENDORVIEW

Richardson RFPD announced immediate availability and full design support capabilities of a new 400 W SMT hybrid coupler and matching termination from Anaren. Part of the Xinger®-III line, the X3C06A4-03S is a low profile, high performance 400 W, 3 dB hybrid coupler for two-way power combining/dividing in a small, easy to use surface mount package that can easily replace bulky, drop-in couplers. The X3C06A4-03S covers 410 to 860 MHz and is well-suited for UHF broadcast and RF plasma lighting applications.
Richardson RFPD Inc.,
www.richardsonrfpd.com.

Single-Pole Double-Throw Switch

VENDORVIEW

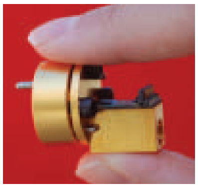


Skyworks introduced a very high isolation (>60 dB) yet low loss (0.8 dB) single-pole double-throw switch with integrated 50 Ω terminations and broadband operation to 6 GHz. The cost-effective SKY13372-467LF targets cellular infrastructure applications requiring feedback and filter-bank switching where low loss and high channel to channel isolation performance is required. The new switch is also ideal for military communication and various RF test and measurement applications. It is pin-to-pin compatible with Skyworks' existing high isolation SPDT switch: SKY13286-359LF.
Skyworks Solutions Inc.,
www.skyworksinc.com.

Power Doublers

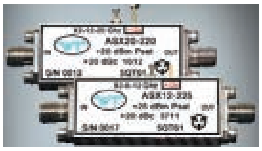
TriQuint introduced two new high performance 12 V infrastructure power doublers: the TAT2801 and TAT8801A1H. Both are ideally suited for line extender output amplifier and distribution node amplifier designs. The TAT2801 provides exceptionally high output and linearity for DOCSIS 3.0 Edge QAM and cable modem termination system (CMTS) applications. It has the highest linearity of the two new doublers. The cost-effective TAT8801A1H is designed to meet most line extender output level requirements through its optimal performance and low power consumption.
TriQuint Semiconductor Inc.,
www.triquint.com.

Waveguide Modules



Vubiq announced new 60 GHz transmitter and receiver integrated waveguide modules. Features include small size, complete transmitter and receiver functions with connectorized interface for I/Q signal inputs and outputs, power and reference clock. RF connection is via WR15 waveguide flange. 57 to 64 GHz frequency coverage; Tx output of 10 dBm; and Rx noise figure of 6 dB. Fully integrated SiGe BiCMOS Tx and Rx in an easy to use waveguide module package. Also available: complete development system with GUI software.
Vubiq Inc.,
www.vubiq.com.

Multipliers



Wright Technology introduced broadband frequency operation multipliers with improved harmonics and low input drive, with increased output power available. Model ASX20-220 has an input frequency of 8.75 to 9.75, output frequency of 17.5 of 19.5, 10 dBm minimum Pin, 20 dBm minimum Psat out, -20 dBc maximum harmonics, -60 dBc typical spurious, and 400 DC mA typical at +12 VDC.
Wright Technologies Inc.,
www.wrighttec.com.

Amplifiers

GaN Amplifier

Model SSPA 2.9-3.1-300 is a high power, pulsed or CW GaN RF amplifier that can be employed throughout the S-Band frequency range. It is optimized for operation from 2.9 to 3.1 GHz. The devices in the amplifier are not matched, therefore it can operate from

2.7 to 2.9 GHz or 2.7 to 3.5 GHz with similar performance. This amplifier operates with a base plate temperature of -40° to +85°C. It is packaged in a modular housing that is approximately 5" (width) × 8" (long) × 1.94" (height).
Aethercomm Inc.,
www.aethercomm.com.

Single Band Amplifiers

VENDORVIEW

Model 15S1G6 and 50S1G6 are single band 15 and 50 W amplifiers that cover the 1 to 6 GHz frequency band. The ability to use one band instead of two means you use less power, and don't require the amplifiers to be switched from one band to the other to perform the required tests. Along with excellent performance, it has a remote interface standard (a feature that is an extra with competitive amplifiers), a lower noise figure, and an exceptional output VSWR of 1.5:1.
AR RF/Microwave Instrumentation,
www.arworld.us.

Transimpedance Amplifier

The MATA-038032A is a dual channel differential linear TIA with AGC for 100G DP-QPSK (32 Gbps ×4) receivers. Each channel has differential input and output. It offers both manual and automatic gain control modes. In manual mode the gain can be controlled from 200 Ω to 5 KΩ differential via an external pin. In automatic mode, the gain is automatically adjusted to provide a constant output voltage. The TIA provides a linear amplification for current levels from 0.1 to 2 mA differential and has adjustable bandwidth between 17 and 25 GHz.
M/A-COM Technology Solutions Inc.,
www.macomtech.com.

Low Noise Amplifier

VENDORVIEW

The AMFW-4F-12401800-25-18P-WR62F is a very low noise, high dynamic range weatherproof Ku-Band waveguide front end, operating 12.4 to 18 GHz. It includes a pressure sealed WR62 waveguide input and SMA (F) connector output. The LNA is lightweight with a small profile and footprint, the aluminum alloy housing is sealed against most severe environmental conditions. It includes reverse voltage, over current and over temperature protection in addition to full internal regulation. Total weight is approximately 270 g, and dimensions are 2.1" × 1.31" × 1.31".

MITEQ Inc.,
www.miteq.com.

Power Amplifier

VENDORVIEW

RFMD's new RFPA2089 is a single-stage InGaP HBT power amplifier specifically designed for wireless infrastructure applications. It offers high-gain linear operation at a comparably low DC power making it ideal for next generation radios requiring high efficiency. Its external matching allows for use across various radio platforms. It features -60 dBc ACPR at 13 dBm WCDMA, 0.25 W OP1dB, 17.6 dB gain at 2.65 GHz, single-supply 5 V operation and class 2 (2000 V) HBM ESD.

RF Micro Devices,
www.rfmd.com.

Sources

Clock Generators

VENDORVIEW

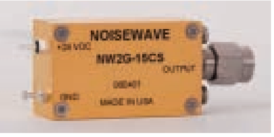
The HMC1033LP6GE and the HMC1035LP6GE offer programmable frequency synthesis from 25 MHz to 2.5 GHz in both integer and fractional relationships to their reference clocks. The HMC1033LP6GE is ideal for clocking DSP, FPGA and high performance processors as well as physical layer devices, and operates from 25 to 550 MHz. The HMC1035LP6GE is de-

signed to meet the stringent requirements of high speed data converters (ADC/DAC) with excellent phase noise floor performance of -162 dBc/Hz, and operates from 25 MHz to 2.5 GHz.
Hittite Microwave Corp., www.hittite.com.

DFRM

NEL Frequency Controls announced the release of the dual frequency reference module (DFRM). The new module consists of two ultra low phase noise OCXOs at 10 and 100 MHz that are phase locked together to provide a fully characterized "plug and play" solution. The DFRM provides customers both low frequency (10 MHz) and intermediary frequency (100 MHz) references in their applications to frequency lock with each other. This solution is integrated in a module with optimized phase noise performance.
NEL Frequency Controls, www.nelfc.com.

Coaxial Noise Source



NoiseWave announced the NW2G-CS coaxial noise source. The unit is available in 6, 15 and 30 dB ENR and features a small profile housing of 0.75" by 0.5" by 1.25" excluding connectors. It has flatness better than ± 1 dB over the frequency range 10 kHz to 2 GHz and comes with calibrated cardinal ENR frequencies. The NW2G-CS is available with a variety of connectors. Standard operation is from +28 V DC with a 20 mA maximum current draw.
NoiseWave, www.noisewave.com.

Software

Compliance Testing Software

VENDORVIEW

Agilent announced the industry's only test suite for compliance testing of computer and embedded DDR/2/3/4 and LPDDR/2/3 memory applications. With this software suite and an Agilent logic analyzer, digital designers can monitor DDR/2/3/4 or LPDDR/2/3 systems in real time to identify elusive, intermittent violations in protocol or bus-level timing. The new software allows users to customize tests, either by adding to existing test groups or by defining unique test groups of valid logic analyzer triggers for protocol or bus-level timing violations.
Agilent Technologies Inc., www.agilent.com.

Test Equipment

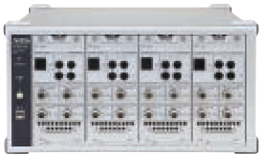
Frequency Sources

Berkeley Nucleonics commercially released a full line of high performance, robust, and extremely cost effective RF/microwave signal generators. The line sets a new standard in performance to cost. Capable of producing in excess of 20 GHz, with very low phase noise, fast switching speeds and extensive modulation capabilities in a variety of packaging options, including benchtop, portable battery operation, 1U 19" rackmount and card-level for OEM integration. These instruments offer a wide array of options to meet almost any application requirement.

Berkeley Nucleonics Corp., www.berkeleynucleonics.com.

Wireless Test Set

VENDORVIEW

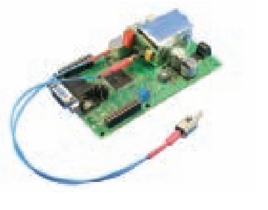


Anritsu introduced the MT8870A universal wireless test set with manufacturing test capability for up to eight UE devices in a single mainframe without the need for external switching. The tester's basic module includes an integrated VSA, VSG and

multi-core processor, and users can configure a mainframe with up to four modules with four VSAs and four VSGs, depending on test requirements. Combining this high-density test capability with the latest parallel TX/RX calibration and verification test modes enables high-speed production test throughput and highly flexible line layouts.
Anritsu Co.,
www.anritsu.com.

Temperature Measurement

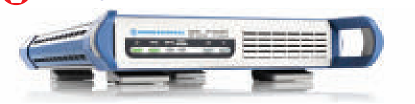
The FOTEMP1-OEM-MNT measures temperature in high electromagnetic interfered environments and other environments where



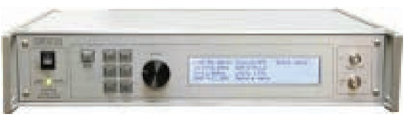
measurement with common electric temperature sensors is not possible. The sensor is completely non-conductive, with an outer jacket made from PTFE and a GaAs-crystal sensor tip. It is designed to withstand harsh and corrosive environments. Since the position of the band gap is temperature dependent, it shifts about 0.4 nm/Kelvin. The measurement device contains a light source and a device for the spectral detection of the band gap.
OPTOcon AG,
www.optocon.de.

Vector Signal Generator

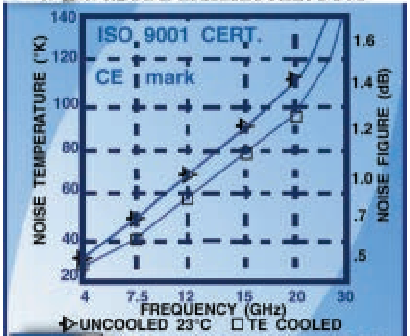
VENDORVIEW

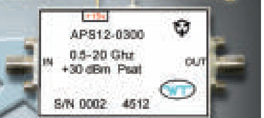


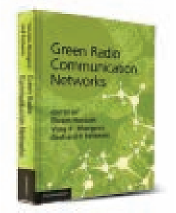
Rohde & Schwarz has enhanced its fully integrated R&S SGS100A by adding a model for I/Q modulated signals from 80 MHz to 12.75 GHz. Combined with an I/Q baseband generator, the instrument can be used to generate test signals for all radio standards in this frequency range. The I/Q modulator's wide RF bandwidth of 1 GHz makes it possible to generate pulses with high chirp bandwidths and steep pulse edges.
Rohde & Schwarz GmbH & Co. KG,
www.rohde-schwarz.com.



MICRO-ADS







Green Radio Communication Networks

Edited by Ekram Hossain, Vijay K. Bhargava and Gerhard P. Fettweis

As Gerhard Fettweis authored our cover story this month on a vision for 5G networks of the future, it is only fitting that we review a book co-authored by him, *Green Radio Communication Networks*. The importance of reducing energy costs, reducing CO_2 emissions and protecting the environment are leading to an increased focus on green, energy-efficient approaches to the design of next-generation wireless networks. At the same time there is great pressure to reduce operational expenses for network operators.

The information and communications technology industry sector accounts for about 2 to 6 percent of the energy consumption worldwide and a significant amount of this is wireless/mobile communications, according to the book preface. *Green Radio Communication Networks* presents state-of-the-art research on green radio communications and networking technology by leaders in the field. Summarizing existing and ongoing research, the book consists of articles covering different aspects of green cellular radio communications and networking issues that include network architecture; performance models for green radio networks including energy-harvesting wireless networks; physical communication techniques for green radio, including novel modulation and coding techniques and joint physical and medium access control optimized techniques; dynamic power-management/energy-conservation techniques for base stations in cellular wireless networks; relaying and user cooperation techniques and energy-cognizant wireless protocols for green radio communications; and standardization initiatives, test-beds, prototypes, practical systems and case studies.

Green Radio Communication Networks is written for researchers and professionals working in wireless communication and one of the first books written in this area of study. It is a good reference for key concepts and design techniques for energy-efficient communications and networking and provides information for the design of future-generation cellular wireless systems.

To order this book, contact:

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

410 pages, $125
ISBN: 978-1-10701-754-2

2013 Microwave Wireless Industry Exhibition in China (MWIE 2013)
2013 National Conference on Microwave and Millimeter Wave

MWIE 2013

Sponsors: Chinese Institute of Electronics (CIE)

Co-Sponsors: Microwave Society of Chinese Institute of Electronics
Chongqing Acoustic-Optic-Electronic Co., Ltd. of CETC
33rd Research Institute of China Electronics Technology Group Corporation (CETC33)
Kingradio Technology [Shenzhen] Co., Ltd.

Collaborating Media: Journal of Microwaves(China) Mobile Communications (China)
Microwave Journal (USA) Mwrfchina and Rfeda

2013 Microwave Wireless Industry Exhibition（MWIE2013） and 2013 National Conference on Microwave and Millimeter Wave in China (NCMMW2013) will be held in Xuehao Hotel, Chongqing, China, in 21~23 May, 2013.
NCMMW2013 is China's largest conference on microwave and millimeter wave technologies. It is organized by Chinese Institute of Electronics (CIE) and held every two years (every odd year).
MWIE has already been held for over 10 years. It is one of most important events of the National Conference on Microwave and Millimeter Wave in China held every odd year, and the International Conference on Microwave and Millimeter Wave Technology held every even year.

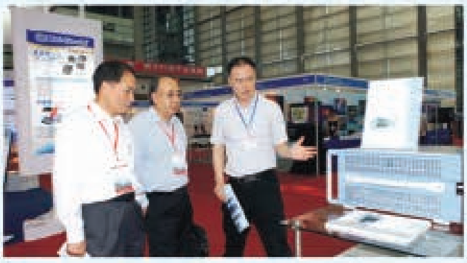
MWIE2013 will be another grand exhibition after "MWIE2012" in Shenzhen, "MWIE2011" in Qingdao, "MWIE2010" in Chengdu, "MWIE2009" in Xi'an, "MWIE2008" in Nanjing China!

Date: May 21~23, 2013 **Venue: Xuehao Hotel, Chongqing, China**

"9th Committee Enlarged Conference of Microwave Society of Chinese Institute of Electronics" will be held during the period of MWIE2013. Nearly 80 Committee members from institutes, universities and companies of all parts of China will attend the conference and visit the exhibition. This is the best chance to let Chinese people know your company and products; exhibit in MWIE2013 is the best choice for your products to enter Chinese market.

Exhibitors to be attended:

Manufacturers / distributors for RF / microwave / millimeter wave devices / components: solid state device and circuits (including mmic): amplifiers, mixers, oscillators, etc. and passive components: filters, duplexers, couplers, attenuators, and antennas etc
Designer / distributor for RF / microwave / millimeter wave software
Manufacturers / distributors for RF / microwave / millimeter wave equipments
Manufacturers / distributors for RF / microwave PCB and connectors
Manufacturers / distributors for microwave absorber
Manufacturers / distributors for microwave / millimeter inductor, capacitor and high power resistor



Why you should attend?

MWIE2013 is the largest event of microwave, millimeter wave and RF field in China, which is sponsored by Microwave Society of Chinese Institute of Electronics
MWIE 2013 is where to provide a platform for enterprises engaged in microwave, millimeter wave and RF field to publicize your company/ products in China.
MWIE 2013 will provide a chromatic page of introduction for each exhibitor in List of Exhibitors, which is free.
MWIE 2013 is where to provide a nice opportunity for the scientists and engineers specialized in the field of microwave and millimeter wave to present your new ideas and learn from each other.

Contact: Mr. Wei Zilun, Gao Xin, Ms. Liu, Ms. Xu E-mail: mwrf@vip.163.com kingradio@188.com

Advertising Index

Coming in January:
Radar and Antennas

- **MIMO Radar: Demystified**
- **A Passive Covert Radar: AULOS**
- **Enabling Full RF Transmitter Linearization Using a Wideband DPD Measurement Platform**
- **Conformal Antenna Array Design on a Missile Platform**

Sales Representatives

Microwave Journal — Frequency Matters.

Carl Sheffres, Publisher

Ed Kiessling, Traffic Manager

Eastern and Central Time Zones
Chuck Boyd
Northeast Reg. Sales Mgr.
(New England, New York, Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
cboyd@mwjournal.com

Michael Hallman
Eastern Reg. Sales Mgr.
(Mid-Atlantic, Southeast, Midwest)
4 Valley View Court
Middletown, MD 21769
Tel: (301) 371-8830
FAX: (301) 371-8832
mhallman@mwjournal.com

Pacific and Mountain Time Zones
Brian Landy
Western Reg. Sales Mgr.
(CA, AZ, OR, WA, ID, NV, UT, NM, CO, WY, MT, ND, SD, NE & Western Canada)
144 Segre Place
Santa Cruz, CA 95060
Tel: (831) 426-4143
FAX: (831) 515-5444
blandy@mwjournal.com

International Sales
Richard Vaughan
International Sales Manager
16 Sussex Street
London SW1V 4RW, England
Tel: +44 207 596 8742
FAX: +44 207 596 8749
rvaughan@horizonhouse.co.uk

Germany, Austria, and Switzerland (German-speaking)
WMS.Werbe- und Media Service
Brigitte Beranek
Gerhart-Hauptmann-Street 33,
D-72574 Bad Urach
Germany
Tel: +49 7125 407 31 18
FAX: +49 7125 407 31 08
bberanek@horizonhouse.com

Israel
Oreet Ben Yaacov
Oreet International Media
15 Kineret Street
51201 Bene-Berak, Israel
Tel: +972 3 570 6527
FAX: +972 3 570 6526
obenyaacov@horizonhouse.com

Korea
Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

Japan
Katsuhiro Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

China
Michael Tsui
ACT International
Tel: 86-755-25988571
Tel: 86-21-62511200
FAX: 86-10-58607751
michaelT@actintl.com.hk

Hong Kong
Mark Mak
ACT International
Tel: 852-28386298
markm@actintl.com.hk

TINY

Wideband Transformers

0.15-6200 MHz *as low as* **99¢** *each (qty. 1000)* RoHS compliant.

Rugged, repeatable performance.
At Mini-Circuits, we're passionate about transformers. We even make own transmission line wire under tight manufacturing control, and utilize all-welded connections to maximize performance, reliability, and repeatability. And for signals up to 6 GHz, our rugged LTCC ceramic models feature wrap-around terminations for your visual solder inspection, and they are even offered in packages as small as 0805!

Continued innovation: Top Hat.
A Mini-Circuits exclusive, this new feature is now available on every open-core transformer we sell. Top Hat speeds customer pick-and-place throughput in four distinct ways: (1) faster set-up times, (2) fewer missed components, (3) better placement accuracy and consistency, and (4) high-visibility markings for quicker visual identification and inspection.

More models, to meet more needs
Mini-Circuits has over 200 different SMT models in stock. So for RF or microwave baluns and transformers, with or without center taps or DC isolation, you can probably find what you need at minicircuits.com. Enter your requirements, and Yoni2, our patented search engine, can identify a match in seconds. And new custom designs are just a phone call away, with surprisingly quick turnaround times gained from over 40 years of manufacturing and design experience!

See minicircuits.com for technical specifications, performance data, pricing, and real-time, in-stock availability!
Mini-Circuits...we're redefining what Value is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yoni2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

377 rev Y

EUROPEAN MICROWAVE WEEK
RAI Amsterdam
EuMW 2012
28 October – 2 November 2012
www.eumweek.com

Photos courtesy of Shmuel Auster