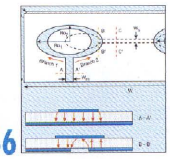
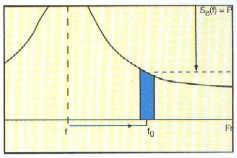
INSIDE TRACK with TRIQUINT SEMICONDUCTOR'S **TIM DUNN** p30

TACKLE MICROSTRIP TO WIDE STRIPLINE p46



MANAGE PHASE NOISE IN MICROWAVE SOURCES p40



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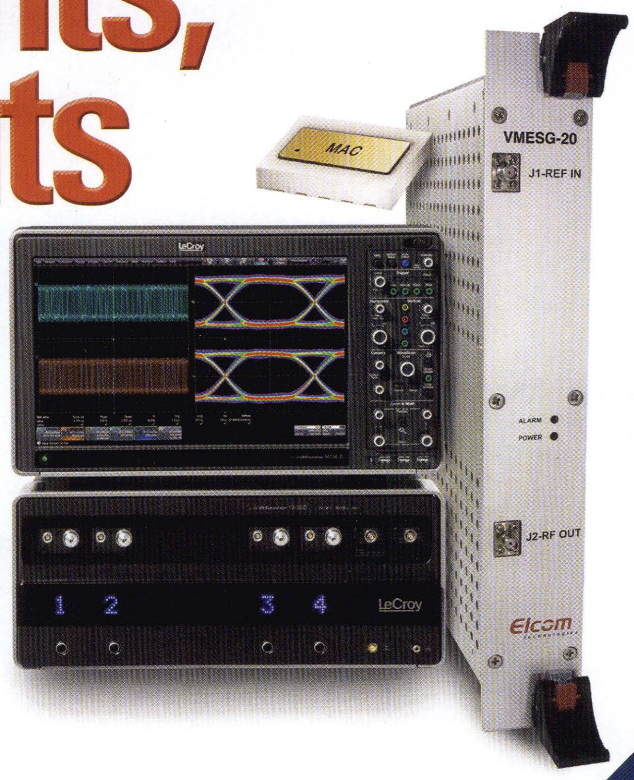
TECHNOLOGY ASSESSMENT

Components, Instruments DOMINATE 2012 TOP PRODUCTS



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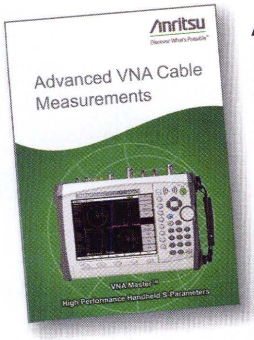

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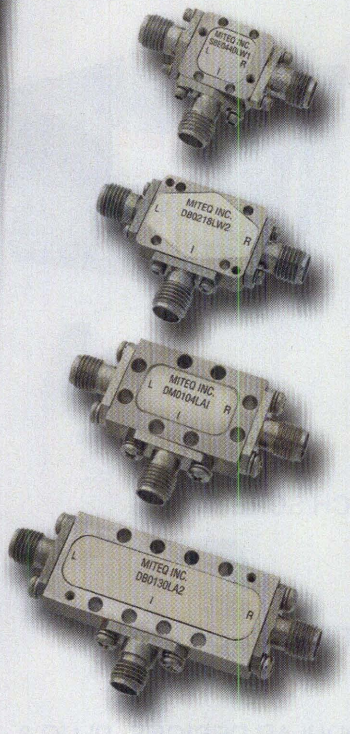


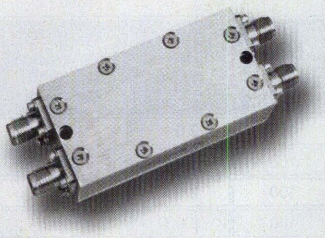
Mixers

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)

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- Switch Filter Banks
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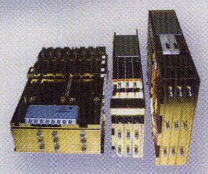
- USB Products



- SWITCH MATRICES & SWITCHING NETWORKS
- HANDOVER TEST SYSTEMS
- RF SWITCH ASSEMBLIES
- PROGRAMMABLE ATTENUATOR ASSEMBLIES
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- FAN-IN & FAN-OUT CONFIGURATIONS
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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

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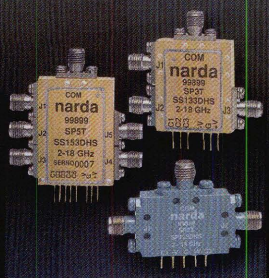
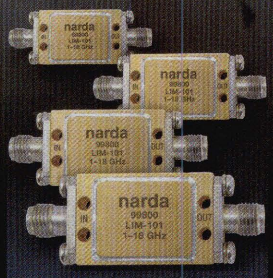


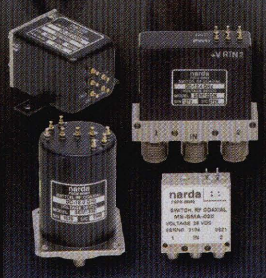
PIN Switches

- Small Package Size
- Fast Switching Times
- Multi-Throw Option



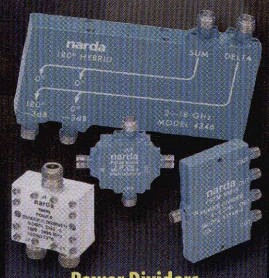
PIN Limiters

- Up to 600 W of Pulsed Power
- Wideband & Narrowband Versions



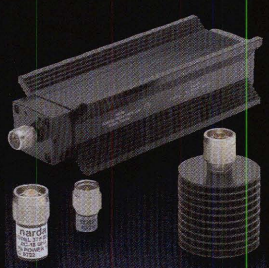
SEM Switches

- SPDT through SP12T
- Transfer Switch Types
- Fail Safe



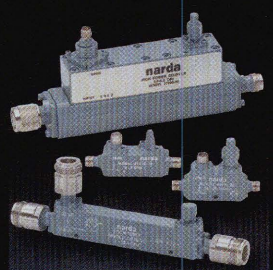
Power Dividers

- Low VSWR
- Many Power Levels
- High Isolation



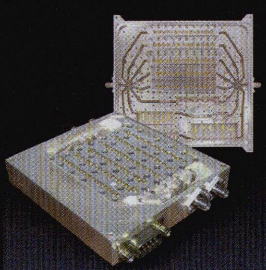
Terminations

- Low VSWR
- High Power



Directional Couplers

- Broadband Coverage
- High Power
- Flat Frequency Response



Switched Filter Banks

- Fast Switching
- Low Loss

Attenuators

- Fixed, Stepped, or Variable
- High Power

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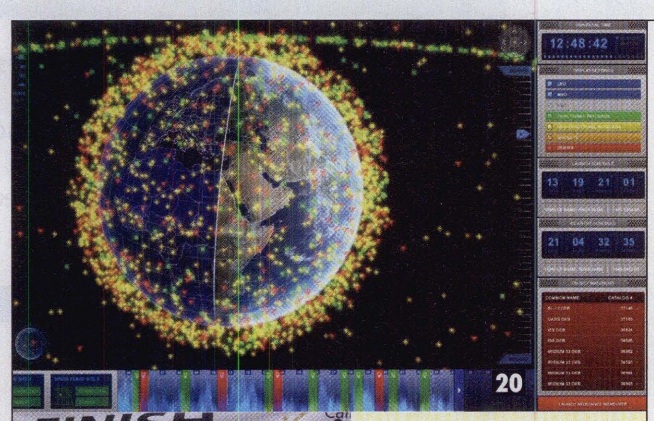
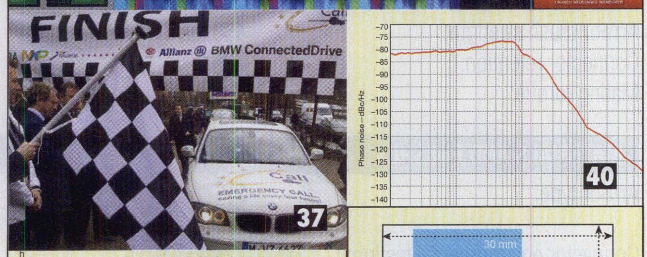
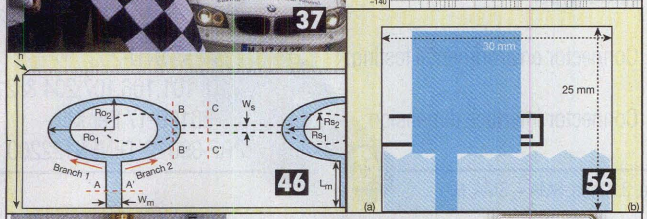
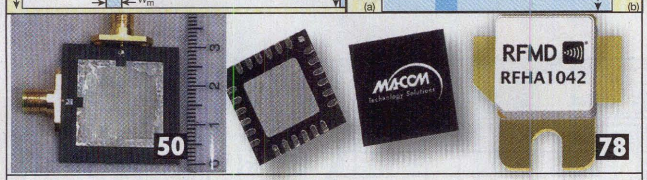








COVER STORY

70 Top 2012 Products Blend Value and Performance

This year's top offerings epitomize the creativity and ingenuity of the design engineers in the RF/microwave industry in meeting the most demanding requirements of their customers.

NEWS & COLUMNS

INDUSTRY TRENDS AND ANALYSIS

DESIGN FEATURES

PRODUCT TECHNOLOGY

Rosenberger® Rmor™ Cables Assembly

PHASE STABLE THROUGH 70GHz

Rosenberger Rmor™ cables are designed for rugged environments for indoor and outdoor applications. Each shielded coaxial cable is protected with flexible, SPIRAL-wound 304 Stainless Steel armor coated with extruded Polyurethane. The connector ends are sealed and encapsulated with a pressure injection-molded polymer strain relief.

This combination of materials and technology provides superior ruggedization, environmental resistance, RF shielding effectiveness and stability under flexure and vibration.

Additional connector interfaces and armor/cable diameters are available on request.

DESCRIPTION

Rosenberger connectors, cable assembly, standard length 915mm or 36 inches

GENERAL ELECTRICAL SPECIFICATIONS

Impedance:	50 +/- 1 Ohms
Operating frequency:	DC to 70 GHz
Return loss:	14 dB minimum up to 70 GHz
Cable insertion loss:	.67 dB/ft @ 10.0 GHz
Velocity of propagation (%):	78 % nominal
Capacitance:	24.7 pf/ft. nominal
Shielding effectiveness:	< -90 dB
Dielectric withstand voltage:	1000 Vrms
Amplitude & phase stable:	+/- .03dB & +/- 1° @10GHz

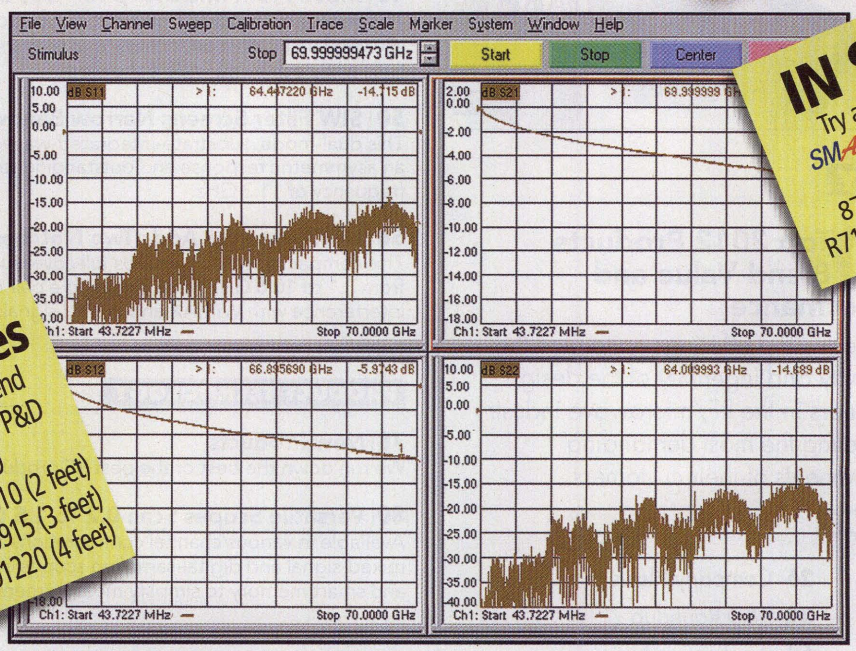
MECHANICAL SPECIFICATION

Cable jacket & armor outer diameter:	092 inches nominal & .250 inches nominal
Minimum bend radius:	.5 inches
Armor crush strength:	450 lbs/in (min)
Connector retention:	≥25 lbs.
Mating torque:	7-10 inch pounds

MATERIALS AND FINISHES

Armor type:	SPIRAL-wound 304 SS & Polyurethane blue jacket
Connector environmental testing:	Per MIL-STD-202, Meth 101,106,107,204 & 213
Connector interface dimension:	IEC 60169-17 Per MIL-PRF-39012 DINEN122200

Note: Cable assemblies also available with interfaces such as 1.85mm, 2.4mm, 2.92mm, SMA +, SMA, N.



Example of typical 36 inches assembly up to 70 GHz

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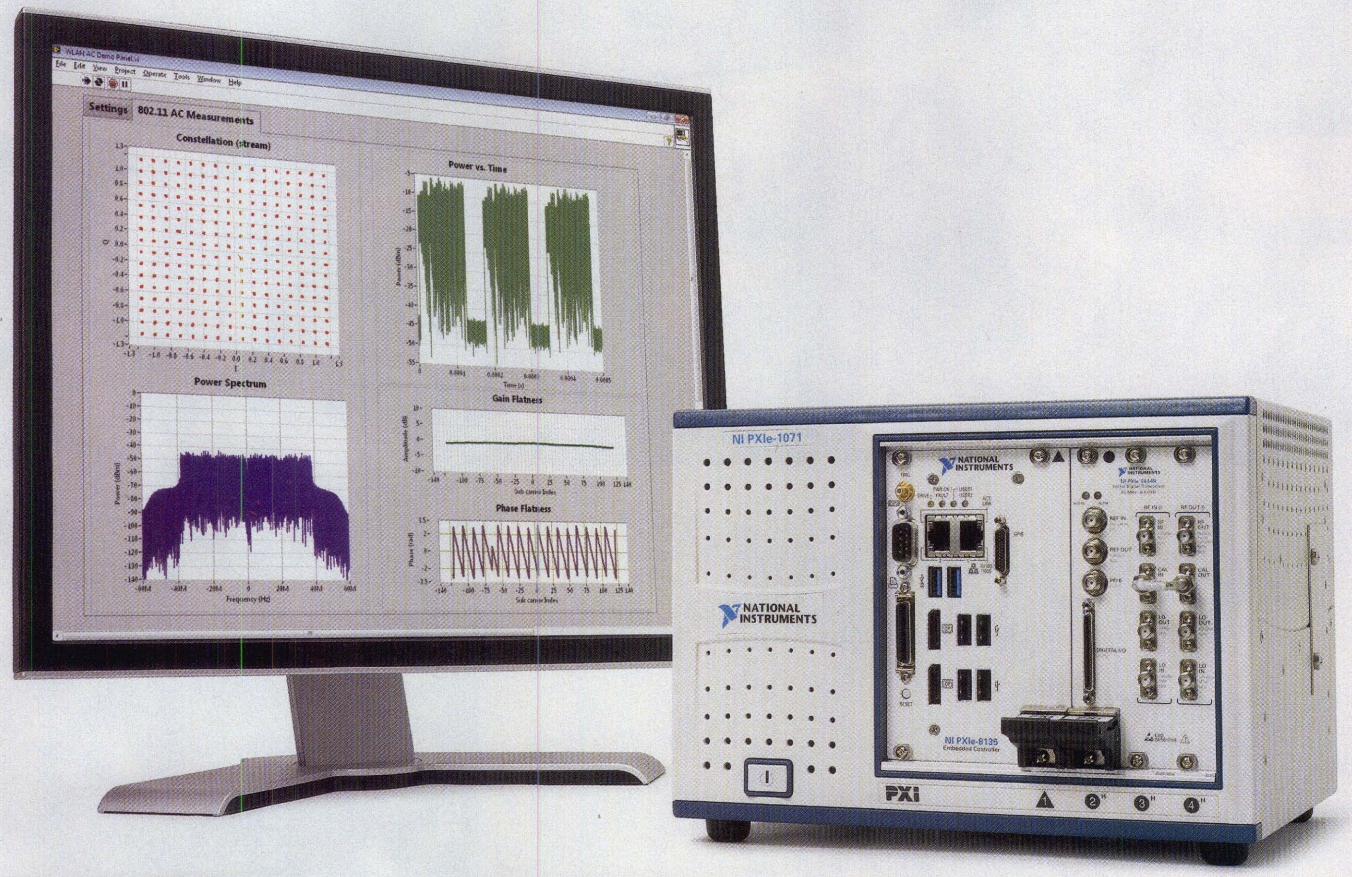

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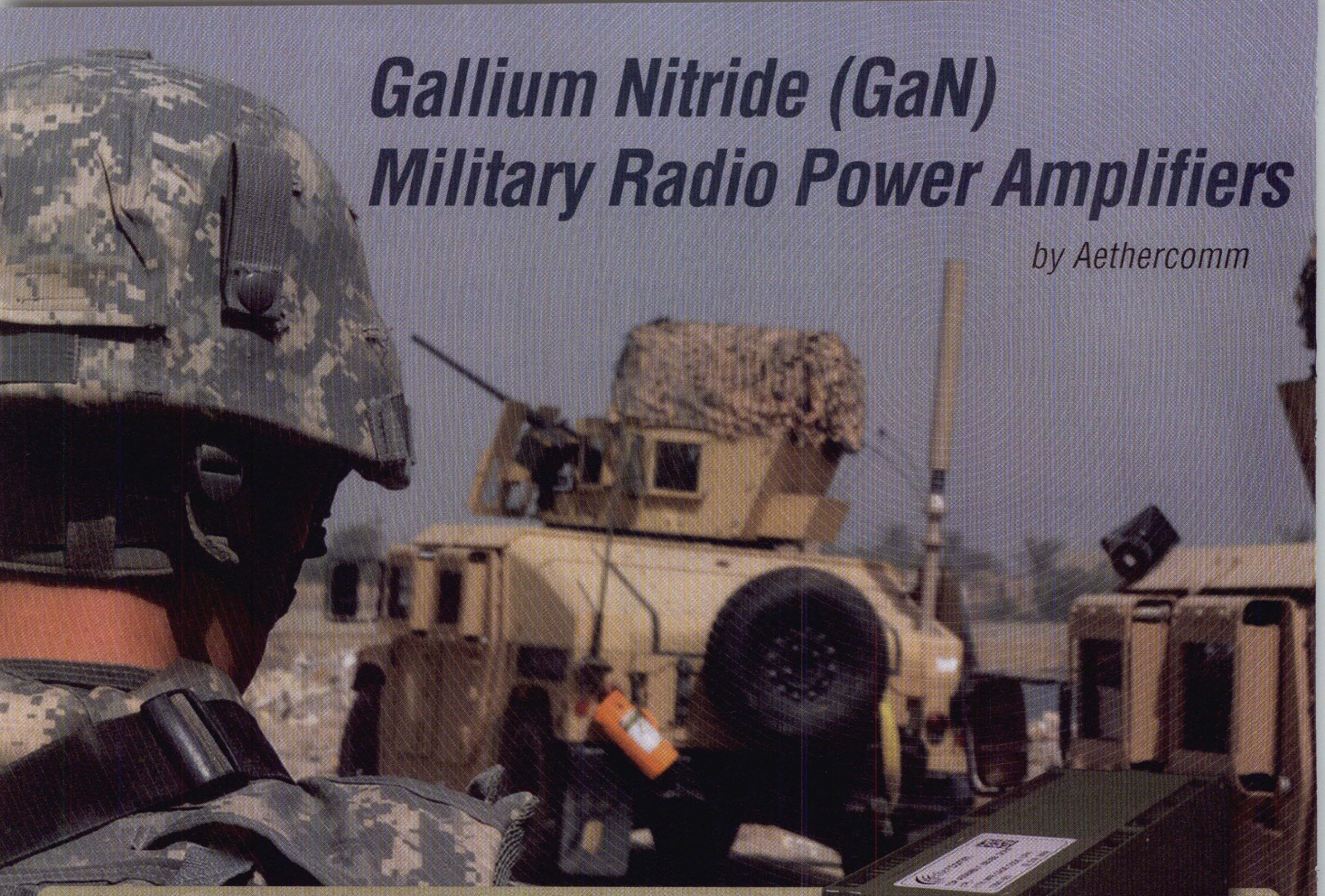

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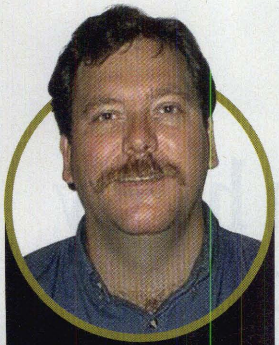
Optimize Signal/Spectrum Analyzer Throughput For High-Volume Manufacturing Test

TO OBTAIN THE HIGHEST THROUGHPUT for the analyzers used in manufacturing test, one should create a test plan that accounts for speed, repeatability, and dynamic range. In this web-exclusive article, Agilent Technologies' Bob Nelson provides you with the blueprint.

To read the article in its entirety, go to http://mwrf.com/contributors/optimize-signalspectrum-analyzer-throughput-high-volume-manufacturing-test.



BOB NELSON

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DAVID A. HALL—Senior Product Marketing Manager, RF and Communications, National Instruments

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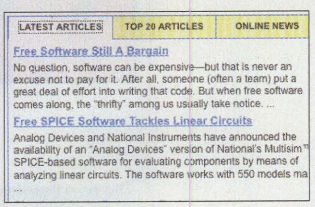

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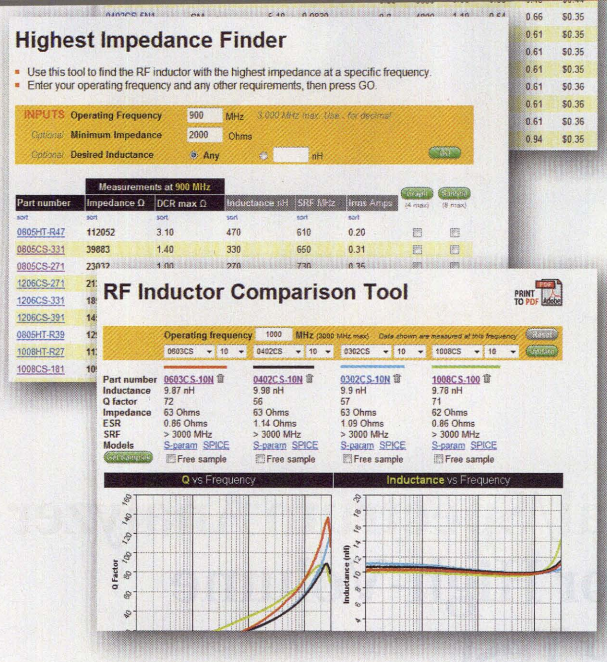

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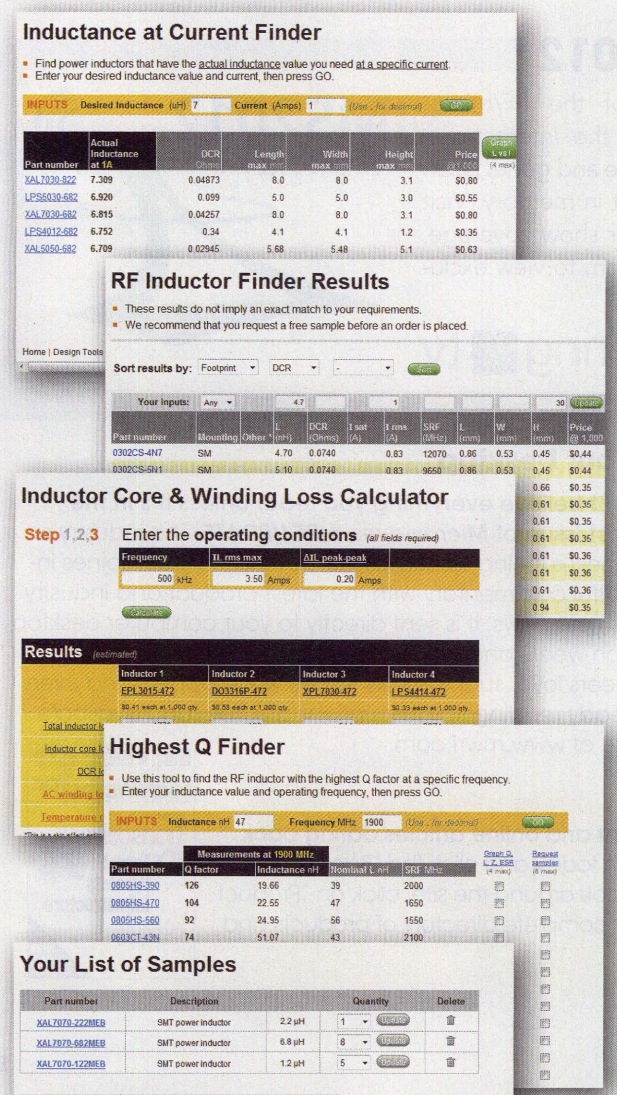

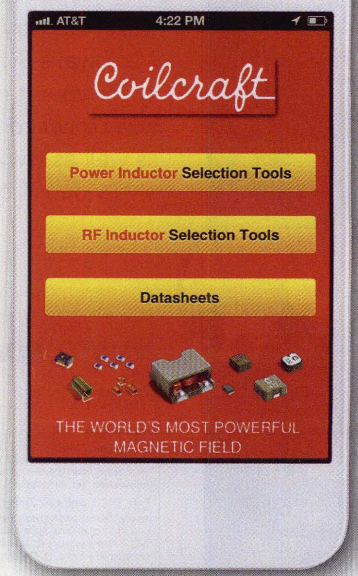

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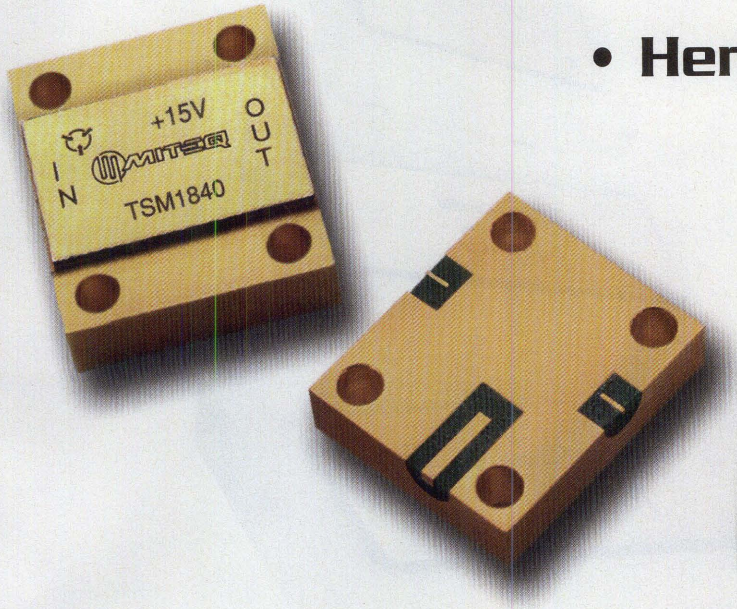

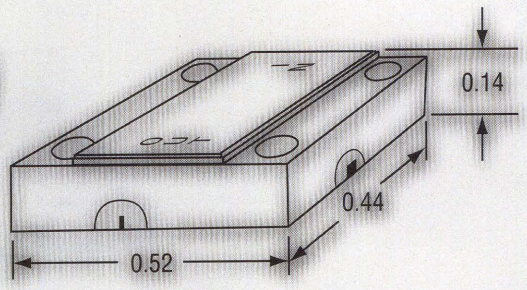

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From the Editor

A Wireless-Power Struggle

IN THE WIRELESS INDUSTRY, the mark of a hot emerging technology is that a standards war will rise around it. With energy harvesting the "next big thing" for wireless devices, automobiles, and more, the ability to wirelessly charge handheld devices is beginning to reach consumers. This progress is in large part due to the work of the Wireless Power Consortium (WPC; www.wirelesspowerconsortium.com), which published the Qi low-power specification in August 2009 in hopes of creating a new protocol for how people interact with power—much as the Wi-Fi Alliance did for wireless networking. While the WPC has made great progress, it now faces some stiff competition from big names in electronics and other markets.

The independently operated Alliance for Wireless Power (A4WP; www.a4wp.org), for example, counts Broadcom, NXP, Qualcomm, and Samsung (also a member of the WPC) as its members. At the end of October, the A4WP announced that its technical working committee had approved a flexible wireless power specification that will allow consumers to charge their mobile devices on a variety of compatible surfaces. The A4WP specification permits spatial freedom based on loosely coupled magnetic-resonance technology. Thus, power can be transferred wirelessly through surfaces to multiple portable devices.

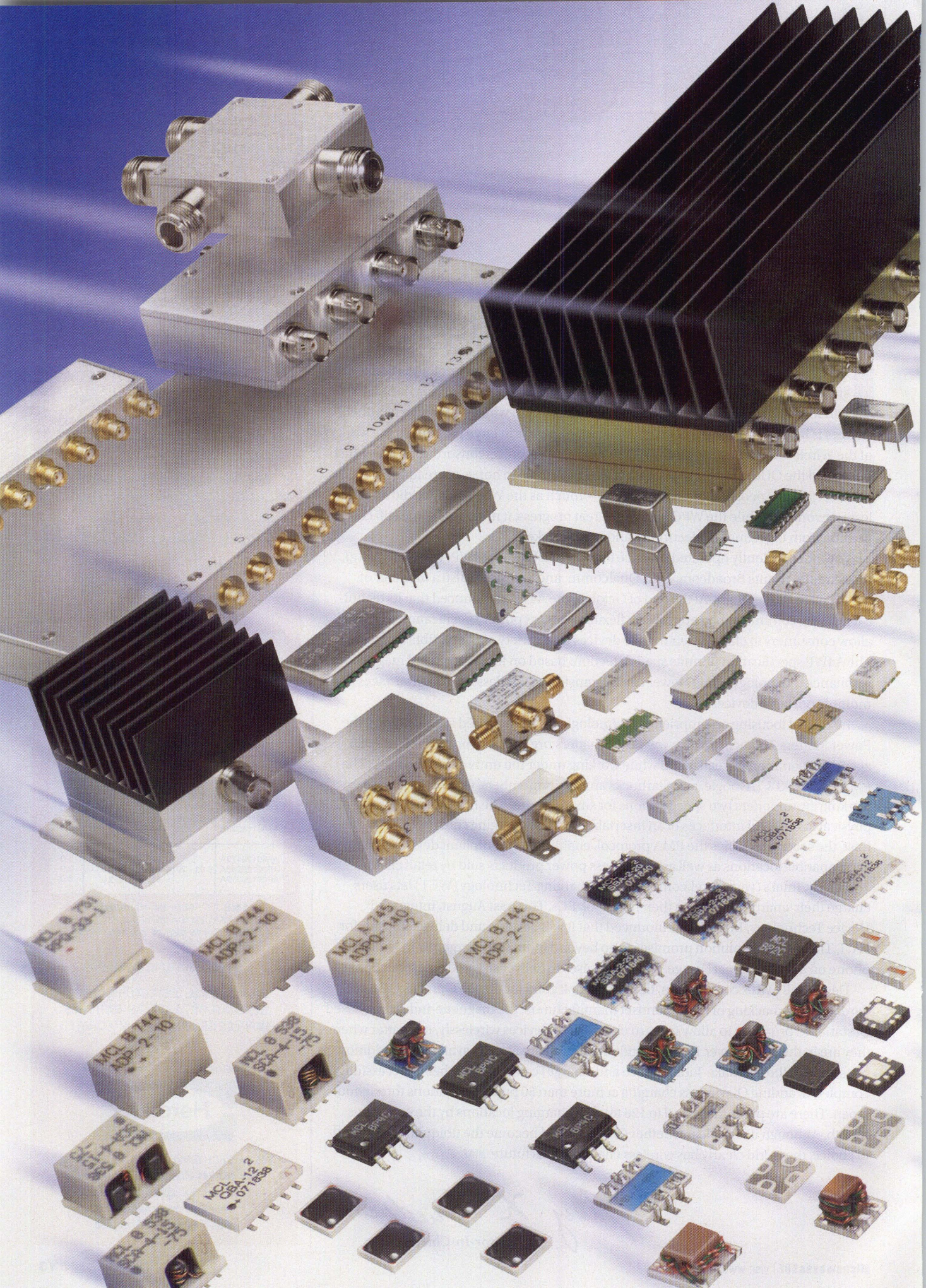
Instead of focusing on proprietary technologies or unregulated specifications, the Power Matters Alliance (PMA; www.powermatters.org) plans to bring the Power 2.0 agenda to commercial realization while working under the umbrella of the IEEE. The PMA counts AT&T, Google, and Starbucks among its members. One of the alliance's working groups offers two specifications for smartphones. The first one defines the physical and logical interfaces of an insertable wireless charging card (WiCC). In contrast, the second specifies the PMA protocol, enabling any compliant device to charge at compatible locations as well as on wireless power products sold by retail chains.

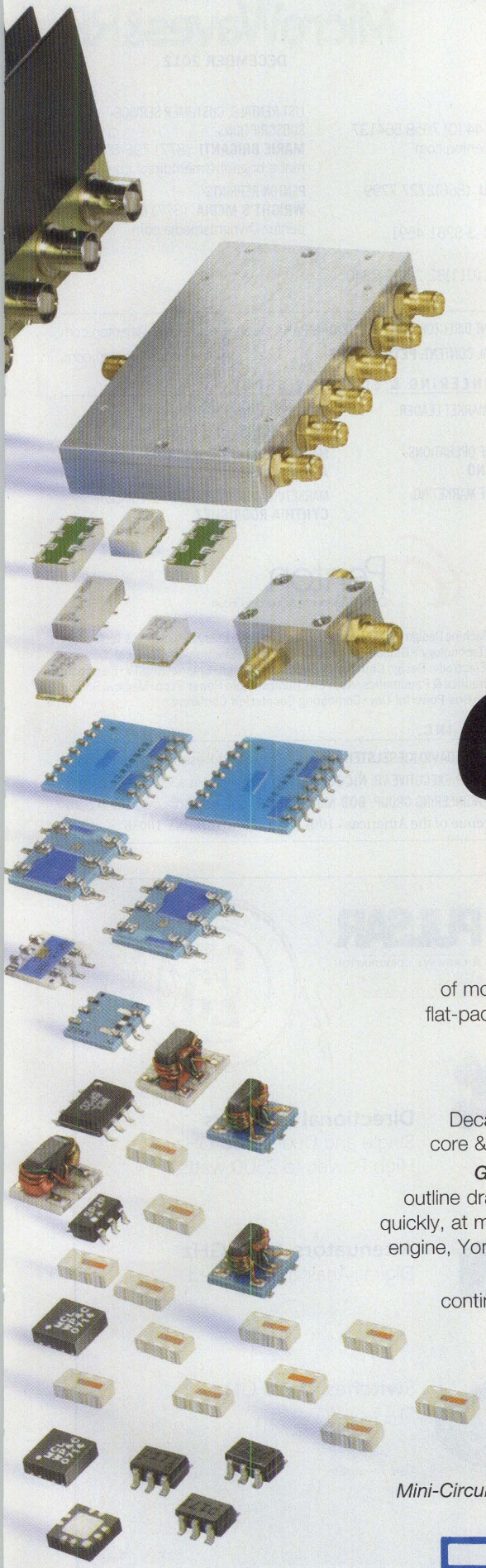
Finally, Intel's (www.intel.com) Wireless Charging Technology (WCT) lets users charge their smartphones from their notebook PCs. This past August, Integrated Device Technology, Inc. (IDT) announced that it will develop and deliver chipsets for WCT. The resulting solution promises to go beyond inductive charging and "smartphone on a charging mat" usage. It also promises to deliver size and cost reductions.

Despite all of this competition, things still look good for the WPC and its Qi standard. With the backing of many handset manufacturers, the magnetic-induction-based Qi standard promises to allow users to charge their devices wirelessly, no matter where they are in the world. Over 100 Qi-certified products are already available. In addition, phase one of the Okudake-Juden (Place and Charge) campaign has been successfully completed, adding Qi wireless charging at more than 60 popular locations throughout Japan. There are plans to expand to 126 total Qi charging locations by the end of this month. Although it is unclear whether Qi will indeed become the ubiquitous standard of choice, the world clearly has wireless charging in its future. MWRF

Nancy K. Friedrich

Editor-In-Chief





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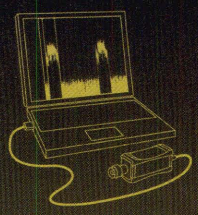

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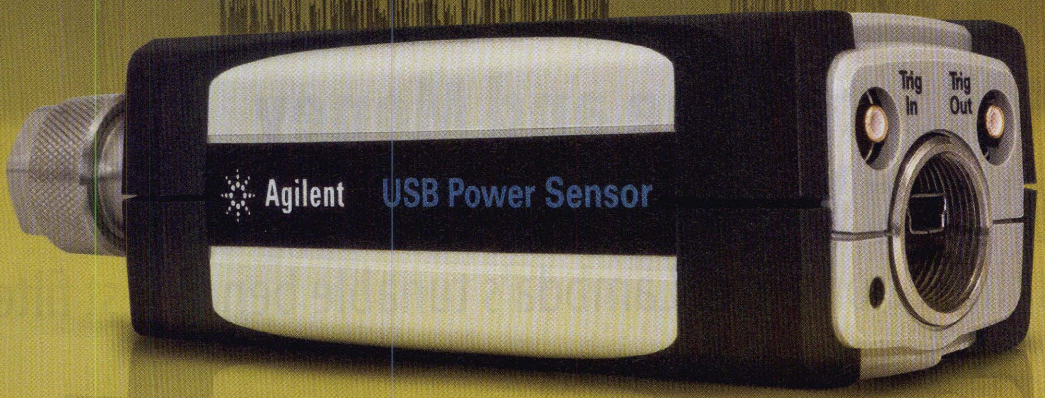

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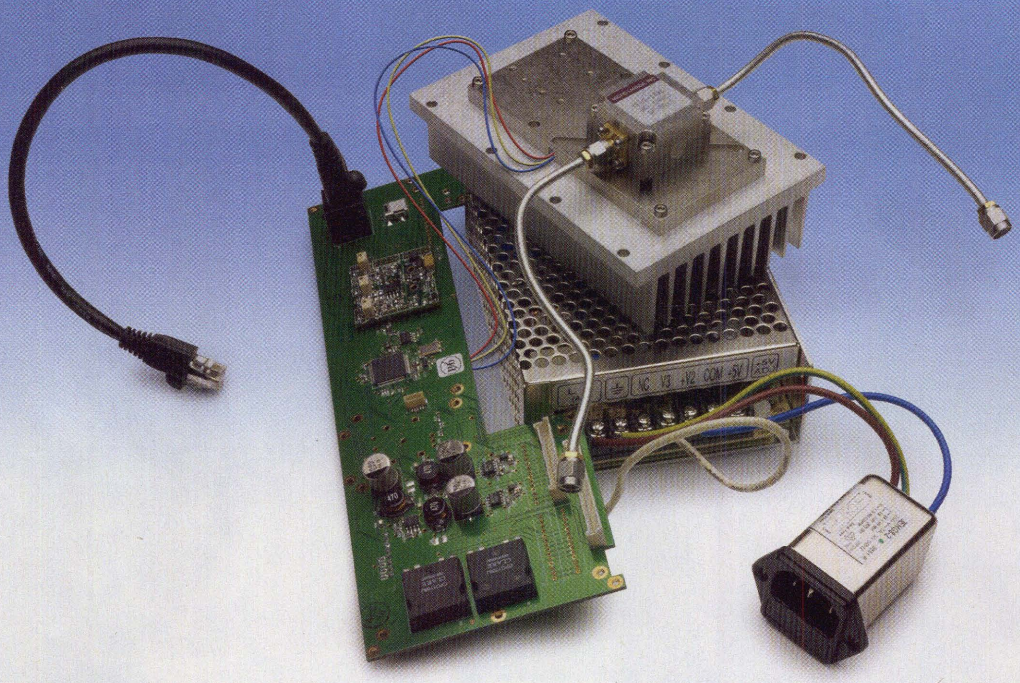

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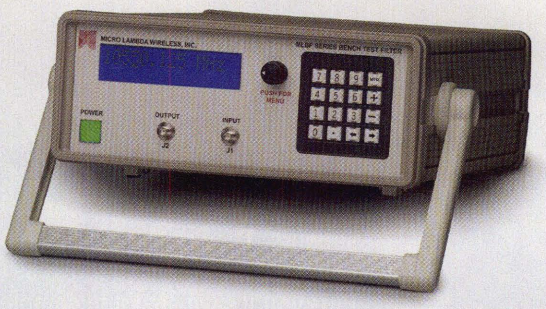

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A LEGEND'S HIGHLIGHTS

Last night, I googled the *Microwaves & RF* Microwave Legends list for the first time. *(Note: To view all of the 2012 honorees, go to http://mwrf.com/content/microwave-legends-2012.)* The people on your list—such as Maxwell—just blew me away! I am very, very happy to be on your list, even though I feel that I should be on the bottom in terms of contributions and importance. Some people may even wonder why I am on this distinguished list at all!

To show what I have contributed, would it be possible to list these accomplishments?

1.) Contributing to the design and building the prototype of the first low drift differential amplifier, with closed loop gain of 1 to 1000, to be put on a chip by Fairchild.

2.) Contributing to the design and building of the Klystron Stations' data multiplexer to the Blockhouse, for the Stanford Linear Accelerator. (I was even invited as a guest for the first turn-on of the system.)

3. Contributing to the design of the B-52 bomber's down-looking radar.

It was very helpful to have Secret Clearance from the Air Force in securing my job at Hewlett-Packard Co.

4. Designing the prototype of a new temperature control system for the semiconductor industry's diffusion ovens. It had 200,000X more bandwidth (not 5 Hz!) than previously for faster settling time, hugely improving yields by eliminating temperature spikes due to line voltage variations.

Sorry about this, but being on a list with people like Maxwell, Marconi, and Tesla just freaked me out! Please, show anything that I have accomplished, just to make me feel like I may almost belong on your list.

JULIUS BOTKA
SANTA ROSA, CA

EDITOR'S NOTE

Julius, as far as how all of us at *Microwaves & RF* (and many, many people in this industry) feel, you belong on that list. You have been an inspiration to a lot of people who have come after you in this industry, and yours is a name that will survive for a long time in it. Sure, people like Maxwell are true pioneers and very special. But it takes a lot of different people to help an industry grow, and you are most certainly one of those people.

Microwaves & RF welcomes mail from its readers. The magazine reserves the right to edit letters appearing in "Feedback." Address letters to:

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News

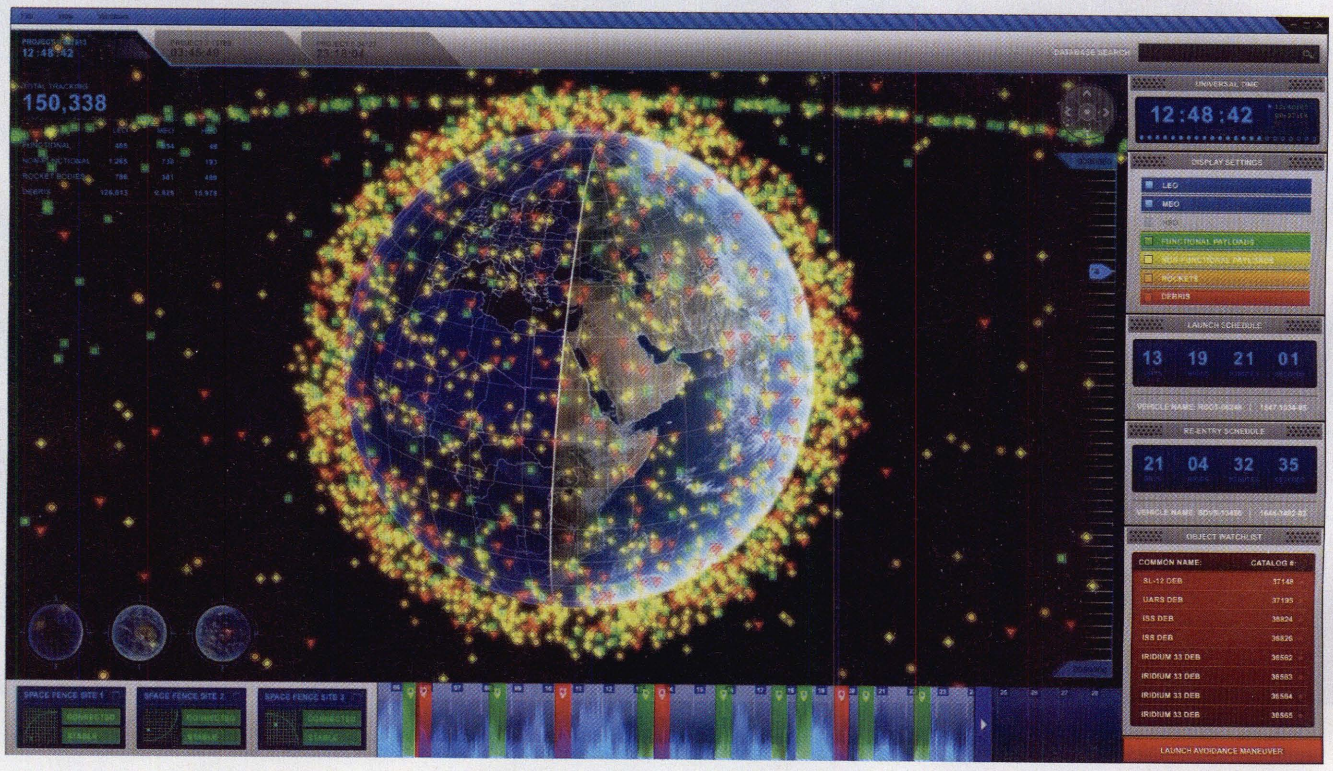
Space-Fence Construction Is Set For 2013

NEXT SEPTEMBER, the Air Force will begin construction at its first site for Space Fence, an advanced ground-based radar system. Located on Kwajalein Atoll in the Marshall Islands, this site's construction puts the program on track to meet its 2017 initial operational capability goal. Using new S-band technology, Space Fence will enhance the way the US detects, tracks, measures, and catalogs orbiting objects and space debris. In addition to improved accuracy, Space Fence will provide the US with better timeliness and increased surveillance coverage.

Once Space Fence is operational, the Air Force will be able to decommission the aging US-based Air Force Space Surveillance System. Installed in 1961, that system was not designed to detect and track the hundreds of thousands of smaller, orbiting objects that are in space today—never mind cataloging them. With its greater sensitivity, Space Fence will be capable of detecting, tracking, and measuring an object the size of a softball orbiting more than 1200 miles in space. Being an uncued tracking system, it also will provide evidence of satellite breakups, collisions, or unexpected maneuvers.

Space Fence will provide this precise positional data on orbiting objects in both low-earth (primary) and medium-earth (secondary) orbits **(see figure)**. Data from Space Fence will be fed to the Joint Space Operations Center at Vandenberg Air Force Base, CA. That data will be integrated with other Space Surveillance Network data to

Construction will begin next fall on Space Fence, an advanced, ground-based radar system that will improve how the US Air Force identifies and tracks orbital objects. (Courtesy of Lockheed Martin)



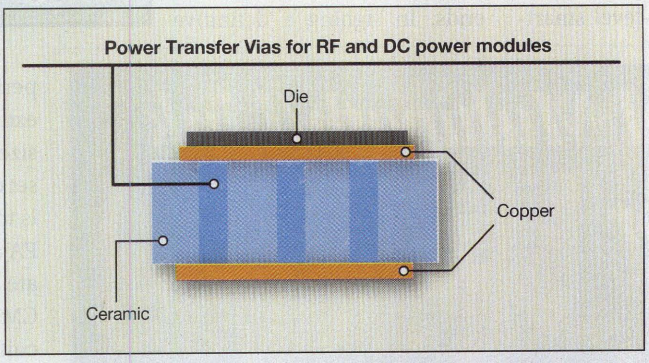
provide a comprehensive space situational awareness and integrated space picture.

Air Force Space Command will award a contract valued at an estimated $1.9 billion over seven years to build the radar. Last month, Lockheed Martin (www.lockheedmartin.com) submitted its final proposal to the US Air Force to build Space Fence. Earlier this year, the company demonstrated its prototype Space Fence radar, which proved that it could already detect resident space objects. The Lockheed Martin-led team includes General Dynamics, AMEC, and AT&T. Raytheon Co. (www.raytheon.com) also has submitted a proposal for the Space Fence program.

Until the final design is determined, it is unknown exactly how many personnel will be required to construct the radar site. Once the radar is operational, a long-term workforce of approximately 10 to 15 contractor personnel will most likely be needed at Kwajalein to maintain the radar.

Via Technology Packages Power Modules

PACKAGING CAN BE CHALLENGING for both RF and direct-current (DC) power circuits. For circuits ranging from chip-scale devices to power modules, however, a new packaging option is now available from Remtec (www.remtec.com). The company has merged its thermally and electrically conductive Power Transfer Vias (PTVs) with the core Plated Copper on Thick Film (PCTF) metallization technology. In doing so, Remtec has achieved a miniaturized, high-performance, and cost-effective packaging solution for high-power gallium-nitride (GaN), gallium-arsenide (GaAs), silicon (Si), and silicon-carbide (SiC) devices **(see figure)**.



When combined with other PCTF features, PTV vias can be used in applications requiring smaller, lower-cost packages, higher switching speeds, efficient heat removal, and higher power and integration levels.

This universal packaging solution boasts high-current-carrying capacity in excess of 50 A, low lead inductance, and thermal resistance below 1°C/W. In addition, it provides a low-loss RF signal transition at a broad frequency range (to millimeter-wave frequencies) and an improved match of thermal coefficient of expansion (TCE) with printed-circuit boards (PCBs) and heatsinks. The PCTF substrates and packages with PTVs are fully compatible with all common assembly methods, such as surface-mount-technology (SMT) reflow solder; gold tin brazing and eutectic die attach; gold and aluminum wire and ribbon bonding; ball-grid arrays; and flip-chip technology.

STANDARDS UPDATE

WiGig And VESA Form Working Group

TOGETHER, THE WIRELESS GIGABIT ALLIANCE (WiGig; www.wigig.org) and the Video Electronics Standards Association (VESA; www.vesa.org) have established a working group to advance WiGig DisplayPort video standard certification. This partnership will address interoperability between the DisplayPort standard and WiGig's Display Extension Protocol Adaptation Layer (PAL). When the group's work is complete, DisplayPort-certified WiGig devices will seamlessly interconnect without wires. Thus, a DisplayPort interface will be able to be used without the use of a DisplayPort cable.

The WiGig Alliance has developed 60-GHz multigigabit wireless standards, which can transmit at speeds to 7 Gb/s. For its part, VESA created, owns, and certifies the digital display interface, DisplayPort, which is mainly used to connect a video source to a display device. According to IDC, DisplayPort will be featured in 89.5% of commercial desktops and 95% of commercial notebooks by 2014. With a wireless extension added to DisplayPort, users will gain a better experience while the protocol itself will be enhanced.

WiGig Alliance published its Display PAL, known as WiGig Display Extension (WDE), in 2011. The specification was developed to support PC peripherals, high-definition televisions (HDTVs), monitors, and projectors. It also supports the latest High-bandwidth Digital Content Protection (HDCP) encryption and is capable of the transmission of both compressed and uncompressed video.

Cellular machine-to-machine (M2M) connectivity services will rise from approximately 107 million connections globally in 2011 to roughly 326 million by 2016.
—IMS Research (www.imsresearch.com), now part of IHS, Inc.

RFMD Scoops Up Amalfi

TELECOMMUNICATIONS FIRMS have been looking to imbue entry-level phones with smartphone capabilities, prompting more users to take advantage of data-centric applications. To serve the growing entry-level smartphone market, Amalfi Semiconductor (www.amalfi.com) provides CMOS power amplifiers (PAs) that help boost operating ranges in cellular front ends. In signing a definitive

agreement to acquire Amalfi, RF Micro Devices, Inc. (www.rfmd.com) is thus strengthening its already powerful presence in the cellular market.

According to Amalfi, its transmit modules deliver superior signal strength while enabling extended battery life and decreasing the size and cost of front-end cellular handset designs. At the heart of those modules is the firm's patented AdaptiveRF CMOS PA architecture. RFMD plans to accelerate the market adoption of Amalfi's RF CMOS and mixed-signal integrated circuits (ICs)—combining Amalfi's products and expertise with RFMD's deep customer relationships, broad product portfolio, in-house manufacturing scale, and global supply chain.

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). The transaction is expected to be accretive to RFMD's P&L within two quarters.

KUDOS

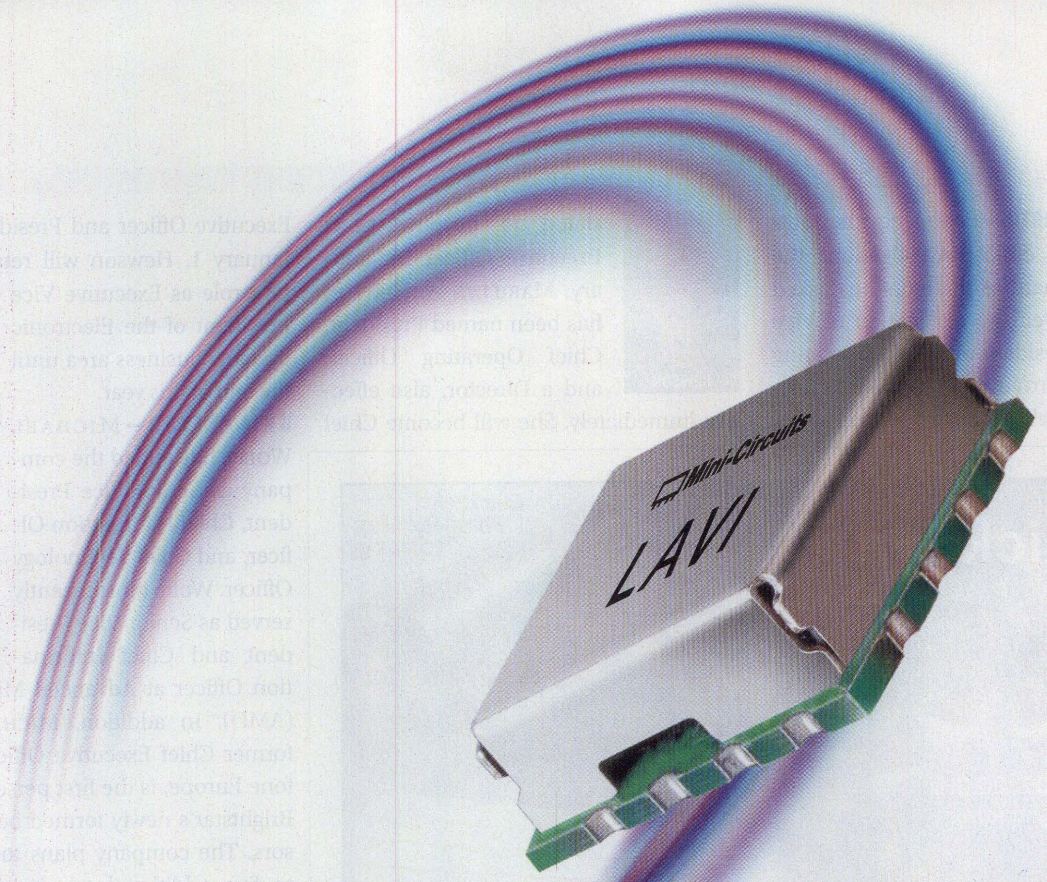
FREEWAVE TECHNOLOGIES—The company's MM2 wireless data radio has received a Machine-to-Machine (M2M) Evolution Product of the Year Award from TMC and Crossfire Media.

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)—Arrow Electronics President BRIAN MCNALLY has been presented with the Gail S. Carter Award, ECIA's highest honor. McNally served as President of the National Electronic Distributors Association (NEDA).

ETISALAT GROUP—Has won four Gold Stevie Awards at the 2012 International Business Awards held in Seoul, South Korea.

NXP SEMICONDUCTORS—Has received two SESAMES Awards recognizing technical innovation in the smart-card and identification industry.

E-CYCLE LLC—Co-Founder and President TONIA IRION has received two Gold Stevie Awards, which were presented as part of the 2012 Stevie Awards for Women in Business in New York, NY.



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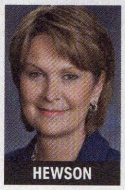
451 Rev J

PEOPLE

LOCKHEED MARTIN—Following the outcome of an ethics investigation, the company's board of directors has asked for and received the resignation of Vice Chairman, President, and Chief Operating Officer CHRISTOPHER E. KUBASIK, effective immediately. Kubasik was previously slated to become Chief Executive Officer in January. MARILLYN A. HEWSON has been named President, Chief Operating Officer, and a Director, also effective immediately. She will become Chief Executive Officer and President effective January 1. Hewson will retain her current role as Executive Vice President of the Electronic Systems business area until the end of this year.


HEWSON

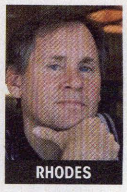

WOLFE

BRIGHTSTAR—MICHAEL WOLFE has joined the company as Senior Vice President, Chief Information Officer, and Chief Technology Officer. Wolfe most recently served as Senior Vice President and Chief Information Officer at Advanced Micro Devices (AMD). In addition, MICHEL COMBES, former Chief Executive Officer of Vodafone Europe, is the first person named to Brightstar's newly formed board of advisors. The company plans to appoint up to five additional telecommunications-industry veterans in the coming months.


COMBES

NGMN ALLIANCE—Has appointed a new board of directors, which will serve a term lasting from 2012 to 2014. The new board members are THIERRY BONHOMME, Executive Vice President of Orange Labs, Networks, and Carriers, France Telecom; ENRIQUE BLANCO NADALES, Chief Technology Officer, Telefonica; JAE-WOAN BYUN, Chief Technology Officer and Head of Technology, SK Telekom; SANDRO DIONISI, Head of TI Lab, Telecom Italia; BRUNO JACOBFEUERBORN, Chief Technology Officer, Deutsche Telekom; LI ZHENGMAO, Executive Vice President, China Mobile Communications Corp.; ANDY MACLEOD, Group Chief Networks Officer, Vodafone Group Services; SEIZO ONOE, Chief Technical Officer and Executive Vice President, NTT DOCOMO; KRIS RINNE, Senior Vice President Network Technologies, AT&T; and BRUCE RODIN, Vice President Wireless Technology, Bell Canada Enterprises.

GLOBAL SEMICONDUCTOR ALLIANCE (GSA)—MATT RHODES has been appointed Chairman of the Emerging Company CEO Council (ECCC). In addition to this role, Rhodes currently serves as Chief Executive Officer of Semitech Semiconductor.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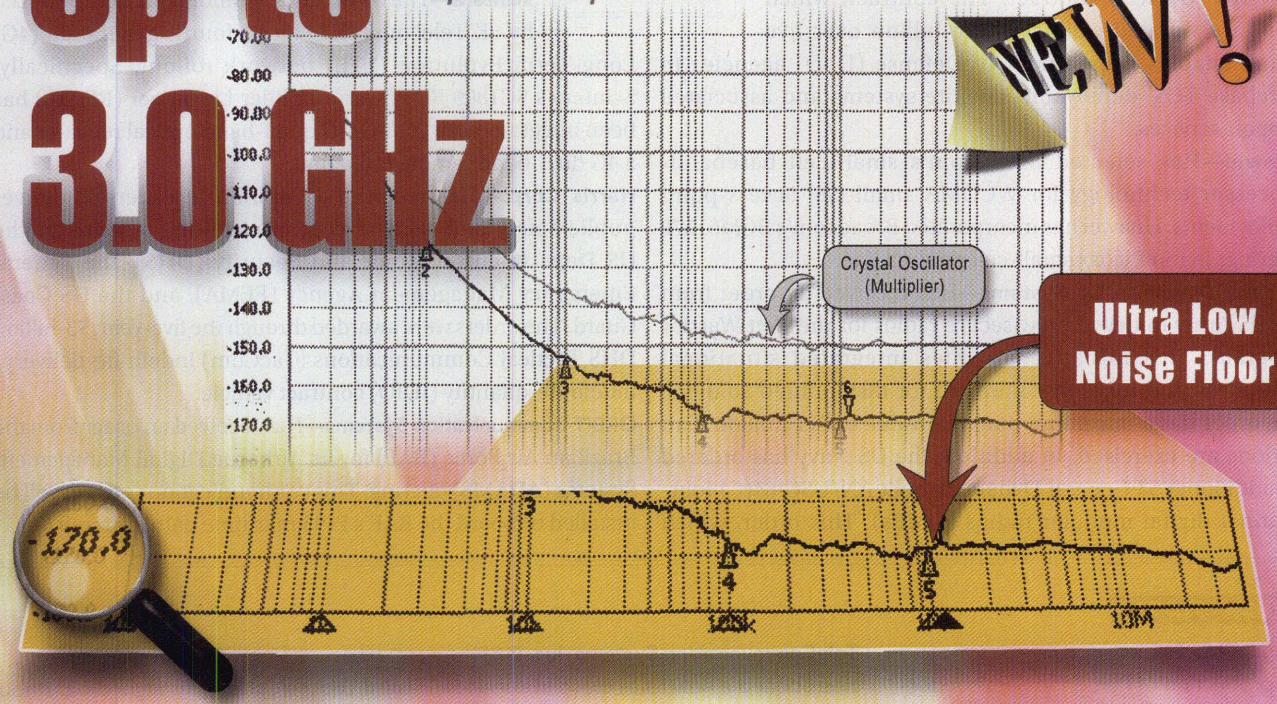

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CONTRACTS

Hughes—Has been awarded a contract by the US Air Force Military Satellite Communications System Directorate. In addition to providing technical support, Hughes will develop management concepts for protected tactical satellite communications.

TeleCommunication Systems, Inc. (TCS)—Has been selected as one of 20 awardees under the Global Tactical Advanced Communication Systems and Services (GTACS) contract. The contract, which has an estimated ceiling of $10 billion over five years, enables Department of Defense (DoD) agencies to purchase TCS' deployable satellite systems and associated support services.

TCS Selected As GTACS Awardee

GENERAL DYNAMICS Scores Army, Navy Radio Deals

Huawei—Has selected Broadcom's small-cell baseband-processor technology for WCDMA small-cell access-point deployments. Huawei has incorporated Broadcom's BCM61670 offerings in its ePicoxx small-cell product line.

General Dynamics C4 Systems—Has received an order from the US Army to deliver new secure radios for the Nett Warrior program. This initiative provides integrated situational awareness and mission command for dismounted soldiers. The order has a maximum potential value of $11 million if all options are exercised. In addition, the US Navy has ordered an additional 53 General Dynamics-built AN/USC-61(C) four-channel digital modular radios (DMRs). This order, which exercises an option on a 2010 contract, has a total potential value of $35 million.

Ceragon—Has announced follow-on orders of more than $6.5 million with Mozambique Cellular (mcel) to expand the carrier's microwave network. Ceragon is extending mcel's backbone network from Beira in central Mozambique to Nampula in the north of the country. It also is upgrading access links nationwide.

Scintera—The company's technology is being utilized by SK Telecom (SKT) for its fourth-generation (4G) Long-Term-Evolution (LTE) network rollout. Specifically, Scintera's SC1889 RF Power Amplifier Linearizer (RFPAL) has been integrated in a 2G/3G/4G quad-band optical repeater and a 4G dual-band remote radio unit.

Harris Corp.—Has received $7 million in orders to deliver public-safety and tactical-communications systems to the US Department of Homeland Security (DHS), the Federal Emergency Management Agency (FEMA), and the US Coast Guard. The orders were awarded through the five-year, $3-billion DHS Tactical Communications (TacCom) indefinite-delivery/indefinite-quantity (IDIQ) contract vehicle.

ORBIT Communication Systems—Has received an order from the Brazilian Air Force (BAF) for its Airborne Digital Management Systems (ADAMS) offering. This communications system will be installed onboard the BAF's P-95 maritime patrol aircraft.

FRESH STARTS

MagnaChip Semiconductor—Has expanded production of Peregrine Semiconductor's STeP5 UltraCMOS product line. The STeP5 products are produced at MagnaChip's Cheongju, South Korea facility.

NuSil—Has completed the fourth phase of expansion at its Bakersfield, CA facility. The newest building—NuSil's fourth on the 15-acre campus—is part of a multi-year plan to expand to seven buildings.

RFMW—Is now offering sales and technical support for Florida RF Labs' SXU series of RF power samplers.

Agilent Technologies—Has equipped a newly opened terahertz measurement laboratory at the University of Leeds (Leeds, England). The lab was established in memory of Roger Pollard, the university's former Dean of Engineering. In addition, Agilent recently equipped a laboratory at Bangor University's School of Electronic Engineering (Bangor, Wales).

Qualcomm Life—Has expanded its wireless healthcare services to Europe. The 2net Platform and Hub are each certified as Class I Medical Devices in Europe.

TeleCommunication Systems, Inc. (TCS)—Has opened a new sales office in Johannesburg, South Africa. This office will be the focal point of the company's marketing and sales activities throughout the African continent.

Lockheed Martin—Has acquired unmanned systems integrator Chandler/May, Inc. The company will become part of Lockheed Martin's Mission Systems & Sensors (MS2) business.

Micross Components—Has reached a distribution agreement with Aeroflex/Metelics Hi-Rel Components. The agreement authorizes Micross Components to promote, sell, and support Aeroflex/Metelics' bare-die diode and transistor product lines.

Pasternack Enterprises—Has appointed Altaix Electronica, S.A. as its exclusive RF distributor for Spain and Portugal. Pasternack's full catalog is now available through Altaix.

MDA—Has completed its acquisition of Space Systems/Loral (SS/L) from Loral Space & Communications, which received in excess of $1 billion at closing.

Laird Technologies—Has signed a distribution agreement with Avnet Abacus for its electromagnetic-interference (EMI) and thermal-management product lines. With this agreement, Avnet Abacus customers in Austria, Germany, and Switzerland will have access to Laird offerings.

Richardson RFPD—The company's Small Cell (Femto, Micro, Pico) New Product Selector Guide is now available. It can be accessed through the Richardson RFPD website.

Anritsu—Has opened a Bangalore-based Indian subsidiary, which includes marketing, sales, engineering, services, and support staff. The company also plans to offer a branch-office operation in Noida within this fiscal year. In addition, Anritsu was a sponsor of the third-annual Disaster Management Initiative (DMI), held November 4-5 at Carnegie Mellon University. There, Senior Product Manager David Witkowski led a session focusing on digital radio technologies for public safety, government, and infrastructure users.

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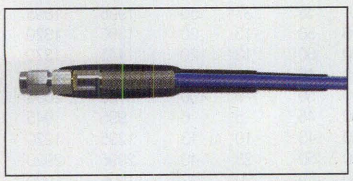
Model Family	Freq. (GHz)	Connectors (male)	Lengths† (ft)	Temp (°C)
Performance Test (CBL)	DC-18	SMA‡, N	1.6-25	-55/+105
Quick Lock (QBL)	DC-18	SMA	1.0-6.6	-55/+105
Armored (APC)	DC-18	N	6.0-15	-55/+105
Low Loss (KBL-xx-LOW)	DC-40	2.92	1.5-6.6	-55/+85
Phase Stable (KBL-xx-PHS)	DC-40	2.92	1.5-6.6	-55/+85

*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.

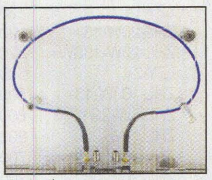
† Custom lengths available by special order.

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

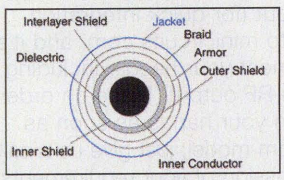
K-Connector is a registered trademark of Anritsu Company.



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.



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

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Model (with heat sink/fan*)	Frequency (MHz)	Gain (dB)	Pout @ Comp. 1 dB (W)	Pout @ Comp. 3 dB (W)	$ Price (Qty. 1-9) with heat sink	$ Price (Qty. 1-9) without* heat sink
LZY-22+	0.1-200	43	16	32	1495	1470
ZHL-5W-1	5-500	44	8	11	995	970
• ZHL-100W-GAN+	20-500	42	79	100	2395	2320
• ZHL-50W-52	50-500	50	40	63	1395	1320
• ZHL-100W-52	50-500	50	63	79	1995	1920
LZY-1+	20-512	43	37	50	1995	1895
• ZHL-20W-13+	20-1000	50	13	20	1395	1320
• ZHL-20W-13SW+	20-1000	50	13	20	1445	1370
LZY-2+	500-1000	46	32	38	1995	1895
NEW ZHL-100W-13+	800-1000	50	79	100	2195	2095
ZHL-5W-2G+	800-2000	45	5	6	995	945
ZHL-10W-2G	800-2000	43	10	13	1295	1220
ZHL-30W-252+	700-2500	50	25	40	2995	2920
ZHL-30W-262+	2300-2550	50	20	32	1995	1920
ZHL-16W-43+	1800-4000	45	13	16	1595	1545
ZVE-3W-83+	2000-8000	36	2	3	1295	1220
ZVE-3W-183+	5900-18000	35	2	3	1295	1220

Listed performance data typical, see minicircuits.com for more details.

** To order **without** heat sink, add **X** suffix to model number (example: LZY-22X+).*

• Protected under U.S. Patent 7,348,854

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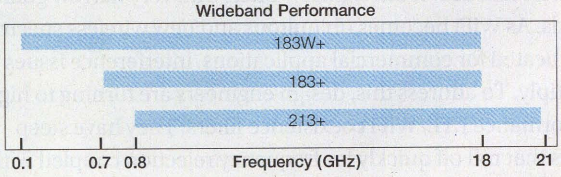
Electrical Specifications (-55 to +85°C base plate temperature)

	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



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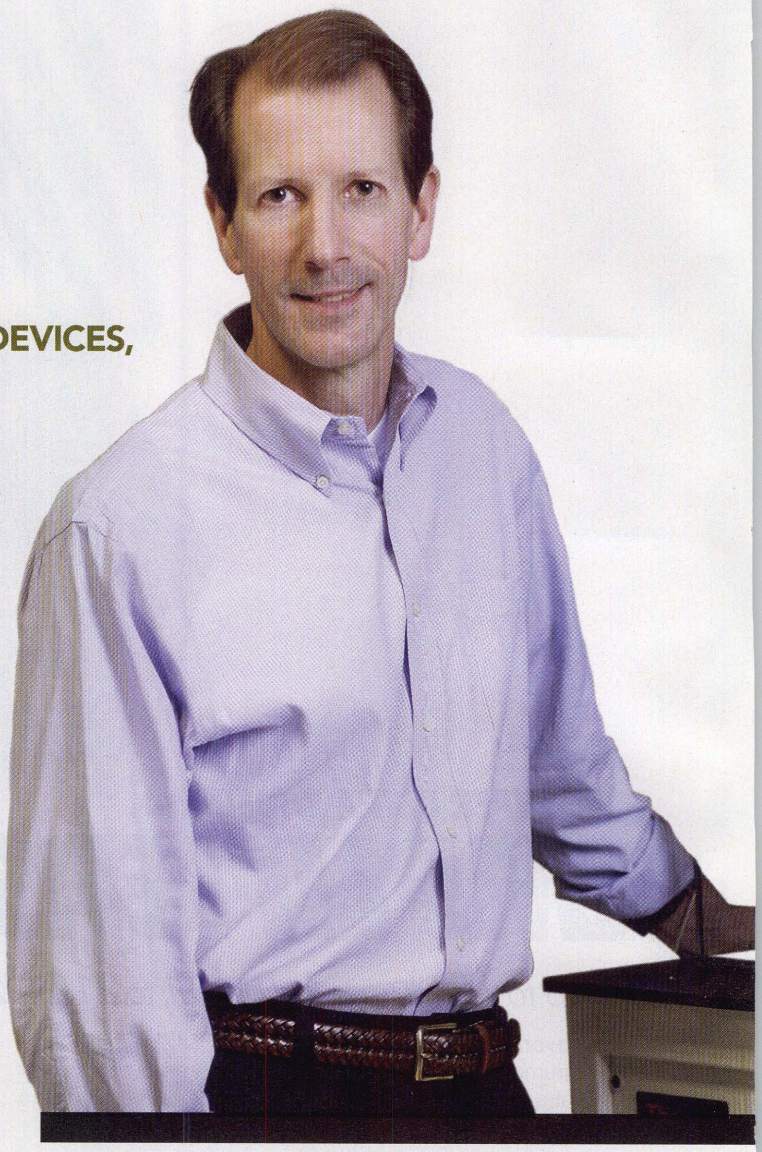
440 rev M

Inside Track with Tim Dunn,

VICE PRESIDENT OF MOBILE DEVICES, TRIQUINT SEMICONDUCTOR

Interview by NANCY FRIEDRICH



NF: Cellular phones have gotten much "smarter." For all this power and convenience, RF/microwave frequencies (such as those used in WCDMA and LTE systems) must be kept separated within compact handsets. What type of filtering technologies does this require?

TD: As fourth-generation (4G)/Long Term Evolution (LTE) networks deploy, the number of RF bands within each device is increasing significantly. At the same time, the global demand for more spectrum is leading governments around the world to re-farm existing spectrum and allocate new bandwidth for wireless services within a crowded landscape. Robust filter technology is critical to mitigate potential interference issues. While surface-acoustic-wave (SAW) filter technology is widely used for band frequencies up to about 1.9 GHz, higher frequencies are better served by advanced bulk-acoustic-wave (BAW) and temperature-compensated-SAW (TC-SAW) technologies.

NF: As smartphones increasingly support WiFi, what demands are placed on filtering technologies?

TD: LTE bands are commonly located next to the unlicensed, international, industrial, scientific, and medical (ISM) bands between 2.4 and 2.5 GHz. These bands are used worldwide for WiFi and Bluetooth signals—often with very narrow guard bands. As WiFi becomes ubiquitous and new wireless spectrum is allocated for commercial applications, interference issues multiply. To address this, design engineers are turning to high-performance LTE/WiFi coexistence filters. They have steep skirts that roll off quickly for frequency rejection coupled with low insertion loss.

NF: Because of the multiple frequency bands being processed within such small circuits, do you see increased opportunities for combination filters or duplexers in smartphone designs?

TD: TriQuint organizes filters in various combinations. These range from duplexer banks that consolidate several filters into a single module [thus reducing printed-circuit-board (PCB) space] to two-in-one duplexers that permit the use of two-receiver operation simultaneously and independently. For wideband TD-LTE filter applications, it's conceivable that two or more bands could be accommodated in one device, which would eliminate the need for a separate filter.

NF: TriQuint offers extensive lines of BAW and SAW filter products. How do your filter technologies differ in their capabilities and how do they match up to different frequency

bands within a smartphone?

TD: SAW filters are well suited for frequencies through 1.9 GHz, such as standard GSM, CDMA, and third-generation (3G) bands—with the exception of the US-PCS band (Band 2). Some new 3G and 4G WCDMA duplexers and filters are best served by TC-SAW, which reduces temperature drift for more challenging specifications. For example, TriQuint uses TC-SAW to support Band 13, Band 20, and Band 26 duplexers.

BAW is ideal for many of the new LTE bands above 1.9 GHz, delivering superior performance with lower insertion loss, steeper slopes, and excellent rejection. BAW excels in applications where the uplink and downlink separation is minimal and when attenuation is required in tightly packed adjacent bands. TriQuint's BAW advantages are instrumental in serving the following bands: Band 25, Band 3, Band 7, Band 38, Band 40, and Band 41 LTE filters.

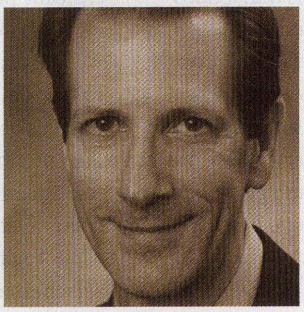
NF: For these emerging smartphone applications, which architectures make the most sense for designers?

TD: Designers select the best architecture to meet a specific set of requirements. For a low-band-count phone with more board space, some designers may like the flexibility of a discrete approach. For a high-end smartphone, they often opt for an integrated RF front end that allows them to squeeze in more bands and offer feature-rich content. LTE filters are more likely to be discrete because they're relatively new. Designers simply add LTE "satellite" components to existing layouts to offer regional 4G variants.

NF: Because TriQuint offers many other components for a communications device, is the company increasingly combining component functions (such as amplifiers, attenuators, and filters)?

TD: Yes, we've been selling hundreds of millions of multifunction units in different combinations. Increasing RF complexity is driving the trend toward integrated solutions. One approach for multi-band devices is an integrated module that combines power amplifiers with duplexers (PADs) in single-, dual-, and multi-band configurations. This optimizes performance along the transmit path while reducing the amount of PCB space required. TriQuint has powered the world's top smartphones with over a half billion PADs. Our integration-enabling technologies like CuFlip shrink size, improve performance, and reduce cost. We're also adding wafer-level packaging (WLP), which offers significant advances in miniaturization and reduced height compared to traditional chip-scale packages.

Another integrated approach for RF design is the multi-mode, multi-band power amplifier (MMPA), which gives OEMs more PCB room for richer feature sets while minimizing engineering time and resources. Strategy Analytics predicts the market for MMPAs will reach more than $700 million in 2016.



Deciding which filter technology is right for a particular band is usually a balancing act between performance, size, and cost.

NF: What are the most challenging performance requirements for filters used in LTE handsets? What tradeoffs are involved in achieving the required performance levels?

TD: Deciding which filter technology is right for a particular band is usually a balancing act between performance, size, and cost. Some LTE bands require higher-performance filters with lower insertion loss for improved signal reception and longer battery life. BAW filters deliver the lowest loss, which helps compensate for the higher losses associated with combining multiple bands in a smartphone. Featuring steep filter skirts and superior out-of-band rejection, BAW filters also provide higher isolation for better receive sensitivity, higher attenuation to cope with increased band coexistence, and higher linearity to handle LTE modulation.

NF: What percentage of your filters is used in tablets?

TD: Many of our smartphone customers offer tablets, but they don't report to us the breakdown between phone and tablet models. Although tablet shipments are increasing steadily, they represent a much smaller percentage of the overall mobile-device market. Tablets contain WiFi but, so far, only a portion includes the cellular option.

NF: For customers who have a particularly difficult requirement, will you share some of your in-house filter models so that they can perform software simulations—at the circuit or system level—to better understand the impact of your filters on their designs prior to fabrication?

TD: We collaborate closely with customers as they develop their next-generation products. As trusted partners, we provide technical information, such as S-parameters and other data, to help them implement their software simulations and design our products into their systems.

NF: Does TriQuint provide testing services to help these cellular-device customers evaluate the performance of new filters? If so, are those services available at circuit and system levels?

TD: We provide customers with excellent applications support—including on-site support and recommendations for layout options and optimizing matching solutions—to help them meet their performance targets. Our field application engineers provide all of the data required to use different filters, as well as detailed application notes for each device.

NF: How do customers work with you to define these tests?

TD: We collaborate very closely to compare bench set-ups and often provide detailed specifications that they incorporate into their test programs and calibration routines. MWRF

RFID STENT TAG Senses Vessel's State

RF-IDENTIFICATION (RFID) TECHNOLOGY has the potential to provide information beyond logistics, such as a physical state and its time-evolution. Essentially, the tag may act as a self-sensing device, thanks to the dependence of its input impedance and radar cross section (RCS) on the physical and geometrical features of the tagged object or—in general—the close surrounding environment. Among the advantages to this approach is that it does not require any specific embedded sensor or local power supply. At Italy's DISP-University of Roma Tor Vergata, a team of researchers has extended this idea to implanted antennas. The team's goal was to sense the evolution of a physiological and pathological process involving a local change of effective permittivity inside the body.

The researchers—Cecilia Occhiuzzi, Giordano Contri, and Gaetano Marrocco—used an ad-hoc design methodology. With the self-sensing tag, there is no decoupling from the operative and structural point of view between the antenna and sensor. In other words, the antenna functions as the sensor and vice versa. As a result, the system's sensitivity and dynamic range are strictly connected to the antenna's features—especially its quality factor and bandwidth. Due to their high water content, however, human tissues are characterized by high permittivity and significant losses. Thus, even with a large bandwidth, the implanted tag will exhibit typically poor sensitivity to the change of the local environment.

The team found that sensing performance could be improved with various degrees of freedom, such as the shape of the antenna. The researchers focused on a realistic medical case in which an endovascular device is modified, thereby achieving a STENTag that can sense the state of the vessel wherein that device has been implanted. See "Design of Implanted RFID Tags for Passive Sensing of Human Body: The STENTag," *IEEE Transactions On Antennas And Propagation,* July 2012, p. 3146.

600-W, C-BAND GaAs SSPA Rivals TWTAs

TO PROVIDE a C-band uplink signal, commercial satellite broadcasters usually use traveling-wave-tube amplifiers (TWTAs). Yet some of these uplink terminals may be just as well served by a solid-state power amplifier (SSPA). Because broadcast stations are redundant, there may be a redundant amplifier standing by for every transmitting amplifier. SSPAs require very little warm-up time, which means the redundant station's standby amplifier can be held in a reduced-power-consumption mode until it is needed. At Wavestream Corp. (www.wavestream.com), a C-band amplifier boasting saturated output power beyond 600 W has been designed by Ha Trong Than, George W. Sun, Blythe C. Deckman, Michael P. DeLisio, Younkyu Chung, M.E. Moya, N.T. Schultz, G.S. Cuellar, and Jiyang Zeng.

The team implemented a two-deck approach to improve heat dissipation and reliability. Because deck-amplifier architectures use spatial power combining, the team combined the output power of 16 internally matched, 45-W gallium-arsenide (GaAs) field-effect transistors (FETs). Each FET had rated output power of 45 W with small-signal gain of 9 dB.

This 24-x-19-x-8.75-in. unit features pre-amplification and driver amplification stages and a level-control variable attenuator. A pre-distortion linearizer splits the signal into two paths. One path contains a nonlinear saturating element. By recombining these signals with proper phasing, the team is able to achieve enough gain expansion and phase change to compensate for the PA's saturation. By performing power combining on two 600-W amplifiers with a magic-T waveguide combiner, the researchers created a solid-state amplifier with 1.4 kW of saturated C-band output power. See "Design and Performance of a 600-W C-Band Amplifier Using Spatially Combined GaAs FETs for Satellite Communications," *IEEE Journal Of Solid-State Circuits,* Oct. 2012, p. 2309.

Terahertz Imaging System Uses BWO As Source

MUCH RESEARCH HAS shown that terahertz waves can penetrate a number of materials while generating images with high spatial resolution. A number of these terahertz imaging solutions rely on continuous-wave radiation sources like a backward-wave oscillator (BWO). BWOs offer high output power, good wave-front quality, working-wavelength tunability, and a high signal-to-noise ratio. At China's Southeast University, a continuous-wave (CW) terahertz imaging system using a BWO as source, a Golay-Cell as a detector, and an oscilloscope as a data-acquisition unit has been developed by Gang Chen, Jie Pei, Fei Yang, Xiao Yang Zhou, Z.L. Sun, and Tie Jun Cui.

The system's software, which is based on the oscilloscope, is designed to control object movement as well as the capture and display of continuous terahertz-wave image data. To show the system's validity at room temperature, the team tested the imaging of different objects at 450 and 890 GHz. The system was affected by humidity, thickness, and material properties. In addition, imaging resolution was discovered to be better as incident frequency increased. The translation step also impacted imaging, showing that the appropriate frequency and translation step must be chosen to meet practical imaging requirements. See "Terahertz-Wave Imaging System Based On Backward Wave Oscillator," *IEEE Transactions On Terahertz Science And Technology,* Sept. 2012, p. 504.

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Microwaves in Europe

Special EuMW Show Coverage

EuMW Amsterdam Delivers On New Technology

EUROPEAN EDITORS **SALLY WARD-FOXTON** AND **PAUL WHYTOCK** REPORT THEIR FINDINGS FROM THE 15TH ANNUAL EUROPEAN MICROWAVE WEEK.

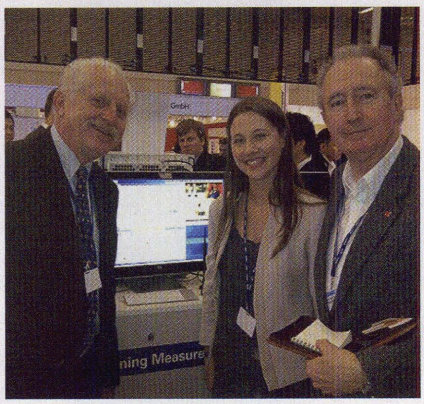
STAGED IN AMSTERDAM, the "Venice" of northern Europe, European Microwave Week 2012 (EuMW) was a small show occupying just one section of the RAI Congress Centre. Yet the show's small size belied the amount of activity at this key industry event. Every fall, numerous microwave and RF companies choose the event as the launchpad for their new products and technologies. Though there are no prizes for the most new technology announcements, such an award would be hotly contested within an industry event that featured new products ranging from components and devices—from gallium-nitride (GaN) products to the latest in test and measurement instruments.

Over the past couple of years, the emergence of GaN-based products at EuMW has steadily escalated. This trend is not surprising, considering GaN's well-recognized advantages compared to other high-frequency device technologies. Among those advantages are high breakdown voltage, wide bandgap, high thermal conductivity, and high current density. Yet the high cost of GaN technology has always been a concern. While this may have been true during the early years of GaN products, newer GaN-based products are benefitting from significant cost reductions, thanks to the development of CMOS-compatible GaN-on-silicon processes.

GaN transistors were among the dozen offerings introduced by TriQuint Semiconductor (www.triquint.com). According to the company, those transistors exhibit product specifications that will allow RF designers to cut the space devoted to RF signal amplification by up to 50%. Also shown was a device dubbed the "Diplexer" module. It combines multiple filter functions inside a 5-x-5-mm module. "This is quick-time custom manufacturing, so the customer calls up the factory, picks the filters they want in the module, and we turn these out as if it was a standard product," explains Mark Andrews, TriQuint Semiconductor's Strategic Marketing Communications Manager, Infrastructure & Defense Products.

Analog Devices (www.analog.com) used EuMW to introduce a family of microwave integrated circuits (ICs)—the ADF55xx series voltage-controlled oscillators (VCOs). They target point-to-point (PtP) communications, instrumentation/test equipment, and satellite-communication (satcom) applications. Featuring very good phase-noise performance, the ADF55xx VCO series covers 3.5 to 13.9 GHz with a broad frequency-tuning range.

Amsterdam also was the venue chosen by AMCAD Engineering (www.amcad.com) to announce an upgrade of its pulsed-current-voltage (PIV) semiconductor-device measurement system for the next generation of high-voltage fast-switching (HVFS) transistors. New HVFS transistor technology, such as enhanced-mode GaN FET and silicon-carbide (SiC) MOSFET devices, offers switching frequencies that can be up to 10 times higher than previous solutions. As a result, electronic designers can use these new devices at lower duty cycles. Previously, no efficient testing solutions existed to characterize these new devices, which can provide simultaneously high-voltage signals and short-pulse/fast-switching capabilities.

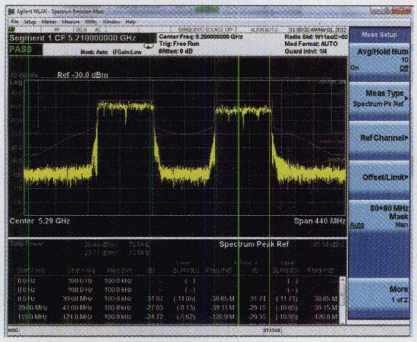


1. Dr. James Truchard ("Dr. T"), National Instruments' Co-Founder and CEO, discusses the finer points of the company's PXIe-5667 with *Microwaves & RF*'s Sally Ward-Foxton and Paul Whytock at European Microwave Week 2012.

Base stations are the focus of two 5-V in-phase/quadrature (I/Q) devices from NXP Semiconductors (www.nxp.com). The BGX7100 and BGX7101 devices operate between 400 MHz and 4 GHz. The main difference between the two I/Q modulators is output power: 0 dBm for model BGX7100HN and +4 dBm for model BGX7101HN, providing solutions for infrastructure cell sizes from small to macrocells.

Along with high dynamic range and low noise floor, the devices boast monotonic output third-order intercept behavior versus frequency. They also stand out for their performance in the lowest unadjusted carrier feed through (–50 dBm feedthrough at –7 dBm output power at 1960 MHz) and in the highest unadjusted sideband suppression in the market (–45 dBc at –7 dBm output power at 1960 MHz). With fast on/off switching, the BGX710x series modulators can shift from power-saving mode to full-performance and stable operation within 1 ms.

At the 2012 EuMW, National Instruments (www.ni.com) launched its PXIe-5667 spectrum-monitoring receiver **(Fig. 1)**. This receiver, available in 3.6- and 7.0-GHz versions, was designed for over-the-air RF measurements. Matthew Friedman, NI's Senior Product Manager for Automated Test, explained that



2. The N9077A-4FP option for the PXA, MXA, and EXA signal analyzers supports the noncontiguous channel SEM of 80+80 MHz in IEEE 802.11ac.

the PXIe-5667 allows users to perform real-time signal analysis—such as continuous spectrum monitoring, spectrogram, and advanced signal processing—when coupled with NI FlexRIO and the NI LabVIEW field-programmable-gate-array (FPGA) module.

The PXIe-5667 features dynamic range beyond 110 dB and distortion performance with a third-order-intercept (TOI) point of greater than +17 dBm. It covers 20 Hz to 7 GHz with up to 50 MHz real-time bandwidth and scan rates to 30 GHz/s.

Also on display was new software from Agilent Technologies (www.agilent.com) for its X-Series signal analyzers, which expands wireless-local-area-networking (WLAN) support to include the emerging IEEE 802.11ac standard. In fact, one-button IEEE 802.11ac testing is now included in the N9077A WLAN measurement application with a new option, 4FP. When combined with the PXA signal analyzer (the high-end model in the X-Series), for example, option 4FP enables measurement of the full bandwidth of IEEE 802.11ac signals for bandwidths from 20 to 160 MHz and 80+80 MHz **(Fig. 2)**.

Also showing its microwave wares was Anritsu (www.anritsu.com), with new capabilities for its ME7838A vector-network-analyzer (VNA) test system. For example, that system now includes four-port test solutions and 500-GHz extensions. Anritsu also demonstrated the 125-GHz noise-figure measurement capability of the MS4640A VNA.

Meanwhile, Rohde & Schwarz (www.rohde-schwarz.com) debuted a new microwave signal and spectrum analyzer, the FSW43. While it is designed for applications to 43.5 GHz, external harmonic mixers can extend the analyzer's frequency range to 110 GHz. External mixers take advantage of the analyzer's high second intermediate frequency (IF) of 1.3 GHz, providing an image-free range of 2.6 GHz for wideband signals. The instrument can perform spectral measurements including on WLAN signals in the 60-GHz band and IEEE 802.11ad signals. With the preamplifier switched on, this analyzer's average noise level is just –164 dBm. With a phase noise of –117 dBc/Hz offset 10 kHz from a 40-GHz carrier, the FSW43 allows high-sensitivity measurements even close to the carrier. MWRF

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Standards Set Limits For Wireless Applications

Wireless technology is reaching well beyond cellular telephones and wireless data networks, improving the quality of applications in industrial, medical, and automotive areas.

WIRELESS TECHNOLOGY APPEARS everywhere, used in applications from the simplest sensors to the most sophisticated communications systems. The frequencies for these different applications are not random, of course, but governed by different standards organizations to minimize overlap and interference as much as possible. Many wireless standards have been created over the years to establish guidelines for the different uses and applications of wireless technology. In spite of the large following for such applications as personal communications systems (PCS)—such as cellular telephones and wireless local area networks (WLANs)—wireless technologies and their standards are still growing at a healthy rate, expanding into application areas that include automotive, industrial, and medical electronic systems.

Communications among cellular network users may still represent the largest single application for wireless technology, but wireless links between machines, or machine-to-machine (M2M) communications, may be gaining ground. The IEEE's group of 1609 standards are being developed for automotive wireless applications at 5.9 GHz. The standards define the architecture, communications model, management structure, security mechanisms, and physical access for applications related to wireless access in vehicular environments (WAVE).

These communications networks include on-board units (OBUs) and roadside units (RSUs). Different sections of the IEEE 1609 standard refer to network management (1609.1), security protocols (1609.2), network layer protocol (1609.3), and extensions to IEEE 802.11 (such as IEEE 802.11p for automotive wireless networking) for physical channel access (1609.4).

Earlier this year, three cars equipped with eCall systems crossed a finish line in Brussels as part of a trial of the eCall system. The event, attended by major players involved in the development of the eCall system, demonstrated that it works successfully throughout Europe. [Photo courtesy of NXP Semiconductors (www.nxp.com).]

The IEEE 1609 channel plan supports 10-MHz channels from 5.850 to 5.925 GHz for short- to medium-range communications (e.g., for roadside-to-vehicle and vehicle-to-vehicle communications). Wireless technology in automobiles enables a number of different applications, such as navigation, remote diagnostics, in-vehicle Internet access, emergency communications, and even stolen vehicle tracking and recovery.

In Europe, the European Union (EU) is promoting an application known as eCall in their attempts to create a location-enhanced emergency response network based on the standard European emergency telephone number: 112. The eCall system blends the features of an in-vehicle system (IVS) with wireless connectivity and Global Positioning System (GPS) location capability with the European Public safety Answering Points (PSAPs) infrastructure to help minimize the response time following a traffic accident. If an IVS device detects an accident it calls a PSAP station, transmits vehicle data and location information, and establishes a voice communications connection. The EU is hoping that eCall will cut the number of highway fatalities in EU countries in half by 2014 **(see figure).** In the United States, similar solutions such as OnStar (www.onstar.com) should

help improve traffic safety.

Growth of wireless technologies will see more electronic devices fueled by multiple wireless standards. Near-field communications (NFC) capability, for example, is being added to many newer cellular telephones. It enables NFC-equipped devices to communicate at low data rates (to 424 kb/s) by touch or over a short distance (less than 0.2 m) using point-to-point communications at 13.56 MHz.

NFC, which is based on radio-frequency-identification (RFID) communications standards including ISO/IEC 1444, is promoted by the NFC Forum (www.nfc-forum.org), a non-profit industry association with more than 170 member companies worldwide. The NFC Forum recently approved a new analog technical specification, which is available for free download from its website. The specification details a common radio interface for NFC integrated circuits (ICs).

Along with applications in automotive systems and personal communications, including in WLAN applications, wireless technologies will continue to expand in medical and industrial applications. IEEE 802.11b and IEEE 802.11g WLAN technologies have long been popular for wireless medical applications, as has traditional Bluetooth technology from 2.4 to 2.5 GHz for medical devices such as wearable electrocardiograph (ECG) monitors.

In addition, a newer form of Bluetooth, Version 4.0 for low-power applications, is emerging as a good fit for medical applications. It employs lower duty cycles than standard Bluetooth for lower overall power consumption, using duty cycles on the order of 0.25%. It shares the 128-b encryption and frequency-hopping characteristics of standard Bluetooth, and offers a communications range of about 160 ft (50 m), but draws only microamperes of current and can power sensors for extremely long time periods on battery power. Low-power Bluetooth also trades off data-rate performance due to its lower power consumption, with capability to about 200 kb/s compared to 1 to 3 Mb/s for standard Bluetooth.

When high-speed data is a requirement, the IEEE 802.11ac version of WLAN brings a number of improvements to a successful wireless technology to boost performance. In contrast to older WLAN versions of IEEE 802.11, such as IEEE 802.11b in the 2.4-GHz band, IEEE 802.11ac is a gigabit WLAN version designed for use in the 5-GHz ISM band. It makes use of 160-MHz channel bandwidths; high-level modulation [to 256-state quadrature amplitude modulation (256QAM)]; and advanced multiple-input, multiple-output (MIMO) antenna schemes, with as many as 8 x 8 MIMO spatial streams to achieve single data streams to 500 Mb/s and multiuser speeds of better than 1 Gb/s.

Communications among cellular network users may represent the largest single wireless application, but M2M appears to be gaining ground.

Perhaps the fastest-growing use of wireless technology will occur in industrial environments, as part of process monitoring and factory automation. Wireless technologies such as the ISA100.11a standard developed by the International Society of Automation (ISA; www.isa.org) and the WirelessHART (www.hartcomm.org) standard—based on the highway addressable remote transducer protocol (HART) architecture—both use the 2.4-GHz ISM band and 802.15.4 WLAN standard radio technology for such applications as sensor monitoring.

Both standards are designed to coexist with many other wireless standards in the industrial workplace, including cellular telephones and WLANs. ISA-100.11a was developed to provide reliable and secure wireless operation for noncritical monitoring and control applications where latencies on the order of 100 ms can be tolerated. WirelessHART, which is based on the Release 7.0 of the HART protocol, features integrated security and targets rotating equipment, such as kiln dryers, as well as environmental health and safety applications like condition monitoring.

Another low-power wireless standard, WAVE2M (www.wave2m.com), is a two-way radio technology developed for such applications as automated meter reading and building automation. Developed by the WAVE2M Community, an international nonprofit standard development organization, this low-power, low-data-rate technology is well suited for industrial and medical applications.

Based on license-free ISM bands including 868 MHz in Europe, 915 MHz in the United States, and 433 MHz in Asia, WAVE2M typically operates at low data rates of 38.4 kb/s or less using automatic frequency control, programmable output power, automatic sensitivity control, and adaptive frequency hopping. WAVE2M networks are not limited in size, but can be as large as several hundred devices. With WAVE2M, wireless monitoring can be performed from fixed access points and/or from portable or mobile devices.

Of course, the expansion of wireless technology is not limited to these "lower frequency" bands. Unlicensed bands exist into the millimeter-wave frequencies; the bandwidth available at 60 GHz, for example, has attracted a number of hardware suppliers to pursue millimeter-wave solutions for high-speed Gigabit Ethernet systems and point-to-point links. A total of 7 GHz (from 57 to 64 GHz) has been allocated by the United States' Federal Communications Commission (FCC) for unlicensed, unchannelized point-to-point use at high data rates, with frequencies from 59 to 66 GHz available for unlicensed use in Japan.

The narrow beamwidths of signals at those frequencies allow for several antennas to be collocated without interference and with fairly good security. As the expansion of wireless applications has shown, the need for wireless solutions knows no limit on frequency or data rates. MWRF

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Managing Phase Noise In Microwave Sources

Phase noise is an inevitable consequence of producing RF/microwave signals, although its sources can be both understood and controlled.

PHASE NOISE HAUNTS every high-frequency signal source at some level. Though it can be minimized through attention to careful design practices and use of good materials, it cannot be eliminated. Phase noise is basically the short-term, random fluctuations of frequency in a signal source, such as an oscillator, frequency synthesizer, or test signal generator. Because some amount of phase noise is inevitable in a high-frequency source, it may be helpful to reach some understanding on what levels might be considered acceptable, and what the effects of phase noise on a system are if those levels are too high.

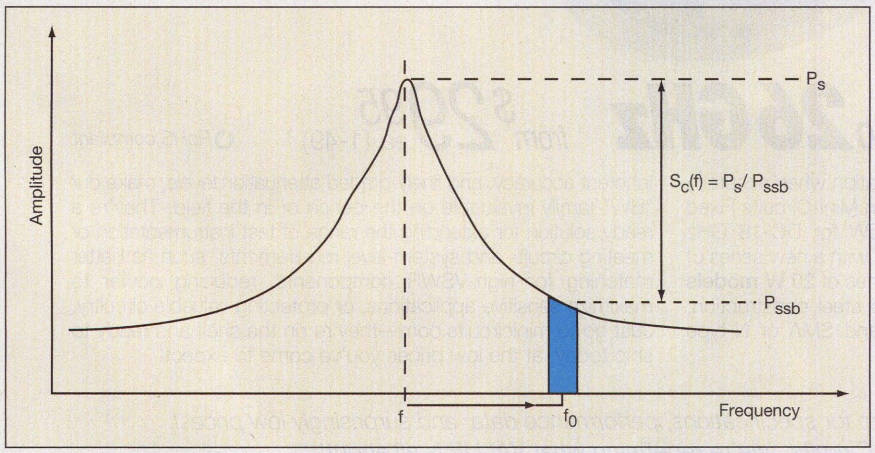
An ideal RF/microwave signal source such as a transistor oscillator would generate an output signal with no fluctuations in frequency or phase, and no noise at the output. If tuned to a particular frequency, the source would remain at that frequency over time, without drift or other variations. Unfortunately, not only will it drift in frequency over long periods of time, but it will also suffer short-term variations in frequency—what we know as phase noise.

If an oscillator's output signal is visualized as the amplitude peak of a sine wave, both lower and upper sidebands of the signal contain noise. A source's phase noise can be characterized for one or both sidebands as single-sideband (SSB) or double-sideband (DSB) phase noise, respectively. Nonetheless, most commercial oscillators, signal generators, and other high-frequency signal sources are specified and compared according to their SSB phase noise, which can be represented on a diagram showing the peak amplitude and the measurement bandwidth for the noise at some offset distance from the carrier. As the shape of the carrier plot shows (**Fig. 1**), the phase noise will decrease as the offset from the carrier increases.

In this plot of phase noise, borrowed from the application note from Mini-Circuits (www.minicircuits.com), "VCO Phase Noise," P_s represents the signal or carrier power; P_{ssb} is the single-sideband power in a 1-Hz bandwidth at some offset distance from the carrier; f_0 is the carrier center frequency; and $S_c(f)$ is the phase noise or power density in one sideband per Hz of bandwidth at an offset frequency, f, from the carrier. As this plot shows, the phase noise is basically the ratio of the noise power in a 1-Hz bandwidth at a specified offset from the carrier to the carrier signal power, given in dBc/Hz. Phase noise in the frequency domain corresponds to jitter in the time domain.

As a standard SSB plot of phase noise indicates (**Fig. 2**), the noise level diminishes as the offset frequency from the carrier increases. The phase-noise offset frequency is often referred to as either "close-in" phase noise or phase noise that is far from the carrier. Both terms can be somewhat arbitrary in nature, with close-in phase noise typically referring to noise at offset frequencies of 100 Hz or less, but often including offset frequencies to 1 kHz. Phase noise that is far from the carrier usually refers to offset frequencies of 1 MHz or greater.

The location of the phase noise can have significance for different applications. For example, in signal-sampling applications using an analog-to-digital converter (ADC), close-in phase noise on the clock oscillator can cause errors in sampling an input signal's frequency. The phase noise that is further from the carrier,



1. This diagram illustrates the carrier portion of a sine wave and the definition of single-sideband (SSB) phase noise referenced to a 1-Hz measurement bandwidth. [Diagram courtesy of Mini-Circuits (www.minicircuits.com).]

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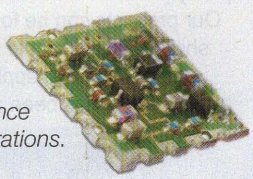

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IF/RF MICROWAVE COMPONENTS

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also known as broadband noise, will cause degradation in the overall signal-to-noise ratio (SNR) of the signal sampling system or circuit.

Many factors can affect phase-noise performance in an RF/microwave source, including the materials used in a resonator, the type of active device in an oscillator, and the reference oscillator used in a frequency synthesizer. Noise on the power supply to the oscillator, for example, can translate to phase noise at the output of the oscillator. For optimal phase-noise performance, an oscillator's active device should exhibit low noise figure as well as low flicker noise.

An oscillator's phase noise will inevitably be limited by thermal noise, N_T, which is caused by the Brownian motion of electrons due to thermal agitations. Thermal noise is often represented by the simple expression:

$N_T = kTB$

where:

k = Boltzmann's constant;
T = the temperature in degrees kelvin, or 290 K at room temperature, or +17°C);
and
B = the bandwidth.

At room temperature or 290 K, N_T = –174 dBm/Hz.

A low-noise oscillator, such as a crystal oscillator, will also exhibit a noise floor which can serve as a limitation in measuring the phase noise of other oscillators, since low-noise oscillators are often needed as a reference source for measurements. The noise floor for a low-cost crystal oscillator may be about –150 dBc/Hz versus about –160 dBc/Hz for a good low-noise version.

For measuring source phase noise, a number of companies offer dedicated (and sophisticated) test systems, such as the PN9000 phase-noise measurement system from Aeroflex (www.aeroflex.com), the E5500 series of phase-noise measurement systems from Agilent Technologies (www.agilent.com), and the BluePhase 1000 phase-noise test system from Wenzel

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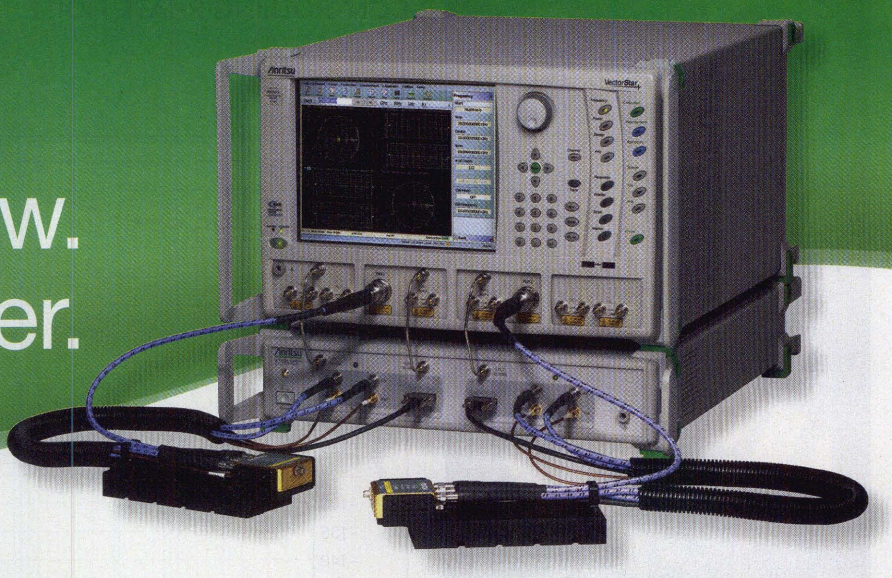

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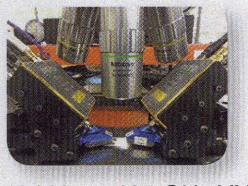

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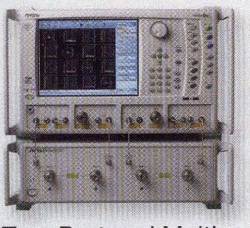

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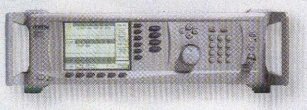

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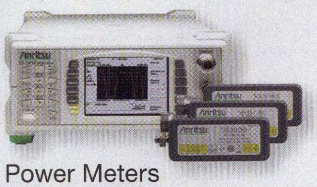

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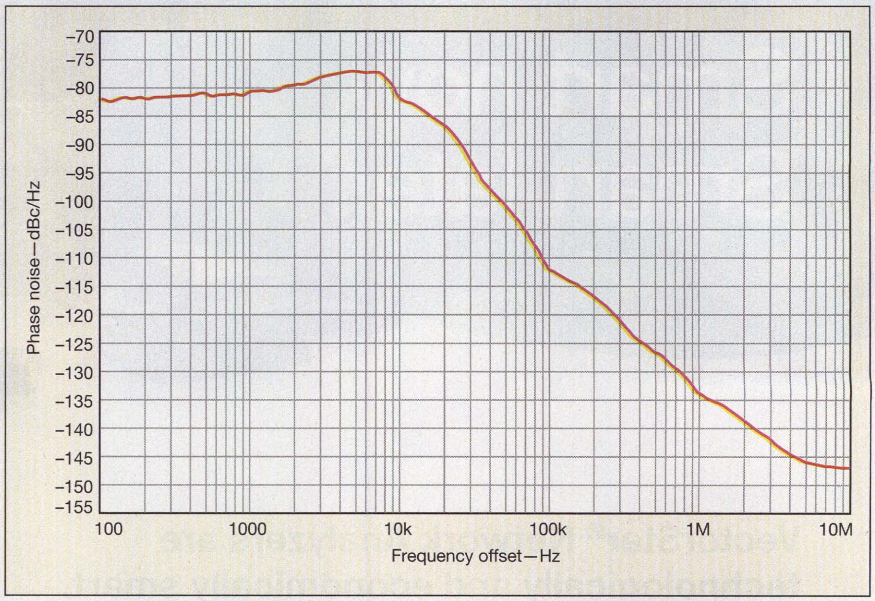

2. This is a standard plot for displaying SSB phase noise at various offsets from the carrier. [Diagram courtesy of Analog Devices (www.analog.com).]

Associates (www.wenzel.com). These systems typically combine a number of different function modules—such as phase detectors, local oscillators (LOs), and power supplies—to achieve a specified measurement performance level.

Some of these systems deliver carrier coverage well into the millimeter-wave frequency range using additional frequency translators and harmonic converters. The PN9000 and E5500 systems offer measurement capabilities at offsets as close as 0.01 Hz to as far as 1 MHz, in the case of the PN9000, and 100 MHz for the E5500 systems. The E5500 systems boast a noise floor of –180 dBc/Hz. The BluePhase 1000 system offers more humble performance levels, working across an offset range of 1 Hz to 100 kHz for carrier frequencies from 5 MHz to 1.5 GHz, but still with an impressive noise floor of –178 dBc/Hz offset 10 kHz from the carrier.

Of course, measuring phase noise can be as simple as using a spectrum analyzer, provided that its internal noise is low enough. Most instrument makers recommend that a spectrum analyzer have phase-noise characteristics that are at least 10-dB better than an oscillator or signal source to be measured. Ideally, the analyzer also includes resolution-bandwidth filters narrow enough to measure the noise power in a 1-Hz measurement bandwidth.

The spectrum analyzer should also provide sufficient measurement dynamic range to display the level of a carrier of interest, as well as the low noise levels far from the carrier (or at least at offsets from the carrier that are important to the measurements). A simple way to check whether a spectrum analyzer's thermal noise will interfere with a phase-noise measurement is to compare noise levels at an offset of interest with and without the source to be tested connected to the analyzer's input port. A clear difference in the noise levels at the offset of interest usually indicates that the analyzer's thermal noise will not be a problem for phase-noise measurements made with the analyzer.

It is also critical when measuring phase noise with any system that the impact of external energy sources be minimized. To minimize external noise effects—especially at the low levels being measured—it may be necessary to enclose the source under test in some form of a shielded enclosure, and to use coaxial cables with high shielding effectiveness (SE) of 100 dB or better to minimize the possibility of the connecting test cables acting as an antenna for external energy sources. The power supply for any test setup should also be properly screened to minimize noise. MWRF

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Move From MICROSTRIP To WIDE SLOTLINE

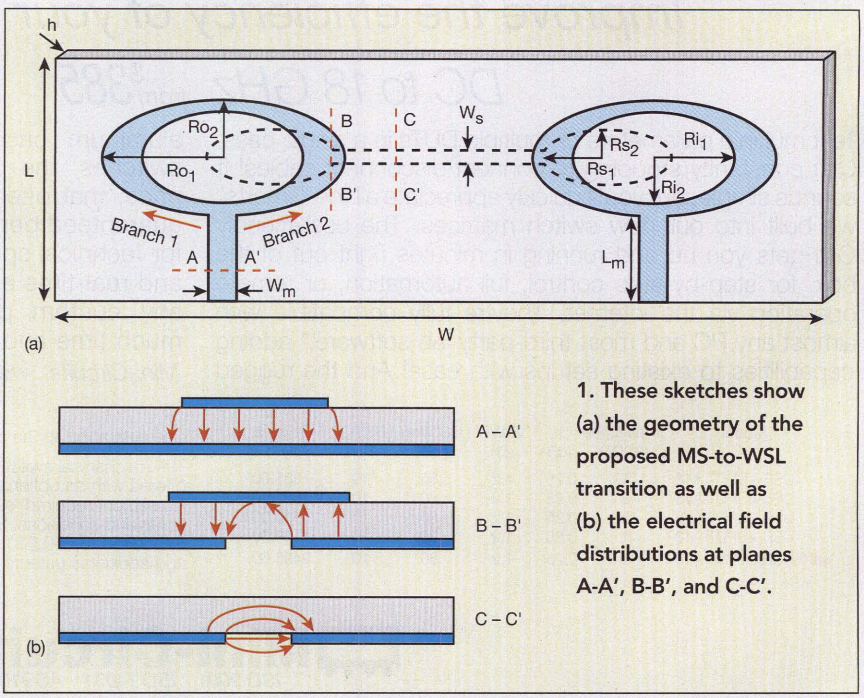
This microstrip-to-wide-slotline transition achieves a smooth shift in impedance between the low- and high-impedance transmission lines while achieving wide bandwidth.

MICROSTRIP IS the most common transmission line in microwave integrated circuits (MICs) and in companion with monolithic-microwave integrated circuits (MMICs). In contrast, wide slotline is not as widely used, but is easy to fabricate and preferable for many MIC and MMIC applications. For those applications employing wide slotline that also use microstrip, a transition is needed between the two transmission-line types.

A number of microstrip-to-slotline transitions have been developed and found useful in both academic and industrial fields.[1-3] But one of the main difficulties is forming these transitions is achieving the match from the low impedance of microstrip to the high impedance of slotline.[4] High-permittivity substrates and narrow slot gaps are often used to suspend the characteristic impedance of slotline, as well as to reduce the impedance difference between microstrip and slotline in forming a transition.[5,6]

Unfortunately, this technique is not always suitable for antenna applications. The high permittivity substrate can degrade an antenna's radiation performance. In addition, fabricating the narrow slot gap is no trivial task. Some researchers have employed multisection impedance transformers to smoothly increase the characteristic impedance of a microstrip transmission line to the higher impedance of a slotline transmission line.[7,8] But when such transformers are used with wide slot antennas, too many sections are required to achieve the desired impedance transition, resulting in a large and bulky design.

Fortunately, a novel transition design has been developed based on a dual branchline configuration. It is capable of achieving a low-loss transition between 50-Ω microstrip and 150-Ω wide-slotline transmission lines across a broad frequency range. The measured results for the back-to-back transition show better than 10-dB return loss and less than 3-dB insertion loss from



1. These sketches show (a) the geometry of the proposed MS-to-WSL transition as well as (b) the electrical field distributions at planes A-A', B-B', and C-C'.

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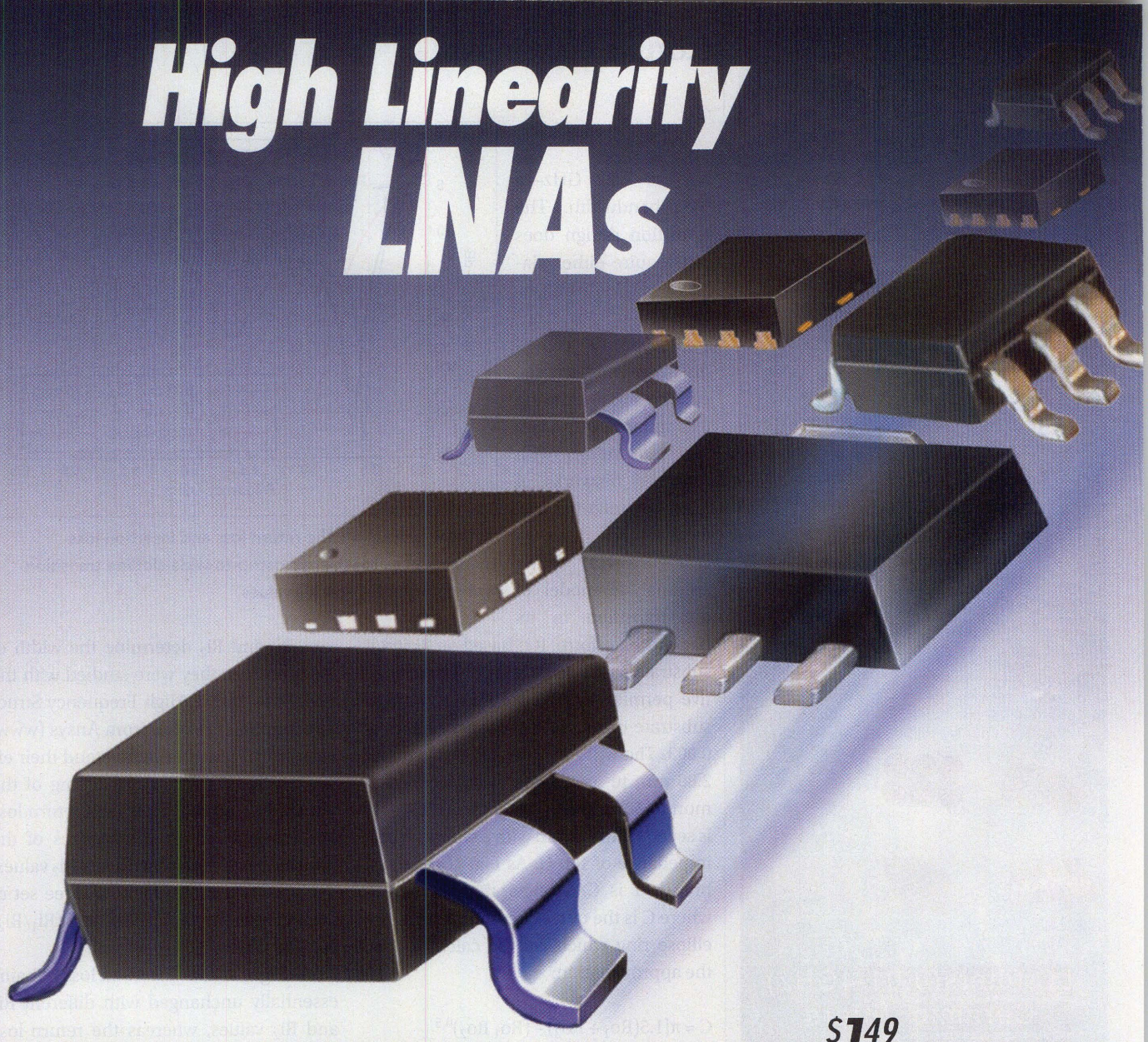

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PMA-5452+	50-6000	14.0	0.7	34	18	40	1.49
PSA4-5043+	50-4000	18.4	0.75	34	19	33 (3V) 58 (5V)	2.50
PMA-5455+	50-6000	14.0	0.8	33	19	40	1.49
PMA-5451+	50-6000	13.7	0.8	31	17	30	1.49
PMA2-252LN+	1500-2500	15-19	0.8	30	18	25-55 (3V) 37-80 (4V)	2.87
PMA-545G3+	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
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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
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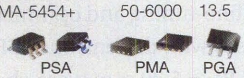

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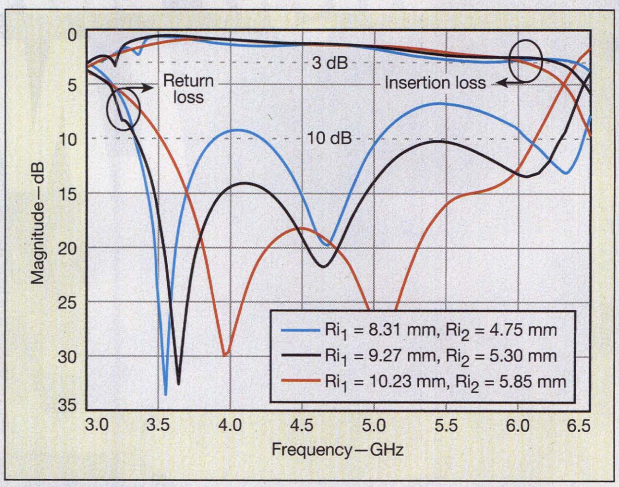
3.20 to 6.22 GHz—a 64% bandwidth. The transition design does not require either via-holes or airbridges. In addition, the transition can be etched on low-permittivity circuit material, making it a suitable candidate for integration with the feed networks of wide slot antennas and arrays.



2. These plots show the return-loss and insertion-loss characteristics for the microstrip-to-wide-slotline transition with different Ri_1 and Ri_2 values.

Figure 1(a) shows an analysis model of the transition in its back-to-back form. It is based on a circuit substrate with thickness, h, of 1 mm, relative permittivity, ε_r, of 2.65, and circuit-substrate dielectric loss tangent, tanδ, of 0.003. The width, W_m, is set to a value of 2.85 mm to match the dimension common to 50-Ω SMA connectors. Width W_s is set equal to 1.5 mm with a characteristic impedance of 150 Ω. As **Fig. 1(a)** shows, branch 1 is C/2 longer than branch 2, where C is the outer circumference of the ellipse ring which can be calculated by the approximation:

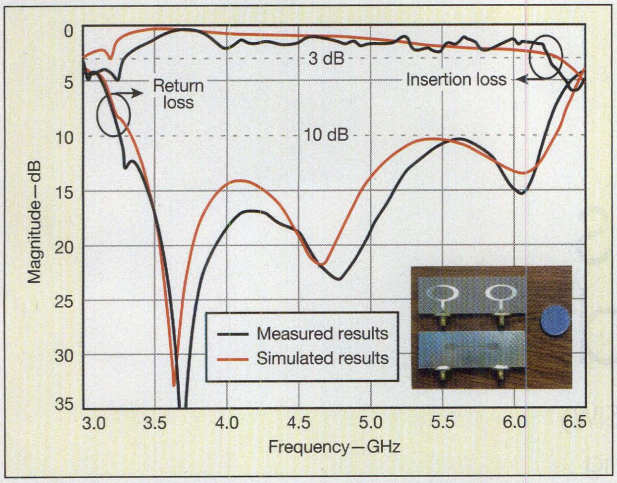
$$C \approx \pi[1.5(Ro_1 + Ro_2) - (Ro_1\, Ro_2)^{0.5}$$

When $C/2 = \lambda_g/2$, where λ_g is the center guided wavelength, a 180-deg. phase difference is achieved between the two branches. **Figure 1(b)** plots the electrical field distributions at planes A-A', B-B', and C-C', respectively (at the center frequency). It is clear that the transition from the microstrip mode (A-A') to the wide-slotline mode (C-C') is mainly realized around plane B-B', where the two branches connect. The out-of-phase signals on the two branches excite in-phase signals on the wide slotline, in the process generating the wide-slotline transmission mode.

In addition to proper electromagnetic (EM) field matching, an effective transmission-line transition should ensure a smooth impedance shift for good wideband performance. Since inner axes Ri_1 and Ri_2 determine the width of the branches, they were studied with the aid of the ANSYS High Frequency Structure Simulator (HFSS) from Ansys (www.ansys.com) to better understand their effect on the impedance matching of the transition. **Figure 2** shows the return loss and insertion loss performances of the transition with different Ri_1 and Ri_2 values. To simplify the comparison, three set of values share the same axial ratio (Ri_1/Ri_2) of 1.75.

As **Fig. 2** shows, insertion loss remains essentially unchanged with different Ri_1 and Ri_2 values, whereas the return-loss performance is sensitive to variations in Ri_1 and Ri_2. The return loss performance is degraded when the dimension of the inner ellipse decreases (correspondingly, with wider branch widths). One explanation for this is that significant reflection, due to mismatching, occurs at the T-junction where the parallel branches connect with the main line. When the dimension of the inner ellipse increases (correspondingly, with narrower branch widths), good impedance matching occurs at the center frequencies although the operating bandwidth tends to narrow. This is because the high quality-factor (Q) value in this case leads to a naturally narrower bandwidth.

After fine-tuning and optimization, inner ellipses with dimensions of $Ri_1 = 9.27$ mm and $Ri_2 = 5.30$ mm were chosen as a compromise to achieve both acceptable impedance matching and relative wide-



3. These plots compare the simulated and measured return and insertion losses for the microstrip-to-wide-slotline transition.

band operation. In addition, the dimensions of the stub slots Rs_1 and Rs_2 were set to values of 6 and 3 mm, respectively, to better cancel the discontinuous effects of the wide slotline short end.

To evaluate the transmission-line transition concept, a prototype transition was fabricated on F4BK265 woven-glass PTFE substrate with relative permittivity of 2.65. The two-port transition was fed by means of 50-Ω SMA connectors. The prototype transition was evaluated by means of a commercial vector network analyzer (VNA), a Wiltron model 37296A (now available from Anritsu Co.; www.anritsu.com). Measured results show better than 10-dB return loss and less than 3-dB insertion loss across the operating bandwidth, which was 3.20 to 6.22 GHz, or a 64% bandwidth.

Figure 3 compares the simulated and measured return-loss and insertion-loss performance levels for the transition. The jitter behavior of the measured insertion-loss curve might be attributed to irregular soldering. A frequency-offset of about 100 MHz cab also be observed between the simulated and measured return-loss curves. This is possibly due to the inappropriate quality of the microwave substrate. Otherwise, the measurements agree fairly closely with the computer simulations, validating the design concept for the microstrip-to-wide-slotline transition.

In summary, an effective microstrip-to-wide-slotline transition has been presented here. Elliptical ring-shaped branches and elliptical wide-slotline end stubs were employed; dimensions were optimized to ensure a smooth field transition and impedance transition between 50-Ω microstrip and 150-Ω wide slotline. The measured results for the transition show that it can support operation from 3.20 to 6.22 GHz, a relative bandwidth of 64%. The transition was printed on a low-permittivity circuit substrate, making it a suitable candidate for integration with the feed networks of wide slot antennas and arrays. MWRF

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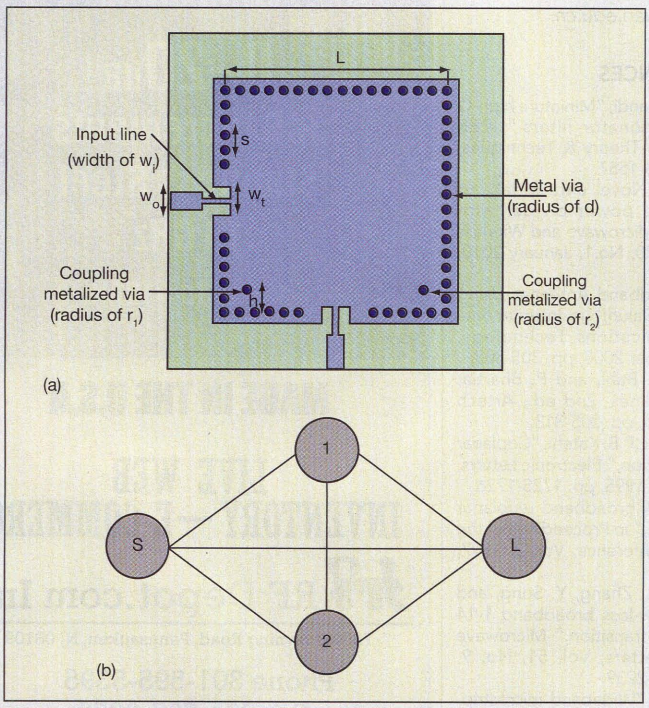
Faculty Member

SIW Filter Screens Narrow Bandwidth

This dual-mode, substrate-integrated-waveguide (SIW) filter offers an asymmetric response and outstanding return loss at a center frequency of 11.3 GHz.

FILTERS EMPLOYING substrate-integrated-waveguide (SIW) technology can achieve high selectivity with low passband insertion loss. By way of demonstration, a narrowband, second-order, dual-mode SIW filter was designed for use at 11.3 GHz. Following computer software simulations, the filter was fabricated and found to have high rejection and low passband insertion loss around the center frequency. The filter includes a square SIW cavity, two coupling metalized vias (CMVs), and input/output microstrip lines. Two CMVs in the corner of the cavity provide coupling between degenerate modes.

Pseudo-elliptic filters with finite transmission zeros are not new, but have been widely studied in the literature.[1-3] The main challenge in developing these pseudo-elliptic filters is to achieve an asymmetric response.[2,3] Dual-mode filters that support cross-coupled network can be designed to satisfy the asymmetric response.



1. The physical configuration of the SIW filter (a) is shown next to (b) the basic filter topology.

Filters based on SIW technology are useful in microwave integrated circuits (MICs), for a wide range of applications in communications, for suppressing unwanted responses and interference. Learning to implement SIW technology on MIC printed-circuit boards can be instructive, as well as add a great deal of value to both active and passive microwave circuits.

For example, SIW technology has been widely used for a number of different types of microwave filters.[4-9] To demonstrate the use of the technology, a narrowband dual-mode second-order filter based on SIW technology with an asymmetric response was designed and fabricated. The filter employs two CMVs for coupling between degenerate modes. The filter achieves two right-handed transmission zeros as a result of source-load coupling and the CMV position.

The configuration of the proposed dual-mode SIW filter is shown in **Fig. 1(a)**. The filter is constructed by a square SIW cavity, input and output microstrip lines, and two CMVs. The two CMVs perturb the electromagnetic (EM) fields and produce an orthogonal mode.

To design a dual-mode filter, a lowpass prototype of the cross-coupled network is first developed, based on the filter topology. In the case of the current filter design, the configuration is a second-order, cross-coupled filter with source load topology as shown in **Fig. 1(b)**. This type of filter topology is capable of providing an asymmetric pseudo-elliptic response. Circuit synthesis can be used to derive the values of the coupling coefficients between the resonators. Synthesis of such cross-coupled filters with an asymmetric response has been determined previously, as noted in the literature.[3] Using filter synthesis and considering the filter topology, the generalized coupling matrices that are obtained are shown by Eq. 1:

$$M = \begin{pmatrix} 0 & M_{S1} & M_{S2} & M_{SL} \\ M_{S1} & 0 & M_{12} & M_{1L} \\ M_{S2} & M_{12} & 0 & M_{2L} \\ M_{SL} & M_{1L} & M_{2L} & 0 \end{pmatrix} \quad (1)$$

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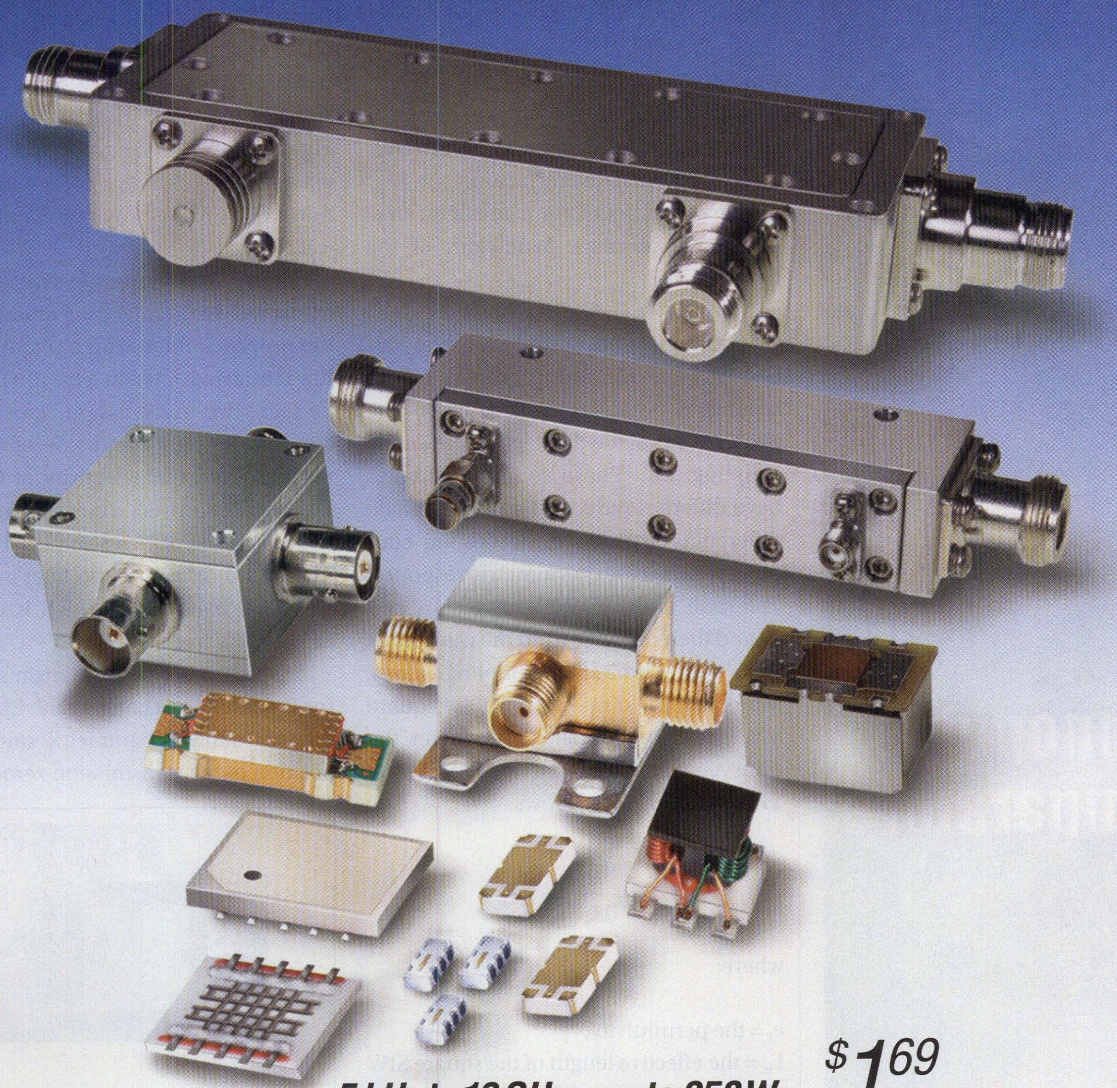

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U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

495 rev A

Denormalization of the coupling coefficients can be performed through the application of the following formulas:[3]

$$k_{ij} = \frac{BW \cdot M_{ij}}{f_0} \quad and \quad Q_e = \frac{f_r}{BW \cdot M_{S1}^2} \qquad (2)$$

where:

k_{ij} = the normalized coupling coefficient;
Q_e = the external quality factor;
f_r = the center frequency of the filter; and
BW = the absolute bandwidth of the filter.

The input and output coupling values, M_{s1} and M_{l2}, are produced by the input and output microstrip lines. The two CMVs provide the degenerate-mode coupling, M_{l2}. These coupling viaholes have different radii with a 90-deg. angle difference to produce the desired coupling values for an asymmetric response. The radii of the CMVs—namely, r_1 and r_2, and their distance from the waveguide wall, h—determine the coupling values. Moreover, the dimensions of the square SIW cavity are obtained based on the transverse electromagnetic (TE) modes, TE_{201} and TE_{102}, as follows:

$$f_r = \frac{\sqrt{5}c_0}{2L_e\sqrt{\varepsilon_r}} \qquad (3)$$

where:

e_r = the permittivity;
L_e = the effective length of the square SIW cavity; and
c_0 = the speed of light in a vacuum.

The value of L_e can be obtained from Eq. 4[5]:

$$L_e = L - \frac{d^2}{0.95S} \qquad (4)$$

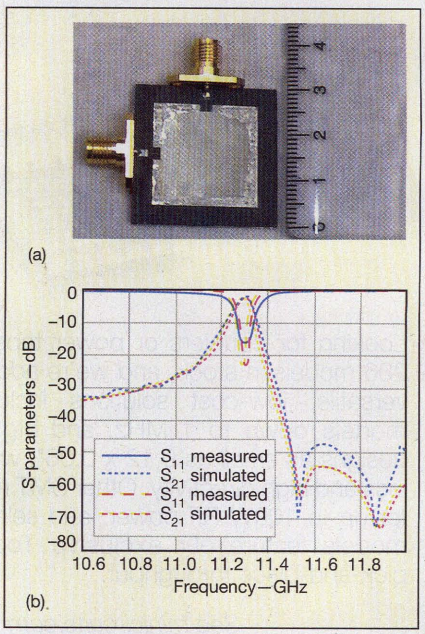
where:

d = diameter of the metalized viaholes;
L = the length of the square cavity; and
S = the center-to-center distance between the two adjacent metalized viaholes, as shown in **Fig. 1(a)**.

To demonstrate the effectiveness of this design approach, the proposed dual-model SIW filter was designed using the coupling matrices. It was fabricated on RT/duroid® 5880 circuit material from Rogers Corp. (www.rogerscorp.com) with relative permittivity of 2.2 and substrate width of 0.508 mm. The overall dimensions of the filter, with layout shown in **Fig. 1(a)**, are: L = 20 mm, h = 2 mm, r_1 = 0.3 mm, r_2 = 0.4 mm, S = 1.3 mm, d = 0.4 mm, W_0 = 1.55 mm, W_i = 0.15 mm, and W_t = 1.255 mm.

Figure 2(a) shows the simulated and measured scattering (S) parameters for the proposed filter, with a photograph of the fabricated filter in **Fig. 2(b)**. As can be seen, two transmission zeros are created on the right-hand side of the filter response and the selectivity of the filter has been improved. The fabricated filter has return loss of 15 dB and insertion loss of only 1.8 dB across the filter's 40-MHz passband bandwidth, which is centered at 11.3 GHz.

Displacement of the transmission zeros is possible by changing the CMV radii. **Figure 3** shows a parametric study of the position of the transmission zeros for dif-



2. The photograph (a) shows the SIW filter fabricated on commercial circuit-board material, while the S-parameters show measured and simulated S_{11} and S_{21} responses.

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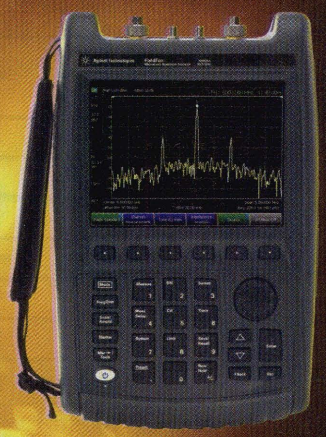

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ferent values of CMV radii. **Figure 3(a)** shows the effects of having the radius of the smaller CMV at a fixed value and the radius of the larger CMV varied.

When the difference between the two CMV radii increases, the spacing between the two transmission zeros increases. **Figure 4** shows the group delay for the proposed SIW filter. As is apparent from the response curve, the in-band group-delay variation is less than 4 ns for the SIW filter.

In summary, the proposed second-order, dual-mode SIW filter uses two right-hand transmission zeros to achieve high selectivity. By adjusting the radii of the two CMVs, it is possible to change the position of the two transmission zeros in the filter's out-of-band response. Comparisons of simulated and measured responses for this experimental filter agree closely, showing that the design is well behaved and predictable. MWRF

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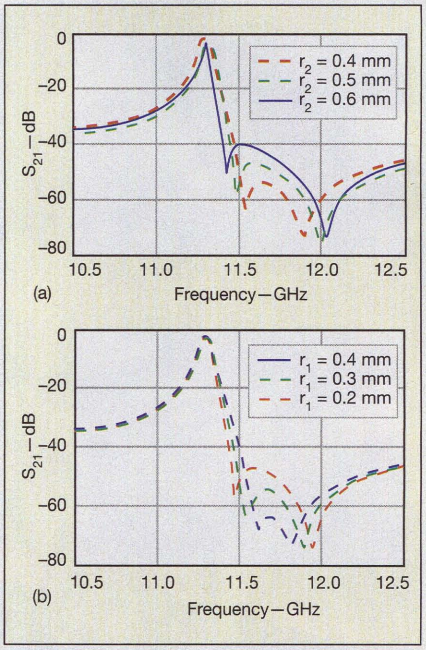
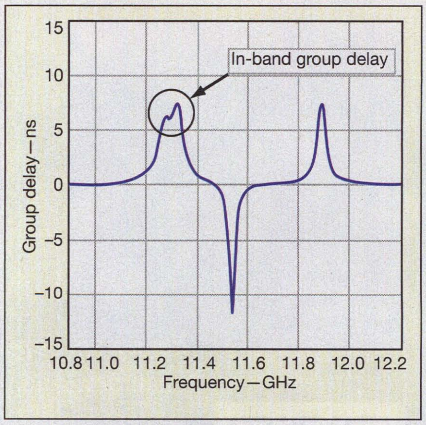


3. The simulated S_{21} responses were generated for different values of CMV radius.



4. The group delay shows very little variation within the SIW filter's passband.

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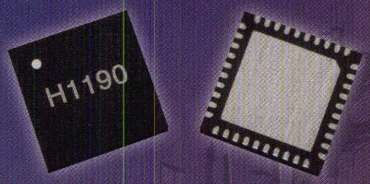

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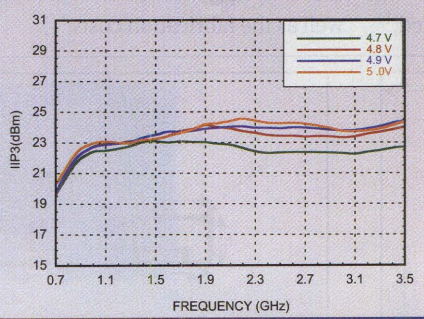

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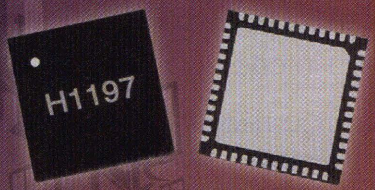

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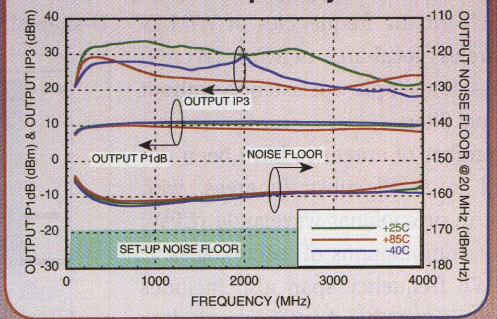

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	Frequency (GHz)	Function	Output IP3 (dBm)	Output P1dB (dBm)	Output Noise Floor (dBc/Hz)	PLL FOM (dBc/Hz) (Int./Frac.)	Package	ECCN Code	Part Number
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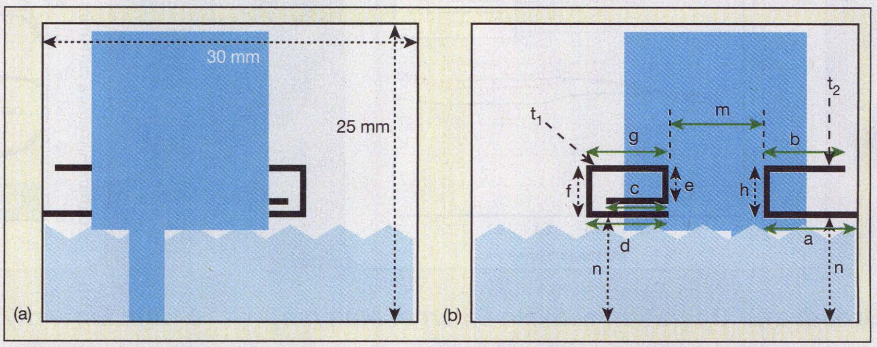
UWB Antenna Adds Two Notches

This compact antenna provides full coverage of the UWB range from 3.1 to 10.6 GHz while including a pair of notches to minimize interference with WiMAX and WLAN signals.

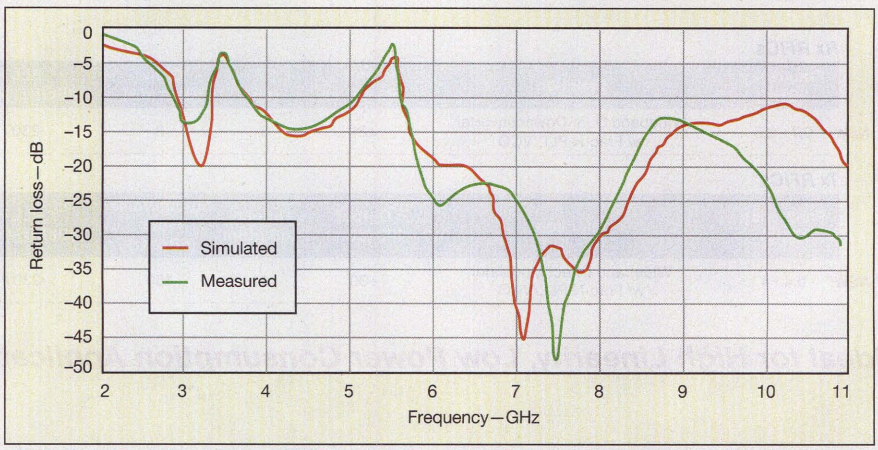
COMPACT ANTENNAS are needed for unlicensed ultrawideband (UWB) applications from 3.1 to 10.6 GHz. For efficient and effective operation with other signals within that band, an UWB antenna has been developed with two frequency notches—one each for the frequencies of WiMAX and wireless-local-area-network (WLAN) systems—for simple coexistence without additional filters.

A number of antennas have been developed in small substrate areas, with microstrip or coplanar-waveguide (CPW) feeds or combinations of technologies.[1-4] The UWB frequency span also includes numerous narrowband services, including WiMAX and wireless local area networks (WLANs), which may interfere with UWB operator (or it with them). Such interference can be suppressed by using a spatial filter—such as a frequency-selective surface—above the UWB antenna, although this adds to the cost and complexity.[5] Another approach is through the use of an antenna capable of filtering WiMAX signals from 3.3 to 3.8 GHz and WLAN signals from 5.150 to 5.825 GHz.

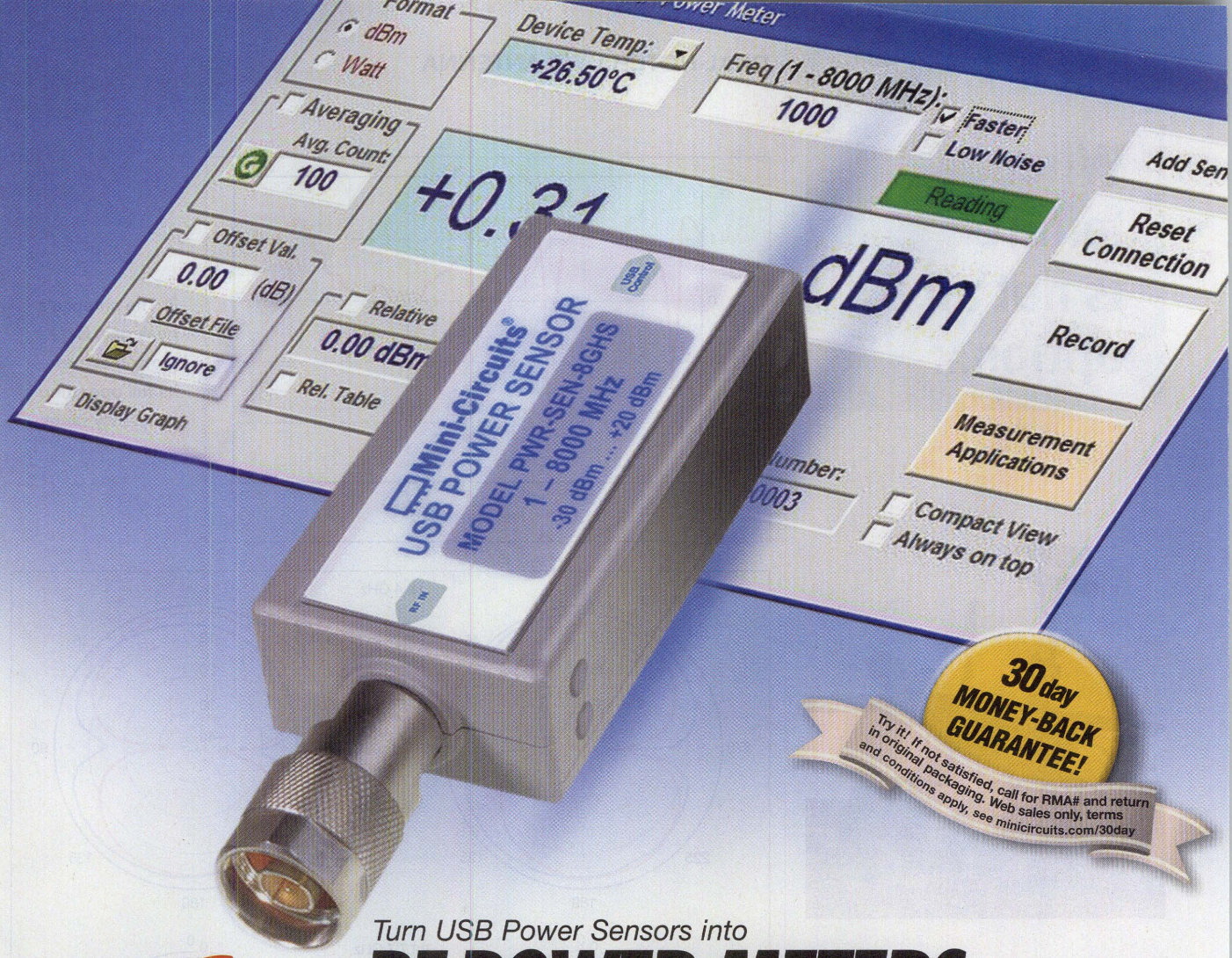
Band-notched antennas can be designed in various ways, including by using an isolated slit inside a patch, two open-end slits at the top edge of a T-stub, two parasitic strips,[6] an embedded semicircular annular parasitic strip,[7] and a semicircular slot inside an elliptical slot.[8] The antenna structure proposed by Lin and Hung[6] is simple, featuring compact aperture size. But while it achieves a broad impedance bandwidth with stable radiation patterns, it requires a large ground plane. Moreover, each of these design approaches can notch only one frequency band. Other ways to design band-notched antennas include by embedding various thin slots on the antenna surface, including U-shaped,[9] L-shaped,[10] square-shaped,[11] pi-shaped,[12] T-shaped,[13] fractal,[14] annular, and H-shaped slots.[15] It can also be accomplished by adding either a split-ring resonator (SRR)[16] or by using a multiresonator load in the antenna structure.[17] Unfortunately, all of these approaches add to the complexity of the antenna structure, as well as the fabrication costs.



1. These diagrams show the geometry of the dual-notched antenna: (a) top view and (b) bottom view.



2. These plots compare the simulated and measured return loss for the dual-notched UWB antenna.



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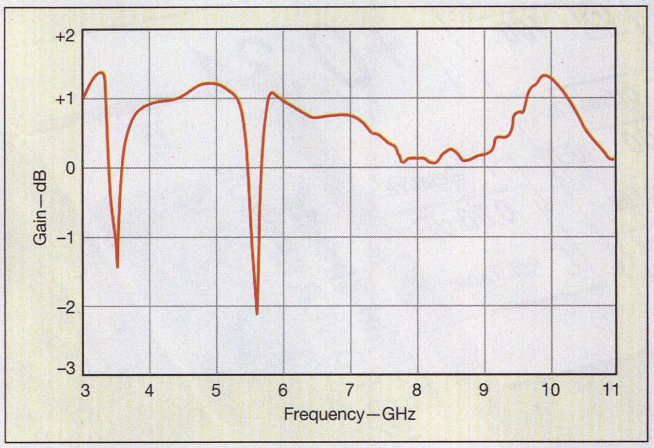
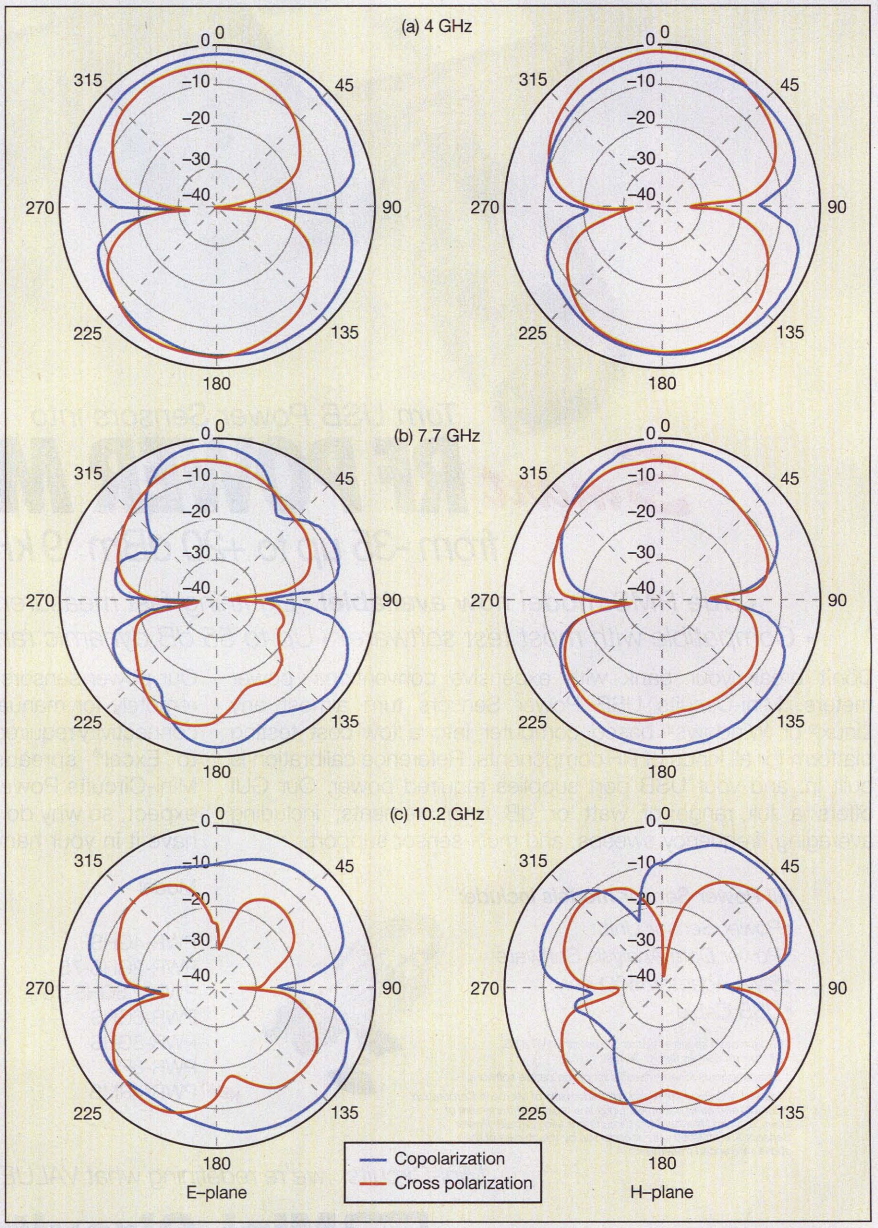
DUAL-NOTCH UWB ANTENNA



3. The antenna's peak gain is plotted across its full operating-frequency range.



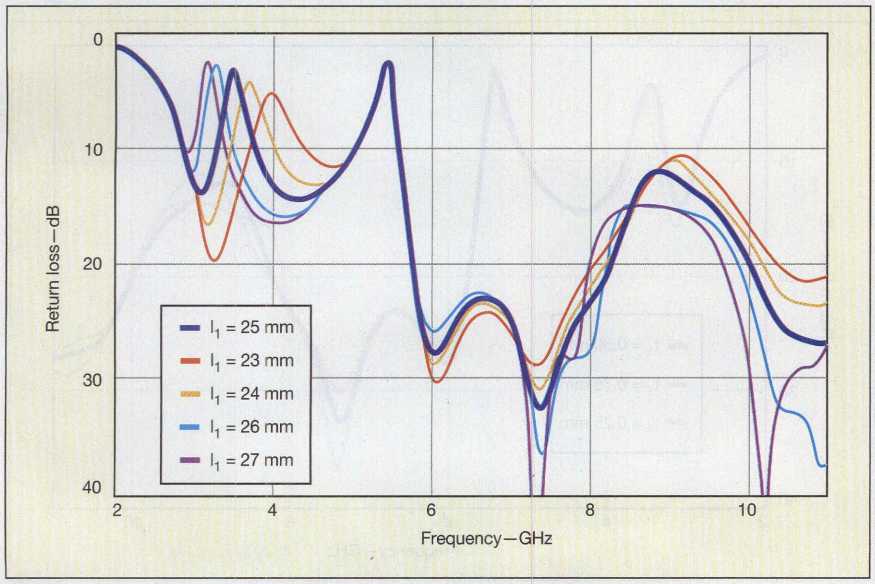
4. These plots show the E- and H-plane responses of the antenna at (a) 4.0 GHz, (b) 7.7 GHz, and (c) 10.2 GHz.

The proposed compact planar UWB antenna is a possible solution. For improved bandwidth, the top edge of its partial ground plane is modified by introducing triangular shape slots to form a symmetrical sawtooth shape.[18-19] The dual band-notched characteristics are achieved by inserting one e-shaped parasitic element and one c-shaped parasitic element on the back side of the patch. The antenna has a simpler design than the other approaches and can be fabricated on low-cost FR4 circuit-board substrate.

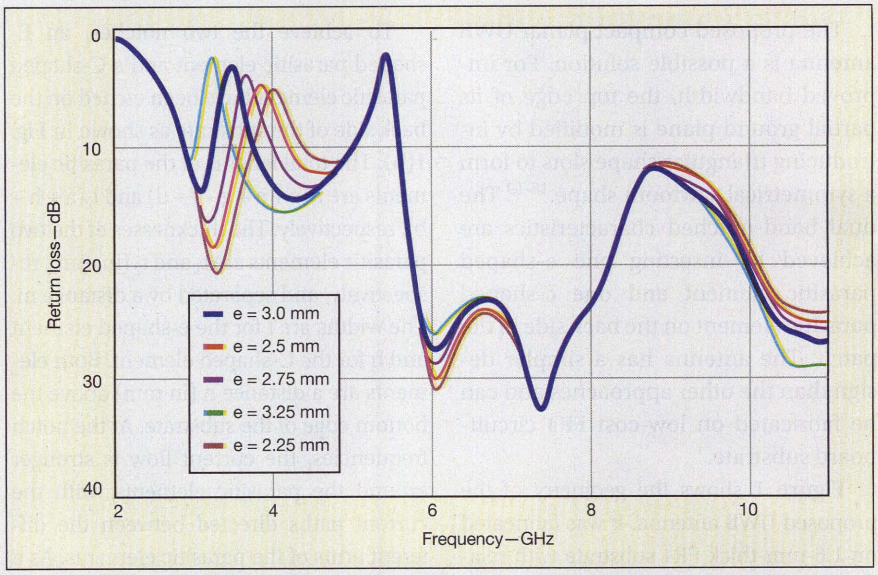
Figure 1 shows the geometry of the proposed UWB antenna. It was fabricated on 1.6-mm-thick FR4 substrate with relative permittivity of 4.6 and loss tangent of 0.02. The antenna consists of a rectangular radiating patch measuring 14.5 x 14.75 mm and a partial ground plane. The partial ground plane is modified by cutting slots on its top edge to form a symmetrical sawtooth shape to enhance the impedance bandwidth. The radiating patch and a microstrip feed line are printed on the front side of a 30 x 25 mm FR4 substrate, while the modified ground plane is printed on the back side. The length and width of the feed line are fixed at 7.25 and 3.0 mm, respectively, to achieve a 50-Ω characteristic impedance. The feed line is terminated in an SMA connector.

To achieve the two notches, an E-shaped parasitic element and a C-shaped parasitic element have been etched on the back side of the substrate as shown in **Fig. 1(b)**. The total lengths of the parasitic elements are l_1(c + e + g + f + d) and l_2(a + h + b), respectively. The thicknesses of the two parasitic elements are t_1 and t_2 (in mm), respectively, and separated by a distance m. The widths are f for the e-shaped element and h for the C-shaped element. Both elements are a distance n (in mm) above the bottom edge of the substrate. At the notch frequencies, the current flow is stronger around the parasitic elements, with the current paths directed between the different arms of the parasitic elements. As a result, the radiating fields cancel at these frequencies and the antennas do not radiate in these frequency ranges, producing the two notches.

The performance of the UWB antenna was simulated with the IE3D full-wave electromagnetic (EM) simulator from Zeland (www.zeland.com). The final design was optimized with the following parameters: a = 7.5 mm, b = 6.5 mm, c = 5 mm, d = 6.5 mm, e = 3 mm, f = 4 mm, g = 6.5 mm, h = 4 mm, $t_1 = t_2 = 0.5$ mm, and n = 14 mm. For experimental verification, a prototype was fabricated on FR4 and characterized on a model E8362C vector network analyzer (VNA) from Agilent Technologies (www.



5. These curves show simulated return loss for different values of l_1.

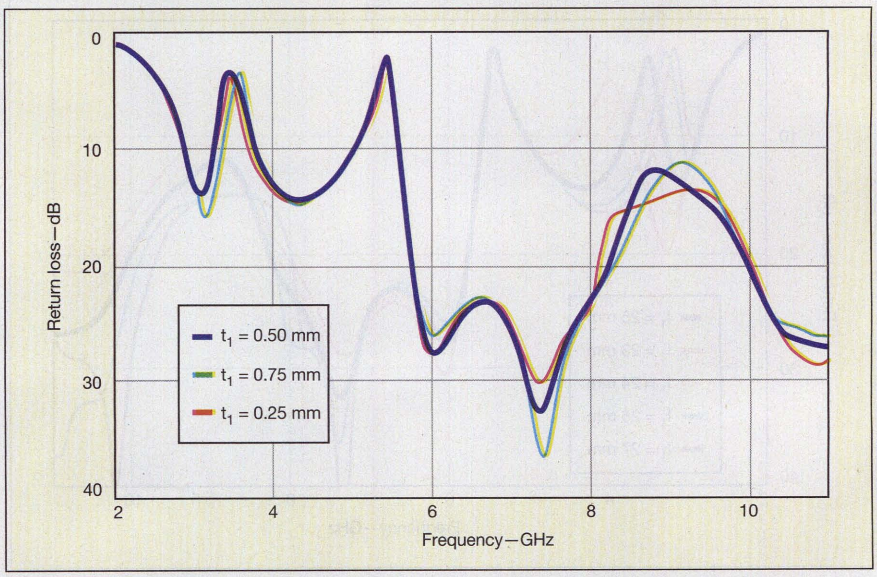


6. These curves show simulated return loss for different values of e.

agilent.com). **Figure 2** shows good agreement between simulated and measured results. The measured impedance bandwidth extends from 2.87 GHz to beyond 11 GHz, with better than 10-dB return loss.

The antenna exhibits two notched bands of 3.3 to 3.8 GHz and 5.1 to 5.6 GHz, covering WiMAX and the lower WLAN bands, respectively. In spite of its small size, the antenna covers the full UWB frequency range defined by the United States' Federal Communications Commission (FCC), with dual-notched bands to minimize interference with WiMAX and WLAN systems. Disparities between measured and simulated results are attributed to manufacturing tolerances and less-than-ideal soldering of the SMA connector on the feed line. Some of these disparities may also be due to the effects of the feed cable used in the measurements, but not included in the simulations.

Figure 3 shows maximum antenna gain across the full operating band; the gain drops dramatically at both notched bands. However, the gain also decreases slightly from 8 to 9 GHz, because of the poor impedance match in that band. In spite of the high loss tangent (0.02) of the FR4 substrate, the antenna exhibits good



7. These curves show simulated return loss for different values of t_1.

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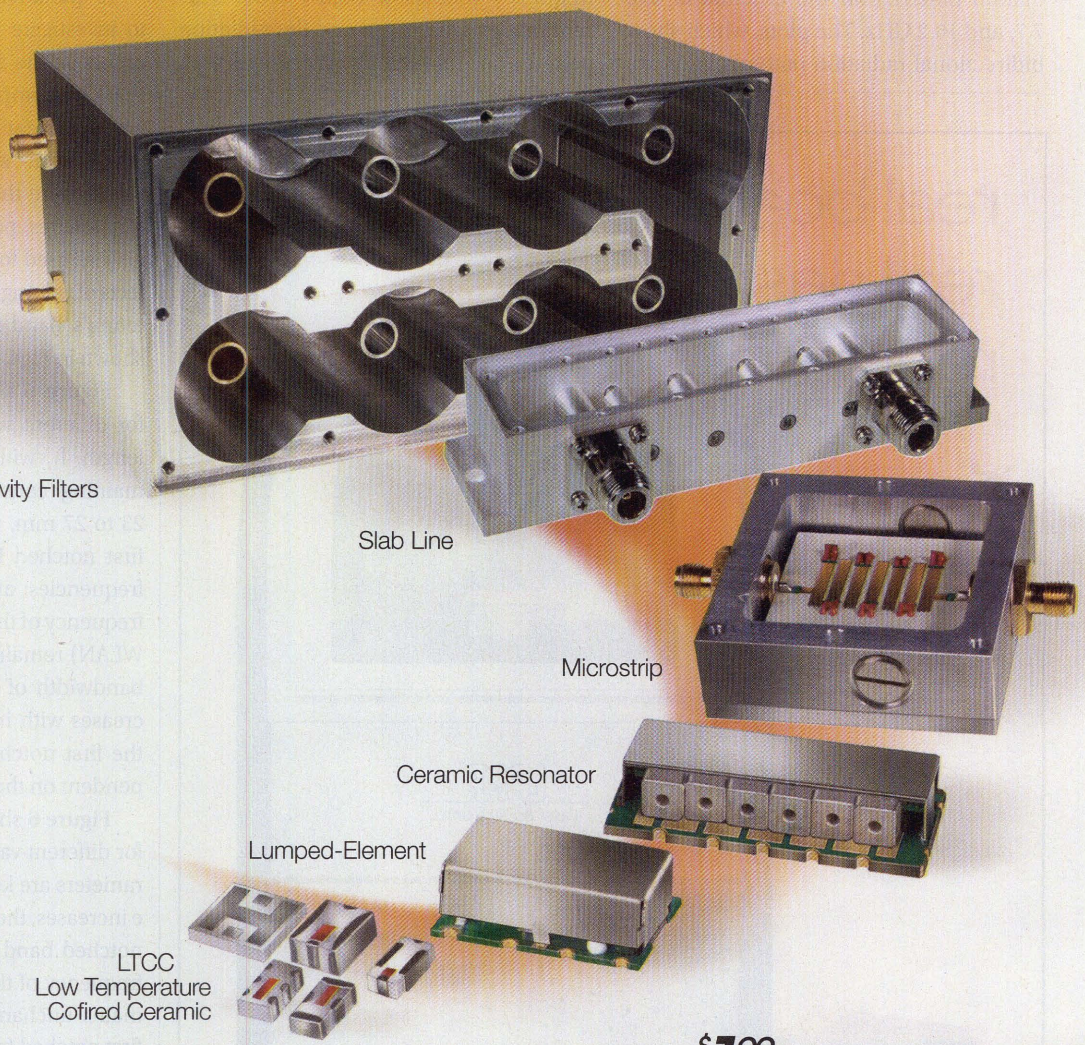

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gain, with less than 1-dB variation across the UWB frequency range (except for the two notched bands).

Figure 4 provides E-and H-plane radiation patterns for the antenna at 4.0, 7.7, and 10.2 GHz. The plots, which show bidirectional radiation patterns, indicate that the antenna has a main beam in the broadside direction. At lower frequencies, the E- and H-plane patterns are about the same as a monopole. As the frequency increases, higher-order current modes are excited and the radiation patterns become slightly directional, with the main-beam tilt away from the broadside direction. Still, the antenna exhibits stable radiation patterns over the operating frequency range.

A parametric study was performed to investigate the effects of parasitic elements on the antenna's dual notches, and IE3D was employed as part of the design and optimization process for the antenna. Since the E- and C-shaped parasitic elements were the main factors in achieving the notches, parameters l_1, e, t_1, l_2, h, and t_2 were used for a sensitivity study. The effects of varying these parameters on the antenna's band-notched characteristics are shown in **Figs. 5 through 10**, respectively.

Figure 5 shows simulated return loss for different values of E-shaped element length, l_1, with the other parameters remaining constant. As l_1 increases from 23 to 27 mm, the center frequency of the first notched band shifts towards higher frequencies; at the same time, the center frequency of the second notched band (for WLAN) remains constant at 5.5 GHz. The bandwidth of the first notched band decreases with increasing l_1, indicating that the first notch bandwidth is strongly dependent on the value of l_1.

Figure 6 shows simulated return losses for different values of e while the other parameters are kept constant. As the value of e increases, the center frequency of the first notched band decreases while the center frequency of the second notched band remains unchanged. The bandwidth of the first notched frequency band is strongly affected by e and decreases with increasing e.

Figure 7 shows that changes in t_1 have little effect on the first notched band and no effect on the second notched band. From these results, it can be concluded that the e-shaped parasitic element affects the first notch band but not the second notched band. In addition, the center frequency and bandwidth of the first notched band are adjusted mainly through the selection of values for l_1 and e.

Figure 8 shows simulated return-loss curve for different values of l_2, the total length of the c-shaped parasitic element. As l_2 increases from 16 to 20 mm, the center frequency of the second (WLAN) notched

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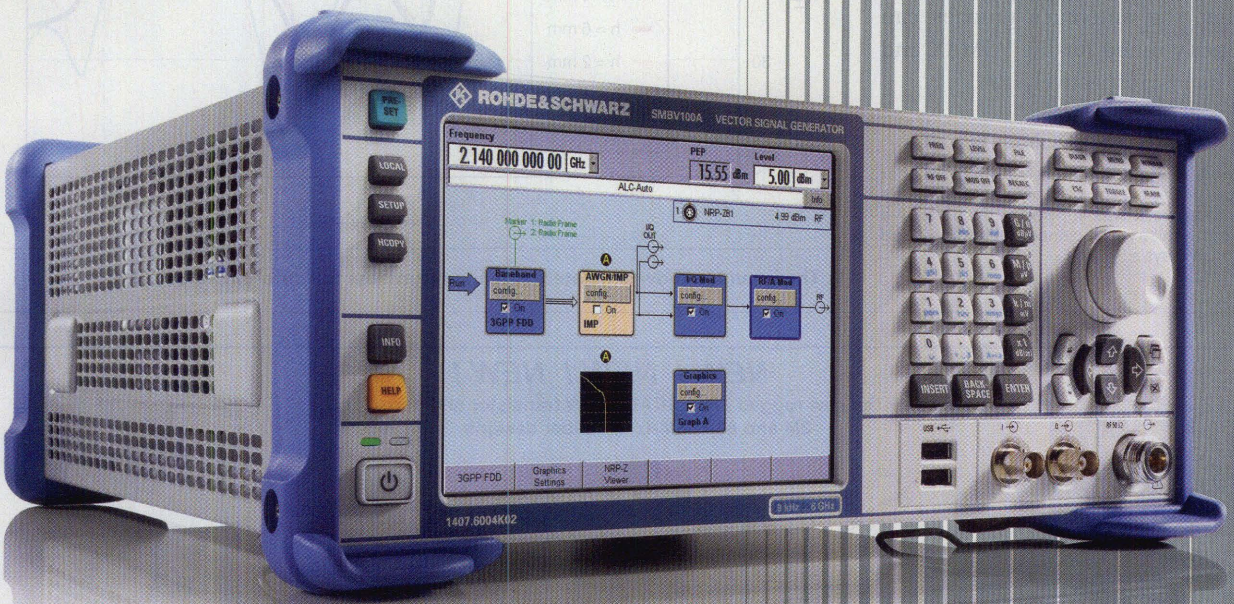

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band shifts from 6.2 to 4.9 GHz. The bandwidth of the second notched band also decreases with decreasing l_2, while the bandwidth of the first notch band remains unchanged.

Figure 9 shows simulated antenna return loss for different values of h. For h = 2, 3, 4, 5, and 6 mm, and other dimensions fixed at optimum values, the center frequency of the second notched band moves toward lower frequencies. Changes in h have no effect on the first notched band. **Figure 10** shows that the center frequency and bandwidth of the second notched band increases with increasing value of t_2, although changes in t_2 have no impact on the first notched band. From **Figs. 5 through 10**, it can be concluded that the antenna's first notched band (for WiMAX) is controlled by the E-shaped parasitic element, even though that element has no effect on the second notched band. And the second notched band is controlled by the C-shaped parasitic element, which has no influence on the first notched band. By carefully adjusting both parasitic elements, the antenna's notches can be properly tuned for the WiMAX and WLAN bands, respectively. MWRF

ACKNOWLEDGMENT

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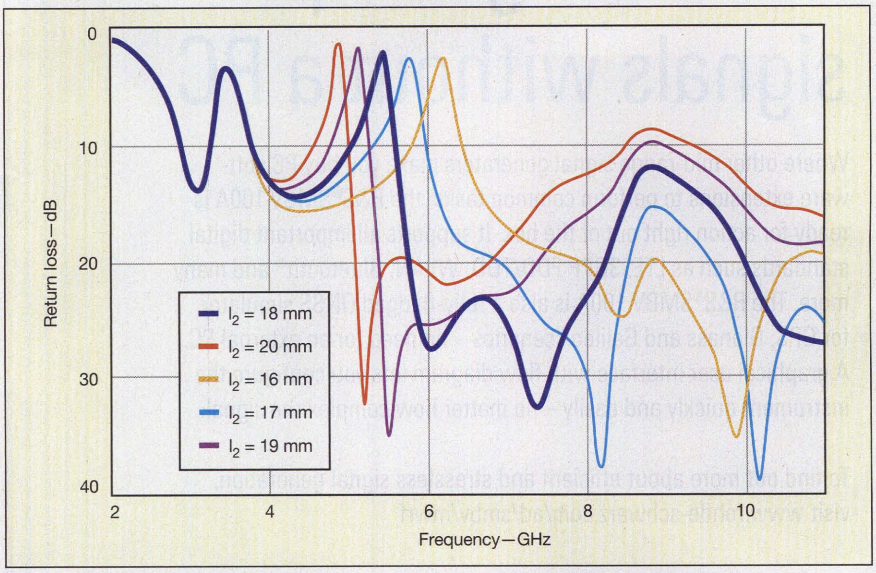
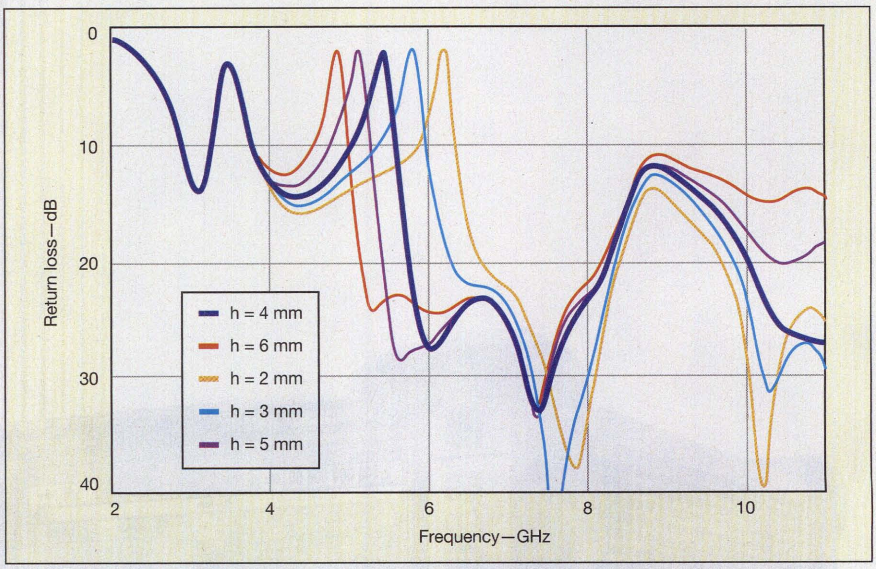
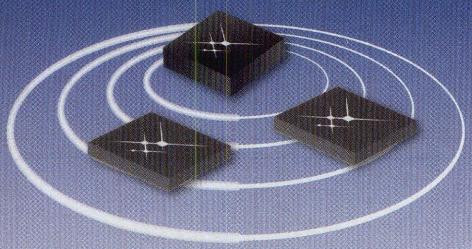


8. These curves show simulated antenna return loss for different values of l_2.



9. These curves show simulated antenna return loss for different values of h.



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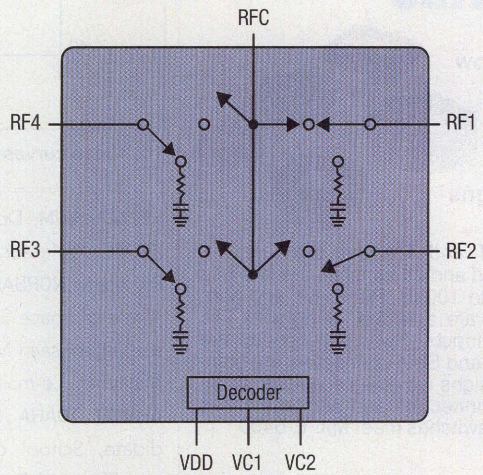

SKY13392-359LF Functional Block Diagram

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

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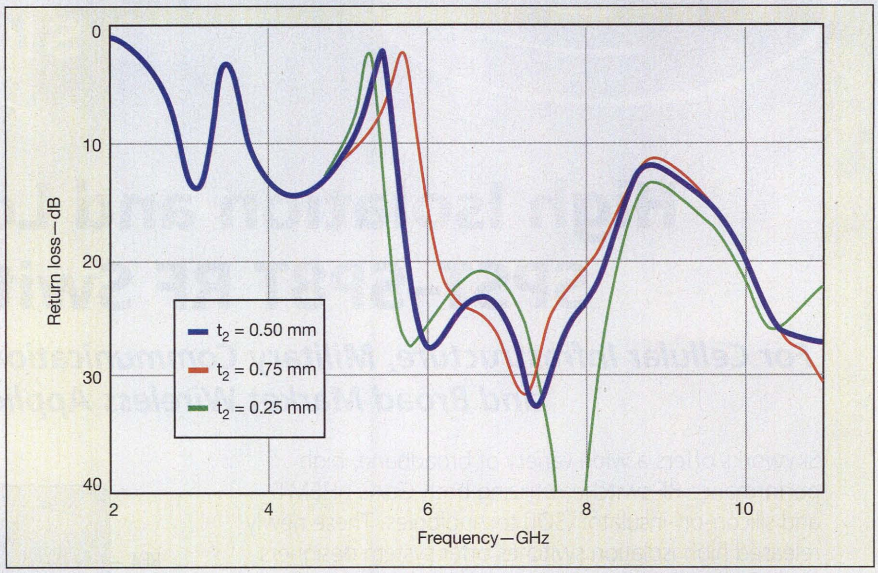

10. These curves show simulated antenna return loss for different values of t_2.

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DCO50100-5	500 - 1000	0.5 - 15	+5 @ 34 mA	-100	0.3 x 0.3 x 0.08
DCO6080-3	600 - 800	0 - 3	+3 @ 15 mA	-105	0.3 x 0.3 x 0.08
DCO7075-3	700 - 750	0.5 - 3	+3 @ 12 mA	-108	0.3 x 0.3 x 0.08
DCO80100-5	800 - 1000	0.5 - 8	+5 @ 26 mA	-111	0.3 x 0.3 x 0.08
DCO8190-5	810 - 900	0.5 - 16	+5 @ 34 mA	-118	0.3 x 0.3 x 0.08
DCO100200-5	1000 - 2000	0.5 - 24	+5 @ 36 mA	-95	0.3 x 0.3 x 0.08
DCO1198-8	1195 - 1205	0.5 - 8	+8 @ 30 mA	-115	0.3 x 0.3 x 0.08
DCO170340-5	1700 - 3400	0.5 - 24	+5 @ 29 mA	-90	0.3 x 0.3 x 0.08
DCO200400-5 DCO200400-3	2000 - 4000	0.5 - 18	+5 @ 46 mA +3 @ 46 mA	-90 -89	0.3 x 0.3 x 0.08
DCO300600-5 DCO300600-3	3000 - 6000	0.5 - 18	+5 @ 35 mA +3 @ 35 mA	-80 -78	0.3 x 0.3 x 0.08
DCO400800-5 DCO400800-3	4000 - 8000	0.5 - 18	+5 @ 20 mA +3 @ 20 mA	-78 -76	0.3 x 0.3 x 0.08
DCO432493-5 DCO432493-3	4325 - 4950	0.5 - 11	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 0.08
DCO450900-5 DCO450900-3	4500 - 9000	0.5 - 18	+5 @ 20 mA +3 @ 20 mA	-76 -74	0.3 x 0.3 x 0.08
DCO473542-5 DCO473542-3	4730 - 5420	0.5 - 22	+5 @ 20 mA +3 @ 20 mA	-88 -86	0.3 x 0.3 x 0.08
DCO490517-5 DCO490517-3	4900 - 5175	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 0.08
DCO495550-5 DCO495550-3	4950 - 5500	0.5 - 12	+5 @ 22 mA +3 @ 22 mA	-83 -85	0.3 x 0.3 x 0.08
DCO5001000-5 DCO5001000-3	5000 - 10000	0.5 - 18	+5 @ 20 mA +3 @ 20 mA	-75 -73	0.3 x 0.3 x 0.08
DCO579582-5	5780 - 5880	0.5 - 10	+5 @ 20 mA	-90	0.3 x 0.3 x 0.08
DCO608634-5 DCO608634-3	6080 - 6340	0.5 - 5	+5 @ 20 mA +3 @ 26 mA	-85 -86	0.3 x 0.3 x 0.08
DCO615712-5 DCO615712-3	6150 - 7120	0.5 - 18	+5 @ 22 mA +3 @ 22 mA	-85 -83	0.3 x 0.3 x 0.08

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

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By minimizing the interference generated by embedded clock oscillators at the source, Yen explains that it is possible to reduce the requirements for post-EMI-generation suppression, such as EMI filters, chokes, and ferrite beads. The key is spread-spectrum technology (SST), which spreads source energy over a broader bandwidth and controlled frequency range (for example, center frequency of ±1%) with a controlled modulation rate. With this approach, the total source energy remains the same. The peak energy, however, has been spread out to nearby frequencies.

Spread-spectrum clock oscillators take advantage of the SST to provide low-EMI frequency sources. In discussing the benefits of these oscillators—and spread-spectrum techniques in general—the note compares center and down spread. It also defines the modulation carrier frequency. The document notes that higher-order harmonic frequencies achieve higher EMI reduction. In addition, the greater modulation percentage more greatly reduces EMI emissions. In addition to all of the harmonics, the fundamental frequency will benefit from reduced EMI reduction with the use of an SST.

Mercury United Electronics, Inc., 9299 9th St., Rancho Cucamonga, CA 91730; 886-2-2406-2779, www.mercury-crystal.com.

UE TESTING EASES TRANSITION TO VoLTE

INSTEAD OF SIMPLY adopting Long Term Evolution's (LTE's) Internet Protocol (IP) -based core infrastructure to totally replace their second- and third-generation (2G and 3G) networks, mobile operators are migrating gradually. Until Voice over LTE (VoLTE) is widely available, a solution must therefore enable LTE to work with existing 2G/3G voice services. Depending on their legacy network environment, operators can leverage options like Circuit Switched Fall Back (CSFB), Simultaneous Voice and LTE Data (SV-LTE), and Single Radio Voice Call Continuity (SRVCC). This Band-Aid approach will present many challenges for developers, who must now create a range of different and more complex LTE user equipment (UE). In a five-page application note, Agilent Technologies stresses that the accurate and efficient voice testing of LTE UE will be needed to ensure that VoLTE delivers a high standard of voice calls.

Titled "Enabling Fast, Accurate, and Efficient Testing of Voice Quality in LTE User Equipment," the application note explains that test requirements for such devices are numerous—whether they are being tested by Perceived Evaluation of Speech Quality (PESQ) or a Perceptual Objective Listening Quality Assessment (POLQA). Testing can be performed using the following: audio analysis; signaling test (including connections to servers, conformance testing, radio aspects, and handovers for fallback support); battery-drain analysis; and SMS/video-call testing. In addition, operator-specific test plans and field testing also may be required.

Depending on the type of test, the form of UE testing also varies. Designers, for example, will perform benchtop testing. Yet the operator will demand infrastructure interoperability testing (IOT) with a variety of UEs, network equipment, and client applications. Conformance testing for standards also will be required. At some point, a combination of all of these tests will be needed.

To satisfy these varied requests, the application note suggests the use of a building-block approach. By combining a variety of products in different configurations, it is possible to address a range of LTE UE tests and test needs. In addition, UE developers can gain greater insight into their designs.

VoLTE battery-drain analysis, for example, calls for the creation of new battery-drain profiles. For a 2G/3G UE, battery-drain testing usually involves the transmission and reception of files, multimedia messaging services (MMSs), the repeated sending of short messaging services (SMSs), and potentially a combination of all of these tasks. Yet VoLTE has to confront its own burst-transmission nature as well as the all-IP network and different discontinuous reception (DRX) patterns for both idle (paging cycle) and connection mode. Using Agilent's IFT software and PXT test set, it is possible for a developer to set up loops that continuously repeat SMS/MMS sends, large file downloads, and voice calls to simulate battery-drain profiles.

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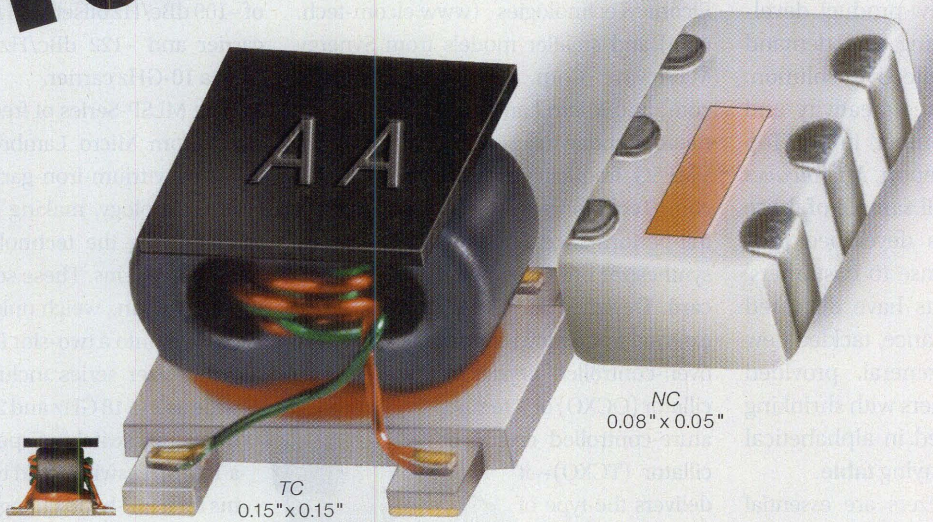

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Top 2012 Products Blend Value and Performance

This year's top offerings epitomize the creativity and ingenuity of the design engineers in the RF/microwave industry in meeting the most demanding requirements of their customers.

CUSTOMER DEMAND will generally drive new-product development. Meeting that demand with a cost-effective solution, however, often requires creativity and ingenuity. Each December, in our Top Products of the Year report, *Microwaves & RF* applauds a small sample of those outstanding products developed during the year in response to customers' needs. These products have delivered new levels of performance, tackled new problems and, in general, provided great value for customers with shrinking wallets. They are listed in alphabetical order in the accompanying **table**.

Frequency synthesizers are essential components in many high-frequency systems. Several were on the 2012 Top Products list, including a broadband unit from Elcom Technologies (www.elcom-tech.com) and smaller models from Synergy Microwave Corp. (www.synergymwave.com) and Micro Lambda Wireless (www.microlambdawireless.com). The model VMESG frequency synthesizer from Elcom Technologies **(Fig. 1)** squeezes a full-performance 1-to-20-GHz frequency synthesizer onto a compact two-slot VME card. Designed for use with a 100-MHz external frequency reference—such as an oven-controlled crystal oscillator (OCXO) or a temperature-controlled crystal oscillator (TCXO)—it delivers the type of performance associated with a larger rack-mount synthesizer, with phase noise of –109 dBc/Hz offset 1 kHz from a 10-GHz carrier and –122 dBc/Hz offset 10 kHz from a 10-GHz carrier.

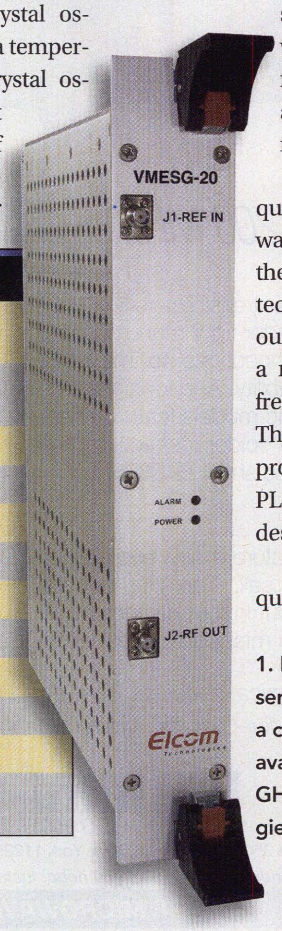
The MLSP-Series of frequency synthesizers from Micro Lambda Wireless are based on yttrium-iron-garnet (YIG) oscillator technology, making great strides in miniaturizing the technology for use in modular systems. These sources measure just 5 x 3 x 1 in., weigh only 15 oz. (426 g), and can fit into a two-slot PXI chassis. The synthesizer series includes models as wide as 2 to 18 GHz and 2 to 20 GHz with frequency switching speeds of 1 ms for a 100-MHz switch, and typically about 7 ms for a full-band change in frequency.

The model KMTS2500-200800 frequency synthesizer from Synergy Microwave Corp. combines direct-digital-synthesis (DDS) and phase-lock-loop (PLL) technologies to generate stable, low-noise output signals. A low-noise PLL multiplies a reference frequency to the maximum frequency allowed by the DDS circuit. The DDS output signal is then filtered and provided as a reference to a secondary PLL that will multiply the frequency to the desired range.

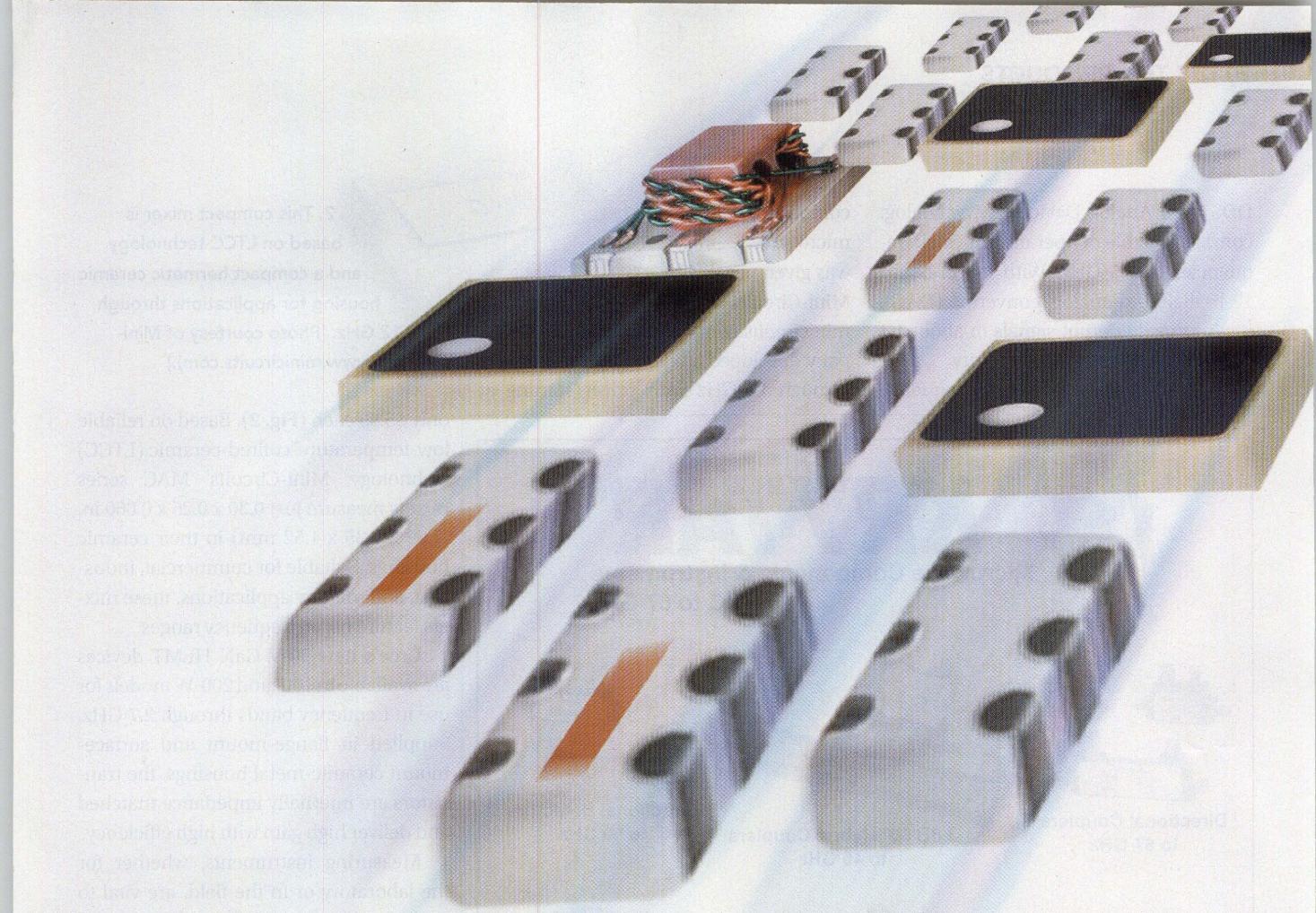
An even smaller, component-level frequency synthesizer, the model AD9914

Top Products of 2012 (listed alphabetically)

Agilent Technologies' 26.5-GHz PXI vector signal analyzer	(August, p. 102)
Analog Devices' AD9914 direct digital synthesizer (DDS)	(September, p. 92)
Anritsu Co.'s PIM Master portable PIM tester	(March, p. 102)
Cree's 50-V GaN HEMT power transistors	(upcoming profile)
Elcom's VME 20-GHz synthesizer	(February, p. 95)
LeCroy's 60-GHz oscilloscope	(February, p. 103)
Micro Lambda's TO-8 YIG-based synthesizers	(June, p. 108)
Mini-Circuits' mixer	(January, p. 92)
National Instruments vector signal transceiver	(October, p. 104)
Rigol Technologies' DSA815 spectrum analyzer	(August, p. 104)
Synergy Microwave's PLL synthesizers	(May, p. 132)
X-COM's 6-GHz record/playback system	(February *Defense Electronics* supplement, p. S24)



1. Frequency synthesizer in the VMESG series provide excellent spectral purity in a compact VME card format, with models available for full coverage from 1 to 20 GHz. [Photo courtesy of Elcom Technologies (www.elcom-tech.com).]



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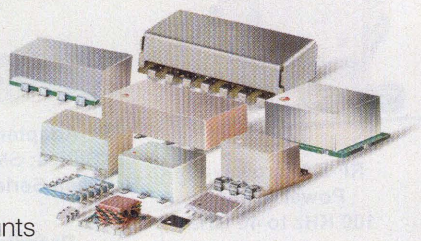

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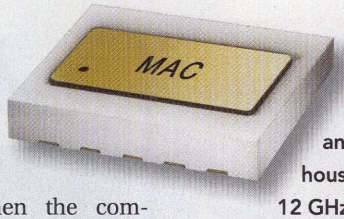
DDS from Analog Devices (www.analog.com), is capable of operating at clock frequencies to 3.5 GHz. With its on-board 12-b digital-to-analog converter (DAC), it can provide output signals to about 1.4 GHz with excellent spectral purity.

Another essential high-frequency component, the RF/microwave mixer, was given new life by Mini-Circuits (www.minicircuits.com) when the company developed a line of hermetic mixers through 12 GHz with prices starting at only $5.95 each **(Fig. 2)**. Based on reliable low-temperature-cofired-ceramic (LTCC) technology, Mini-Circuits' MAC series mixers measure just 0.30 x 0.25 x 0.060 in. (7.62 x 6.35 x 1.52 mm) in their ceramic housings. Suitable for commercial, industrial, and military applications, these mixers feature broad frequency ranges.



2. This compact mixer is based on LTCC technology and a compact hermetic ceramic housing for applications through 12 GHz. [Photo courtesy of Mini-Circuits (www.minicircuits.com).]

Cree's new 50-V GaN HEMT devices are available in 100- and 200-W models for use in frequency bands through 2.7 GHz. Supplied in flange-mount and surface-mount ceramic-metal housings, the transistors are internally impedance matched and deliver high gain with high efficiency.

Measuring instruments, whether for the laboratory or in the field, are vital to the advancement of the industry. The LabMaster 10Zi digital sampling oscilloscopes (DSOs) from LeCroy Corp (www.lecroy.com), for example, leverage silicon-germanium (SiGe) device technology to reach new levels of measurement capability **(Fig. 3)**. These active devices, with cutoff frequencies to 200 GHz, are used in analog-to-digital converters (ADCs) within the oscilloscopes.

Modular instruments are increasingly finding their way onto test benches, not only for their flexibility but for their outstanding performance [including in PXI and PXI Express (PXIe) modular formats]. For example, a PXI-based vector-signal-analyzer (VSA) from Agilent Technologies (www.agilent.com) includes all the modules needed to perform signal analysis on 4 x 4 multiple-input, multiple-output (MIMO) communications systems and devices from 10 MHz to 26.5 GHz. It provides analysis bandwidths as wide as 780 MHz with a number of different PXI and PXIe modules. The VSA system includes a model M9362A PXIe frequency downconverter module with frequency range of 10 MHz to 26.5 GHz, which can simultaneously frequency translate four

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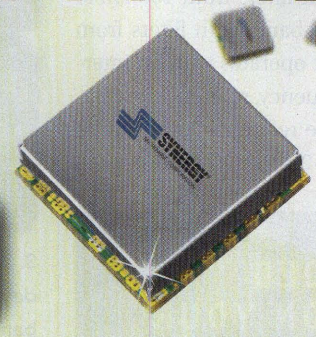

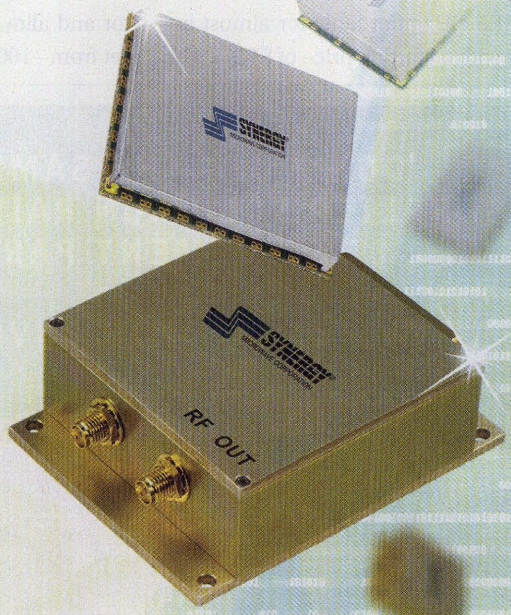

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The DSA815 spectrum analyzer from Rigol Technologies (www.rigolna.com) makes basic measurement power from 9 kHz to 1.5 GHz affordable for almost everyone, with a starting price of $1295. The versatile spectrum analyzer provides resolution-bandwidth filters from 100 Hz to 1 MHz and video-bandwidth filters from 1 Hz to 3 MHz. It operates with an internal 10-MHz frequency reference oscillator and allows the reference level can be set from –100 to +20 dBm in 1-dB steps to show a wide range of signal levels.

3. This line of DSOs employs SiGe active device technology to achieve channel bandwidths as wide as 60 GHz for 10 measurement channels. [Photo courtesy of LeCroy Corp (www.lecroy.com).]

For measurements in the field, the Passive Intermodulation (PIM) Masters series from Anritsu Co. (www.anritsu.com) can generate the test tones needed within specific wireless communications bands for on-site PIM testing of components and systems—including in frequency ranges of 869 to 894 MHz and 1930 to 1990 MHz. The PIM Masters, which can generate test tones at levels to about 40 W, measure only 12 x 17 x 20 in.

For military and other signal-intelligence (SIGINT) applications, the Wideband Acquisition Record and Playback (WARP™) system from X-COM Systems (www.xcomsystems.com) can instantly capture the entire signal spectrum from DC to 6 GHz even over long periods of time, when equipped with adequate memory. The system allows digital storage of signal bandwidth.

In some cases, new types of instruments were needed to keep pace with wireless test needs. Model PXIe-5644R is a vector signal transceiver (VST) from National Instruments (www.ni.com) that combines a vector signal generator (VSG) and VSA with a field-programmable gate array (FPGA), forming a new kind of instrument for wireless communications testing. It tunes from 65 MHz to 6 GHz with instantaneous bandwidth as wide as 80 MHz and 1-Hz tuning resolution. MWRF

Editor's Note: To read an expanded version of this article, go to http://mwrf.com/systems/top-2012-products-blend-value-and-performance.

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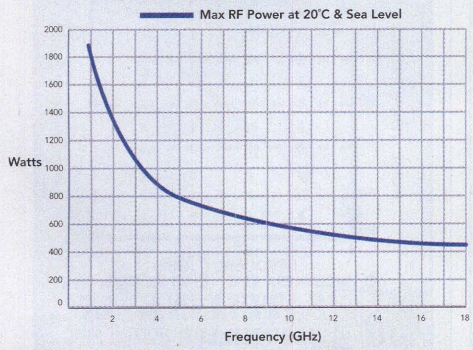
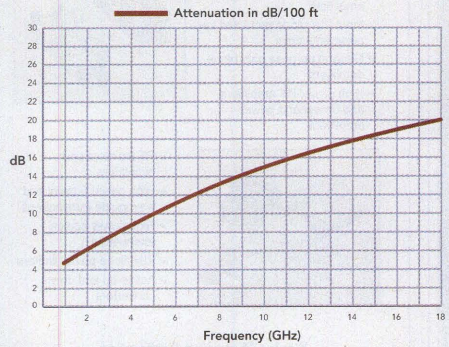


Attenuation in dB/100 ft



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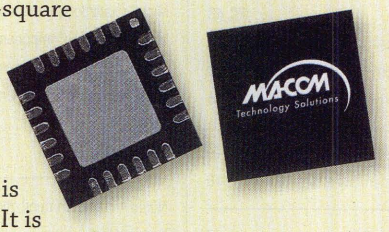
Phase Shifter Tunes C-Band Radars

Model MAPS-011008 is a digital phase shifter from M/A-COM Technology Solutions for C-band radar applications from 5 to 6 GHz. It provides a phase adjustment range of 360 deg. with step size of 5.6 deg. The phase shifter promises ±3 deg. root-mean-square (RMS) phase accuracy across its frequency range. The phase shifter achieves an input third-order intercept point of +48 dBm. Insertion loss is only 4 dB in any phase state, with attenuation variations held to ±0.5 dB or less. The compact phase shifter is housed in a 4-mm 24-lead PQFN package. It is powered by means of a +5-VDC serial or parallel control line.



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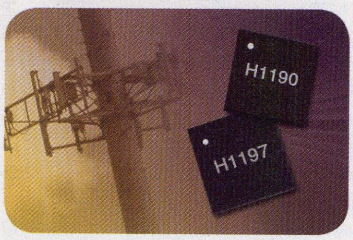
Receiver, Transmitter ICs Span 0.7 To 4.0 GHz

A radio-frequency-integrated-circuit (RFIC) chipset with receiver and transmitter from Hittite Microwave Corp. is suitable for wireless infrastructure frequency-conversion applications from 700 to 3500 MHz. Ideal for use in base-transceiver stations, remote radio units (RRUs), and repeaters, the model HMC1190LP6GE dual-channel downconverter serves the receiver side. It features an integrated phase lock loop (PLL) and voltage-controlled oscillator (VCO). It features 8-dB conversion gain with output power at 1-dB compression of +11 dBm and input third-order intercept point (IIP3) of +24 dBm. Its 2 x 2 spurious products are controlled to below –70 dBc. For transmitters, the model HMC1197LP-7FE is a direct quadrature modulator with integrated fractional-N PLL and VCO. Designed for use from 100 MHz to 4 GHz, it provides as much as +10.5 dBm output power at 1-dB compression with IIP3 of +30 dBm. It has a low noise floor of –160 dBm/Hz. Its single-ended RF output port is matched to 50 Ω with no need for additional external components.



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GaN Amplifiers Reach 1.85 GHz

Two new flange-ceramic-packaged GaN power amplifiers from RFMD are suitable for commercial wireless and military communications applications. Devices in the firm's RFHA104x series include the models RFHA1042 and RFHA1043. The RFHA1042 is optimized for use from 225 to 450 MHz. Its +48-VDC modulated performance includes +45.2 dBm output power with 18.5-dB gain and 42% drain efficiency. Its +48-VDC CW performance includes +51.4-dBm output power, 16-dB gain, and 60% drain efficiency. It provides these performance levels for an operating temperature range of –40 to +85°C. The model RFHA1043 GaN power amplifier operates from 1.20 to 1.85 GHz. Its +48-VDC modulated performance features +45.2-dBm output power, 15.5-dB gain, and 30% drain efficiency, with adjacent-channel-power (ACP) level of –30 dBc. Its +48-VDC CW performance includes +52-dBm output power, 13.5-dB gain, and 51% drain efficiency. The devices are based on an advanced 65-V GaN high-electron-mobility-transistor (HEMT) semiconductor process and are supplied in an air cavity ceramic package, providing excellent thermal stability.

RFMD, 7628 Thorndike Rd., Greensboro, NC 27409-9421; (336) 664.1233, ***www.rfmd.com.***

Signal Source Fixes On 4 GHz

Model SFS4000C-LF is a RoHS-compliant frequency synthesizer for satellite-communications (satcom) and test applications. The fixed-frequency unit is phase locked at 4 GHz using a 10-MHz reference oscillator. The coaxial synthesizer delivers 0-dBm output power and exhibits phase noise of typically –102 dBc/Hz offset 10 kHz from the carrier with typical spurious content of –65 dBc. Second-harmonic levels are typically –15 dBc. The frequency source, which is supplied in a PLL-V12C package measuring 0.60 in. x 0.60 in. x 0.22 in., consists of a voltage-controlled oscillator (VCO) with power consumption of 30 mA at +5 VDC, as well as a phase-lock-loop (PLL) chip with power consumption of 11 mA at +3.3 VDC.

Z-COMMUNICATIONS, INC., 14118 Stowe Dr., Ste. B, Poway, CA 92064; (858) 621-2700, (877) 808-1226, FAX: (858) 486-1927, e-mail: sales@zcomm.com, ***www.zcomm.com.***

Source Sends Digital Modulation To 12.75 GHz

The R&S SGS100A microwave signal generator is now available in a version capable of producing signals with digital in-phase/quadrature (I/Q) modulation from 80 MHz to 12.75 GHz. When combined with an I/Q baseband generator, the test signal source supports testing on all radio standards through 12 GHz, including radar and satellite-communications (satcom) signals. The wide 1-GHz I/Q bandwidth makes it possible to generate pulses with high chirp bandwidths and steep pulse edges. The signal source provides typically +22 dBm output power across its frequency range with an electronic step attenuator for output level control. The switching speed is typically 280 µs. The signal generator can work with high reference frequencies from 100 MHz to 1 GHz. It features –76-dBc nonharmonic spurious performance with typical phase noise of –130 dBc/Hz offset 20 kHz from a 1-GHz carrier.

ROHDE & SCHWARZ USA, INC., 8661A Robert Fulton Dr., Columbia, MD 21046-2265; (888) TEST-RSA [(888) 837-8772)], (410) 910-7800, FAX: (410) 910-7801, e-mail: info@rsa.rohde-schwarz.com, www.rohde-schwarz.us, ***www.rohde-schwarz.com.***

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U.S. Patents 7739260, 7761442

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Versatile Scopes Scan 0.2 To 1.5 GHz

Available in a number of different channel configurations and bandwidths, these mixed-signal and digital-sampling scopes use touchscreen displays and smart memory to simplify measurements.

OSCILLOSCOPES ARE mainstay test instruments for many labs and test facilities. They have grown with technology over the years, but perhaps none as much as the InfiniiVision 4000 X-Series oscilloscopes from Agilent Technologies (www.agilent.com). These mixed-signal oscilloscopes (MSOs) and digital-sampling oscilloscopes (DSOs) take advantage of novel segmented memory, a special application-specific integrated circuit (ASIC), and 12.1-in. capacitive touchscreens.

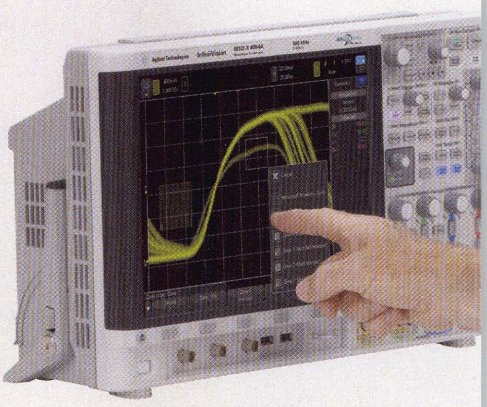
The InfiniiVision 4000 X-Series family **(see figure)** numbers eight MSOs and eight DSOs, with bandwidths from 200 MHz to 1.5 GHz. The DSO models offer two or four analog input channels, while the MSO models add 16 digital input channels to the two or four analog input channels **(see table)**. These instruments actually house five measurement tools in each enclosure, with multiple analog test signal channels, digital channels, protocol analysis capability, a dual-channel arbitrary waveform (ARB) generator for signal generation, and an integrated digital voltmeter (DVM).

Each instrument has a sampling rate of 2.5 GSamples/s on all measurement channels, and this capability can be interleaved to 5.0 GSamples/s when making half-channel measurements. All instruments feature a fast update rate of 1 million waveforms/s.

To assist in snaring anomalies and transient signal events, the InfiniiVision 4000 X-Series incorporates patented MegaZoom IV ASIC smart memory technology. Working with the instruments' segmented memory, this technology helps capture more waveform data than conventional oscilloscopes.

When waveforms are displayed on screen, the large 12.1-in. capacitive touchscreen works as an ally to help isolate anomalies and portions of interest. The InfiniiScan Zone touch triggering capability makes it possible to draw a box around a signal of interest on the touchscreen and trigger on it.

The update rate of this InfiniiScan Zone touch triggering capability is 200,000 waveforms/s. In their standard configuration, the InfiniiVision 4000 X-Series scopes include 4 Mpoints of memory, plus segmented memory for capture of transient events. MWRF



InfiniiVision 4000 X-Series oscilloscopes are available with analog bandwidths from 200 MHz to 1.5 GHz and an easy-to-use 12.1-in. capacitive touchscreen.

Editor's Note: In order to read an expanded version of this article, go to http://mwrf.com/test-amp-measurement-analyzers/versatile-scopes-scan-02-15-ghz.

The InfiniiVision 4000 X-series scopes at a glance.

Model	Bandwidth	Risetime	Digital scope channels	Sampling rate (all channels)
4022	200 MHz	≤1.75 ns	2	2.5 GSamples/s
4024	200 MHz	≤1.75 ns	4	2.5 GSamples/s
4032A	350 MHz	≤1 ns	2	2.5 GSamples/s
4034A	50 MHz	≤1 ns	4	2.5 GSamples/s
4052A	500 MHz	≤700 ps	2	2.5 GSamples/s
4054A	500 MHz	≤700 ps	4	2.5 GSamples/s
4104A	1 GHz	≤450 ps	4	2.5 GSamples/s
4154A	1.5 GHz	≤300 ps	4	2.5 GSamples/s

Sampling rate is 5.0 GSamples/s for half-channel and 2.5 GSamples/s for all channels in operation.
All models are available as digital sampling oscilloscope (DSO) or mixed-signal oscilloscope (MSO).

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DC-100	30	±0.5	0682-30F
DC-250	10	±0.5	0682-10F
Uncalibrated models			
DC-60	40	±1.0	0682-40
DC-100	20	±0.6	0682-20
DC-100	30	±0.5	0682-30
DC-200	30	±2.0	0682-30A
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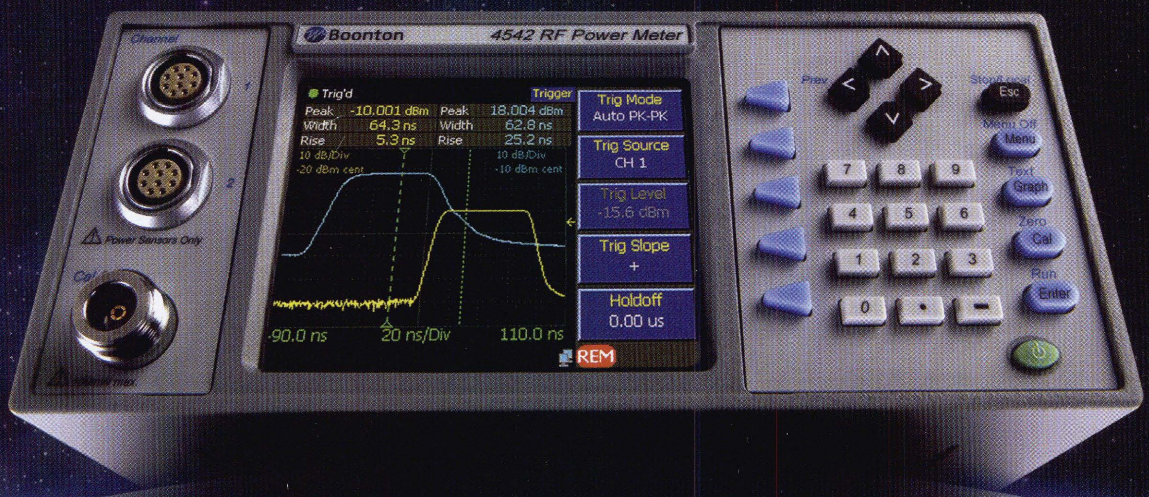

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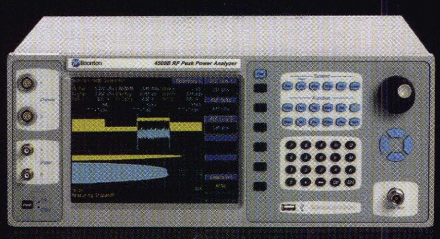

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