Vol. 52 • No. 7

July 2009

Microwave Journal

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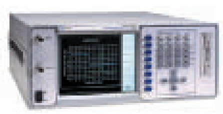

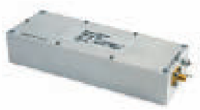

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SPST								
0.2 – 2	SW1-002020RN1NF	1.7	70	1.6:1	10/10	20	35	35/70
2 – 8	SW1-020080RN1NF	2	80	1.7:1	10/10	20	35	35/70
4 – 12	SW1-040120RN1NF	2.2	80	1.7:1	10/10	20	35	35/70
2 – 18	SW1-020180RN1NF	3	80	2:1	10/10	20	35	35/70
1 – 18	SW1-010180RN1NF	3	70	2:1	10/10	20	35	35/70
SP2T								
0.2 – 2	SW2-002020RN1NF	1.5	70	1.6:1	10/10	20	35	60/60
2 – 8	SW2-020080RN1NF	1.8	80	1.7:1	10/10	20	35	60/60
4 – 12	SW2-040120RN1NF	2.2	80	1.7:1	10/10	20	35	60/60
2 – 18	SW2-020180RN1NF	2.8	80	2:1	10/10	20	35	60/60
1 – 18	SW2-010180RN1NF	3	70	2:1	10/10	20	35	60/60
SP3T								
0.2 – 2	SW3-002020RN1NF	1.6	70	1.6:1	20/20	150	180	85/85
2 – 8	SW3-020080RN1NF	1.9	80	1.7:1	20/20	150	180	85/85
4 – 12	SW3-040120RN1NF	2.4	90	1.7:1	20/20	150	180	85/85
2 – 18	SW3-020180RN1NF	3	80	2:1	20/20	150	180	85/85
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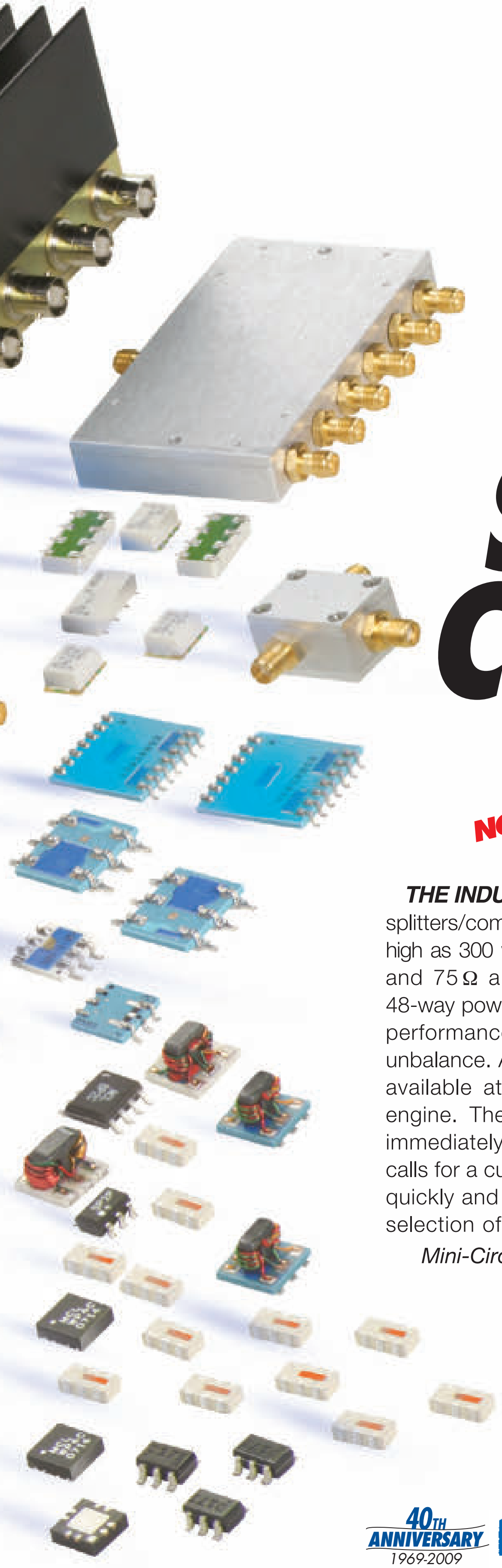

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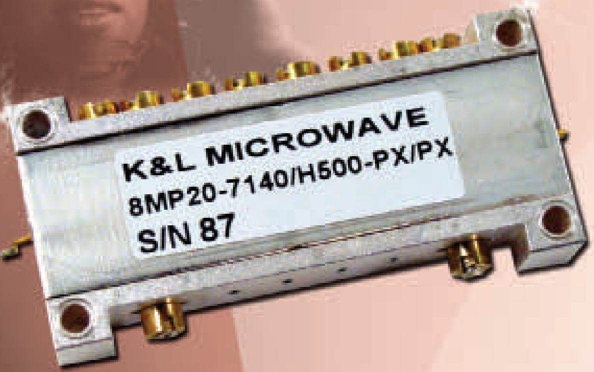

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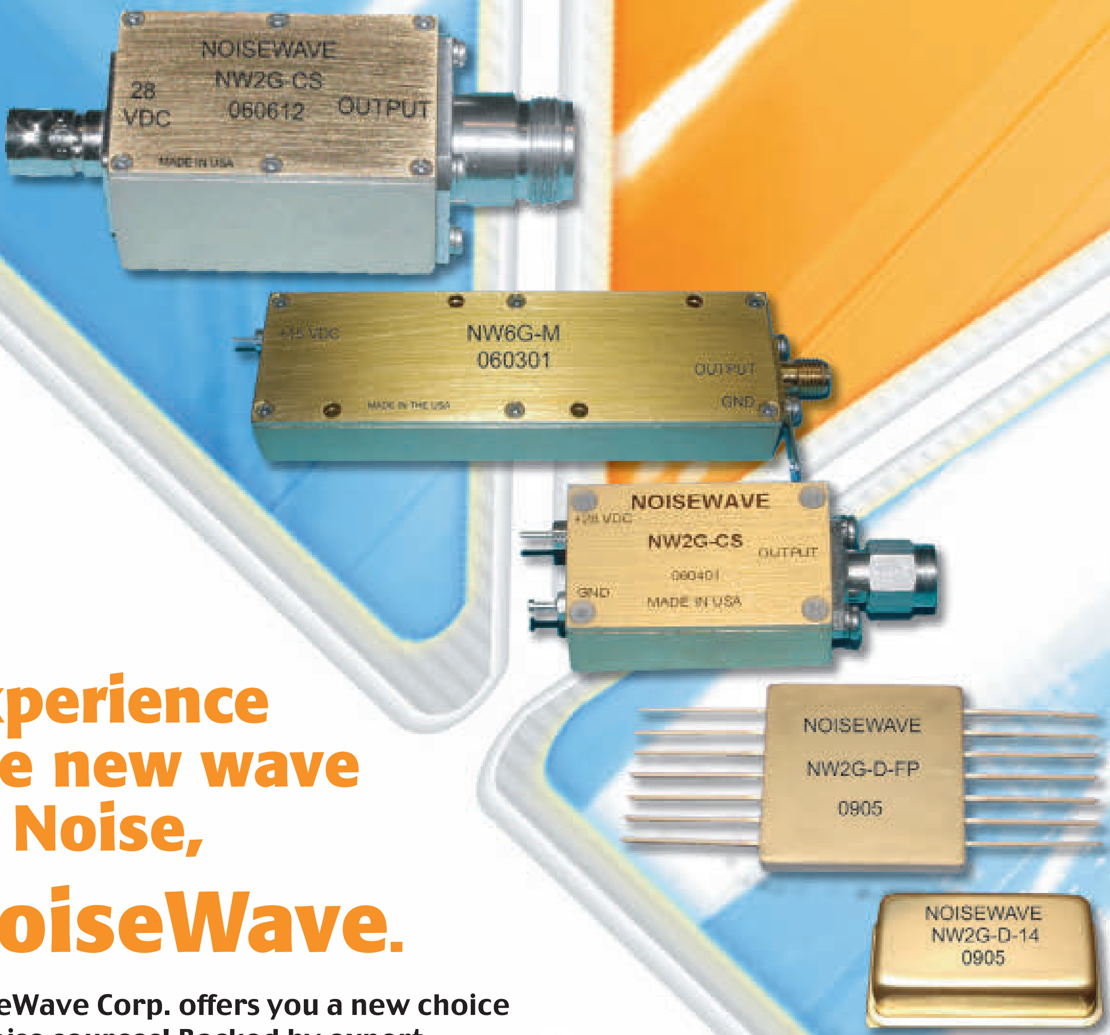
More Noise



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Microwave Journal

JULY 2009 VOL. 52 • NO. 7

COVER FEATURE

TECHNICAL FEATURES

SPECIAL REPORT

PRODUCT FEATURES

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

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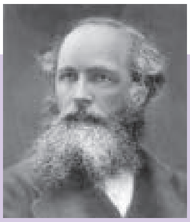

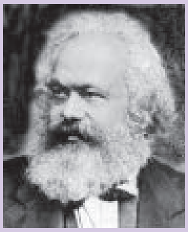

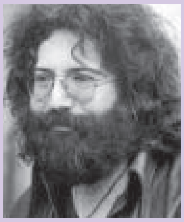

Oscar Wilde once said something along the lines of the following: "It is better to be talked about than not talked about." With this in mind, I was pleased when our May issue inspired so many readers to ask, "Who's that on the cover of *Microwave Journal*?" We typically don't get a lot of feedback on our choice of cover art, so a heightened reaction is worth noting. And yet, I was slightly taken aback that the father of electromagnetism would be unrecognized by so many.

With the current economic situation in mind, we wanted to tip our hat to the important relationship between engineering and commerce by placing an iconic microwave figure overlooking the Boston skyline in anticipation of the upcoming International Microwave Symposium (IMS). I'll admit that iconic microwave "dudes" are hard to come by. Old bearded guys from the past are apparently less rare. I can assure you that we did not put the father of Marxism, or the leader of the Grateful Dead or the guy who works one night a year in the dead of winter on the cover of the May issue. We did put the man who, in four elegant equations, made it possible for the engineering side of the symposium to do their job.

Inside the issue, we shifted our editorial focus toward the exhibition. We did so in order to recognize the role that the commercial side plays in supporting the technical conference. Given the need for a healthy balance between engineering and commerce, I hope we faithfully served both audiences while helping all exhibiting companies achieve a recognizable iconic stature of their own.

David Vye

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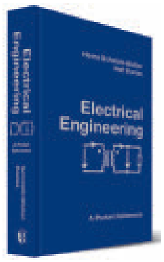

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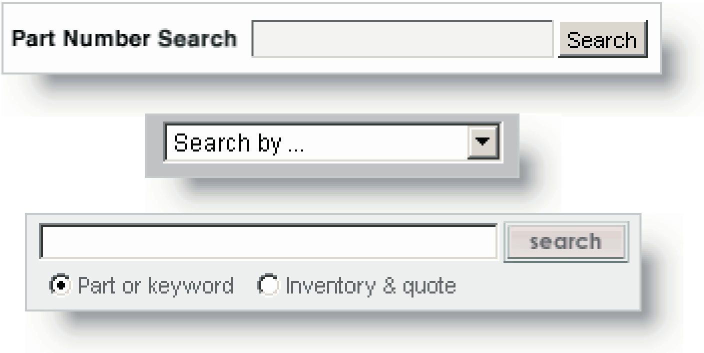
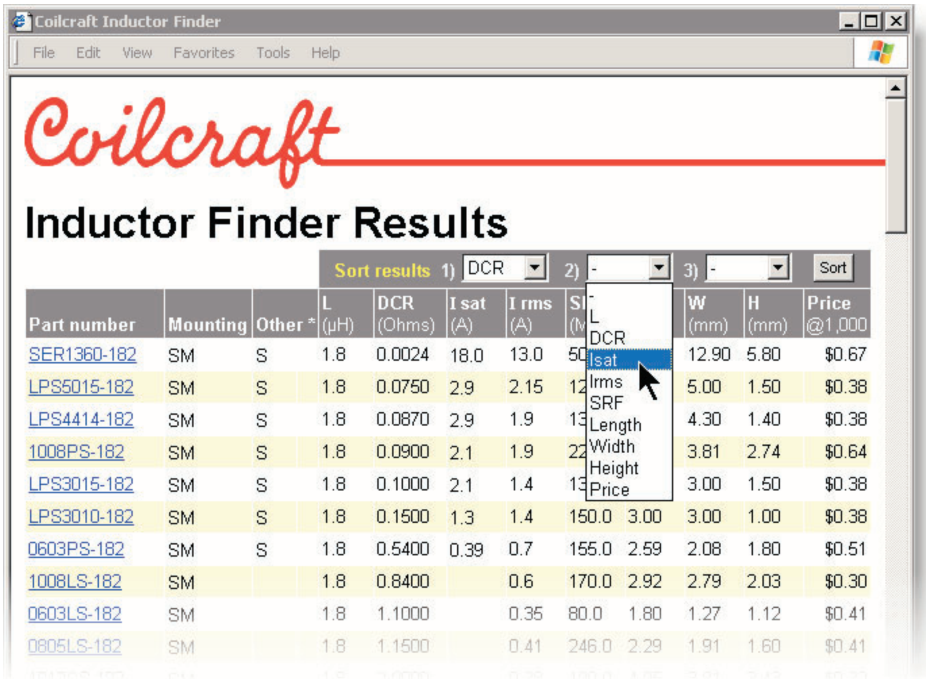


Their sites have search engines. Ours has a find engine.



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AUGUST 2009

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26	27	28	29	30	31	1
2 **Call for Papers IEEE Radio Wireless Week Deadline: Aug. 2, 2009**	3	4 ← **NIWEEK 2009** Austin, TX →	5	6	7	8
9	10 ← **23rd Annual Conference on Small Satellites** Logan, UT → ← **ICEPT-HDP 2009 International Conference on Electronic Packaging Technologies and High Density Packaging** Beijing, China →	11	12	13	14	15 **Call for Papers IEEE Applied Electromagnetics Conference Deadline: Aug. 15, 2009**
16	17 ← **EMC 2009 IEEE International Symposium on Electromagnetic Compatibility** Austin, TX →	18 **MWJ/Besser Webinar: Passive Components Sponsored by Res-Net** Besser Associates The Worldwide Leader in RF & Wireless Training	19	20	21	22
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European Microwave Week
September 28–October 2, 2009
Rome, Italy
www.eumweek.com

OCTOBER

RF & Hyper 2009
October 6–8, 2009 • Paris, France
www.rfhyper.com

International Radar Conference
October 12–16, 2009 • Bordeaux, France
www.radar09.org

AOC 2009
46th Annual AOC International Symposium and Convention
October 18–22, 2009 • Washington, DC
www.crows.org

ISAP 2009
International Symposium on Antennas and Propagation
October 20–23, 2009 • Bangkok, Thailand
www.isap09.org

NOVEMBER

AMTA 2009
Antenna Measurement Techniques Association
November 1–6, 2009 • Salt Lake City, UT
www.amta.org

COMCAS 2009
The International IEEE Conference on Microwaves, Communications, Antennas and Electronic Systems
November 9–11, 2009 • Tel Aviv, Israel
www.comcas.org

DECEMBER

APMC 2009
Asia-Pacific Microwave Conference
December 7–10, 2009 • Singapore
www.apmc2009.org

RFIT 2009
IEEE Radio Frequency Integration Technology Symposium
December 9–11, 2009 • Singapore
www.ieee-rfit.org

AEMC 2009
IEEE Applied Electromagnetics Conference
December 14–16, 2009 • Kolkata, India
www.ieee-aemc.org

JANUARY

IEEE Radio Wireless Week 2010
January 10–14, 2010 • New Orleans, LA
www.radiowirelessweek.org

MEMS 2010
IEEE International Conference on Micro Electromechanical Systems
January 24–28, 2010 • Hong Kong, China
www.ieeemems.org

FEBRUARY

ISSCC 2010
IEEE International Solid-state Circuits Conference
February 7–11, 2010 • San Francisco, CA
www.isscc.org

NATE 2010
National Association of Tower Erectors
February 15–18, 2010 • Orlando, FL
www.natehome.com

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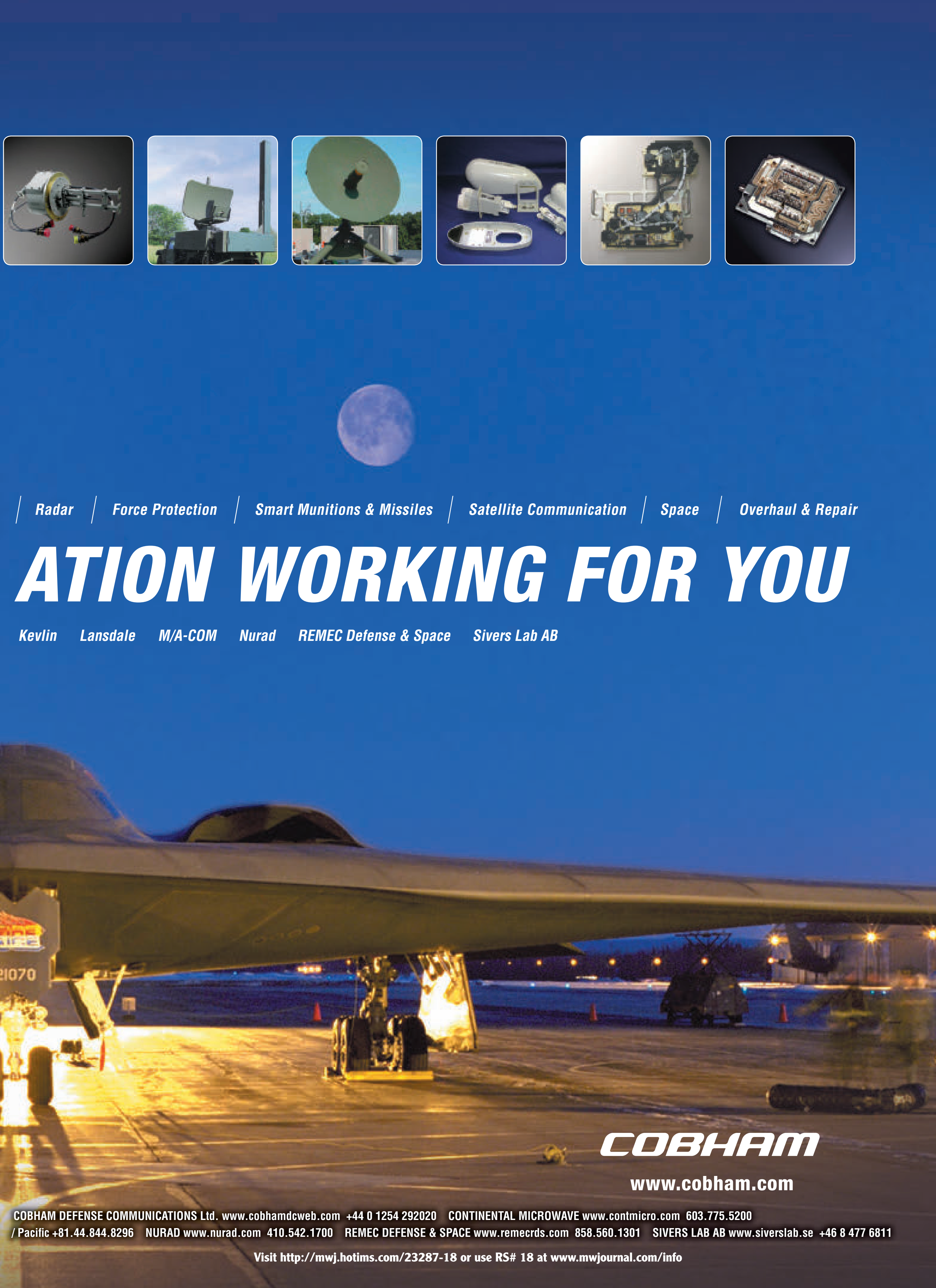
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COVER FEATURE

How Design Software Changed the World

In the beginning… (Around World War II), microwave circuits were heavy and bulky and consisted of voluminous, hollow metallic pipes and tubes known as waveguide. Microwave engineers working in waveguide were referred to as plumbers and their tools included files, ball-peen hammers, epoxy and paint. In the 1960s, planar transmission line circuits, based on two-dimensional layered topologies, were introduced. They were relatively cheap, lightweight and offered the potential for miniaturization, which quickly led to the concept of microwave integrated circuits (MIC).

MICs were also known as "hybrids" for their mix of active and passive components (some components are printed on a substrate, such as thin film caps or spiral inductors, while others are placed in chip form, typically active components such as diodes and discrete transistors). With an MIC, an entire circuit could be printed on one substrate with various components connected to each other in a continuous integrated fashion, thereby replacing individual microwave components connected by waveguide or coax cables. MICs could support mass-production and thus reduce costs. Circuit design, however, was still performed by hand using formulas from text books, pencils, Smith charts, a circuit board, some copper tape, a razor blade, soldering iron and test equipment. Either design task (MIC or waveguide) required a solid understanding of circuit behavior, astute observation of cut and try experiments… and a good deal of time.

Wright Pat and TI

In 1964, the Air Force's Wright Paterson Aeronautical Lab requested Texas Instruments (TI) to submit a proposal for an airborne forward-looking radar system that maximized the use of semiconductors. The goal was to demonstrate that T/R modules could be manufactured at the price point commensurate with future large, active aperture phased-array and ECM systems.[1] The resulting Microwave Electronic Radar Applications (MERA) program, which was co-sponsored by DARPA, would push the state of the microwave art and lead to the demonstration of microstrip transmission on semi-insulating silicon and gallium-arsenide substrates in 1965 including the first silicon MMIC, an X-band T/R switch in 1966, a 500 MHz tuned amplifier in 1966, the first gallium-arsenide MMIC, a 94 GHz local oscillator and balanced mixer in 1967.[2] Out of the technical success of MERA, which culminated in the de-

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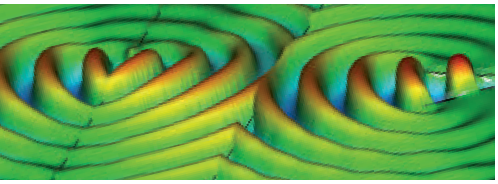

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livery of a complete operating radar system in 1970, other programs were started in most military radar houses throughout the US and abroad. Microwave circuit design would need to ramp up fast.

How did the TI engineers advance the state of microwave circuitry so quickly? One clue is found in US patent 3622762 filed in November 1971 by L.W. Dyer, T.W. Houston and G.J. Policky of Texas Instruments: "Using representations of circuit topologies and initial values of all elements, a circuit design may be modified by an automated data processing machine to improve operation for at least one performance characteristic by changing design variables. A desired circuit topology is selected and the initial values for all the circuit elements are coded and stored in the data processor. In addition, the desired performance characteristic is also selected and coded. Using coded input information, the data processor generates and stores a representation of a continuous analytical objective function. In the operation of the data processor, a value of the objective function is generated and stored."

The patent abstract refers to a circuit simulation and optimization program developed internally by TI for microwave circuit designers supporting the MERA program. The program, known as CAIN (Computer Aided Integrated Networks), operated on an IBM 360 computer using punch cards as described by the patent filers in the August 1969 IEEE-Wescon technical paper, "Computer-aided Design of Microwave Integrated Circuits."[3] While TI engineers used this program for years, it was never commercialized by the company.

THE FIRST COMMERCIAL HIGH FREQUENCY CIRCUIT SIMULATOR

The benefits of using microstrip and stripline transmission lines, which included miniaturization and easier manufacturing, came at the price of design uncertainty. Among the issues, the inhomogeneous medium of microstrip results in an effective dielectric constant that increases with frequency so that the phase velocity decreases, the characteristic impedance changes and discontinuities such as bends, tees (line intersections) and line width steps need to be properly modeled to account for parasitics and accurately represent their high-frequency behavior. Before software, microwave engineers relied on text books and hand calculations in order to roughly approximate circuit behavior, a slow and tedious process.

While a few select companies had internally developed software on their mainframe computers, most microwave engineers at the time did not have access to computers or computer-aided design. Among them was Les Besser, who began his engineering career in 1966 in Hewlett Packard's (HP) Microwave Division, developing broadband microwave components. It was at HP that Besser began working on simulators and impedance matching programs; although at the time, his manager disapproved of this side project.[4]

In the fall of 1969, Professor Ron Rohrer of UC Berkeley returned from a leave at Fairchild and taught a circuit design and analysis course. The course project was to develop the components of a comprehensive and optimal circuit simulator. The result was a program called "Computer Analysis of Nonlinear Circuits, Excluding Radiation (CANCER)". The unusual name was chosen to reflect that the program was not funded by the defense industry, which provided funding for most circuit simulation programs at the time and required them to be able to test a circuit's radiation resistance. One of the principle developers was grad student Laurence Nagel. Under the direction of his new advisor Prof. Donald Pederson (replacing Rohrer), Nagel developed the program into a public-domain general-purpose circuit simulator. The result was called SPICE (Simulation Program with Integrated Circuit Emphasis), which was released to the public as open-source code in 1972.[5]

However, SPICE could not address distributed transmission lines and was unacceptably slow for high frequency simulations. Without any commercially available ones, many companies (including Besser's former employer, HP) developed in-house code. In 1970, Besser left to join Fairchild's Microwave Division where he concentrated on MICs, GaAs FET amplifiers and CATV systems. At Fairchild, Besser wrote SPEEDY, a two-port analysis tool offering a transistor database with high-frequency device S-parameters for Fairchild transistors.

The program's name was chosen to advertise the speed of the program in comparison to the existing time-domain simulators that were not well suited for microwave frequency analysis. At a time when computers (mainframes) were rare and prohibitively expensive, users could access this program worldwide via commercial timesharing through local telephone calls with terminals (i.e., teletype) and modems operating at speeds as low as 110 baud (bits/s).[6] As slow as this was, design tools were faster than prototyping. In the case of ICs, SPICE was proving that they were absolutely essential.

Farinon Electric Co. hired Besser to direct their microcircuit design and development efforts. During that time he authored a program called COMPACT (Computerized Optimization of Microwave Passive and Active CircuiTs). In 1973, the same year that SPICE1 was first presented at conference,[7] Besser commercialized his program and established Compact Software. This represented the first microwave CAD company and the first commercially successful microwave circuit optimization routine.

While limited in capability, it would set the path for future high-frequency design tools. The first versions of the software could only address ideal transmission lines and two-port elements that could be cascaded in series or parallel connections. Over time microstrip elements and discontinuity junctions were added. Later versions could do crude matching network synthesis and plot Smith charts using alphanumeric characters.[6]

According to Besser in his presentation on the history of MIC/MMIC inventions at IMS 2008 in Atlanta, "Recognizing that exact closed-form analytical solution for even a relatively simple microwave circuit, such as a single-stage feedback amplifier, was not practical, the first version of COMPACT included optimization of the circuit components. Although initially it was restricted to two-port type interconnections, generalized nodal connection and noise optimization were added in subsequent releases. (The) Circuit library included a wide range of components, as well as mea-

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Power Amplifier (QFN)	XP1035-QH	5.9-9.5	26.0	+/-1.0	+29.0	+39.0	500 @ 6.0	4x4
Power Amplifier (QFN)	XP1050-QJ	7.0-9.0	15.0	+/-0.5	+34.5 Psat	+48.0	1.2 A @ 8.0	6x6
Power Amplifier (QFN)	XP1042-QT	12.0-16.0	21.0	+/-1.0	+25.0	+38.0	500 @ 5.0	3x3
Power Amplifier (QFN)	XP1043-QH	12.0-16.0	21.5	+/-1.0	+30.0	+41.0	700 @ 7.0	4x4
Power Amplifier	XP1057-BD	13.5-16.0	17.0	+/-1.0	+39.0	+48.0	3.7 A @ 7.5	DIE
Power Amplifier	XP1058-BD	14.5-16.0	27.0	+/-1.0	+36.0	+44.0	2.2 A @ 8.0	DIE
Power Amplifier	XP1072-BD	34.0-37.0	22.0	+/-2.0	+35.0 Psat	-	2.4 A @ 5.5	DIE
Power Amplifier	XP1073-BD	34.0-37.0	22.0	+/-2.0	+37.0 Psat	-	4.8 A @ 5.5	DIE

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sured S-parameter databanks."[6]

The ability to optimize complex microwave circuits eventually convinced many reluctant engineers to accept CAD as a practical design tool and as a result revolutionized circuit design. Time and again, the success of a software product would depend on its ability to improve engineering productivity and/or cut costs. Software with optimization capability offered to shave project times down from months to days, saving up to $24,000 per project according to the advertisements running at the time (see **Figure 1**).[3]

SUPER-COMPACT COST SAVINGS

	Without SUPER-COMPACT	With SUPER-COMPACT	Project Savings
Circuit Design Time	3 months	3 days	
Product Design Time (man-months)	6	2	4
Product Design Cycle (calendar-months)	9-12	3	6-9
Total Design Costs	$36,000	$12,000	$24,000

Annual Manpower Benefits:

With a total of about 30 projects annually, an estimate of manpower benefits can be made as follows:

Number of Projects per year:	**30**
Average Project Savings	**$ 24,000**
Total Annual Savings	**$720,000**

The annual savings shows how the cost of SUPER-COMPACT can be recovered in just a few months of use.

Fig. 1 SuperCompact ad highlighting the per project savings using design software vs. hardware prototypes.

```
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+ AFAG = 38.46 R10 = 3.5 KR = 1.111 VBC = 15 IB0 = 7.13E-6
+ AFAB = 38.46 C10 = 0.42PF K1 = 1.282 RS = 1.144 CF0 = 0.02PF
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+ RDSD = 440 CDSD = 1.15PF NAME = Q1
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BIAS 45 0 V = 5 R = 10 : DRAIN BIAS
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CAP 40 50 C = 20PF
TRL 50 60 W = 0.1MM P = 1.0MM SUB
TEE 60 70 65 W1 = 0.1MM W2 = 0.635MM W3 = 0.635MM SUB
OST 65 W = 0.635MM P = 5.0MM SUB
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DOUB:2POR 10 70
END
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Fig. 2 Example of a netlist with distributed transmission line models (TRL and OST).

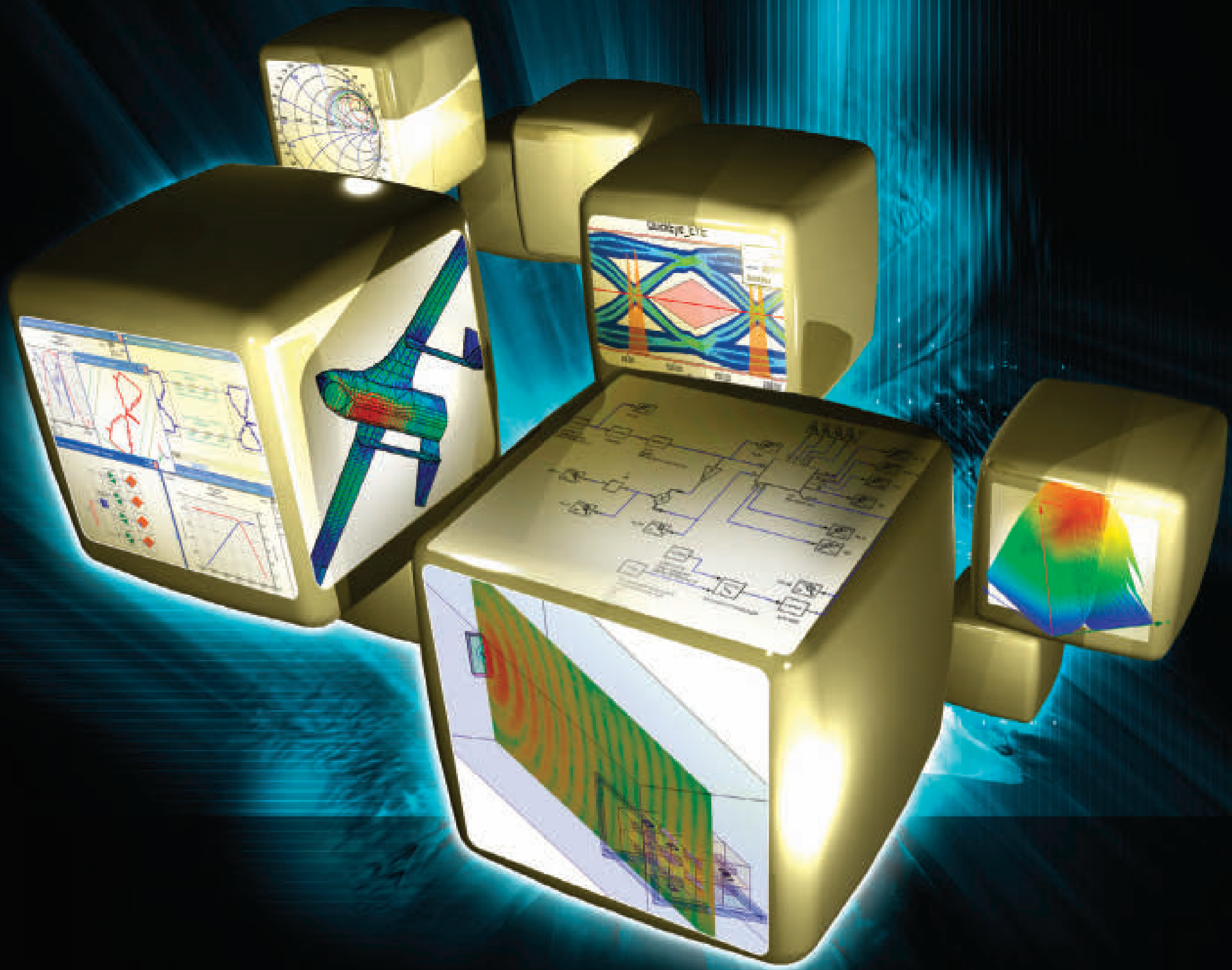
Initially, COMPACT operated only on big mainframes or commercial time-shared minicomputers costing engineering departments $3000 to $5000 per CPU hour (the personal computer did not yet exist). The user interface pre-dated schematic editors; therefore, circuits were defined by text via a netlist editor (see **Figure 2**). Remote terminals hooked up with 300 baud acoustical modems.

In 1980, Compact Software was bought by Comsat and Besser remained associated with the company for the next three years before leaving to start a professional training organization called Besser Associates. During this time, a third-generation program known as SuperCompact™ was developed for mini-computers such as the Digital Equipment VAX, a design workstation, which cost about $250 K. The link between software and the operating platform played a major factor in the commercial fate of design software as the microprocessor and PC revolutionized electronic design throughout the 1980s.

A MORE ACCESSIBLE COMPUTER PLATFORM

Entrepreneur Charles J. ("Chuck") Abronson was co-founder of Amplica Inc. (1972) and served as CEO; he successfully managed the company's IPO in 1981 and subsequent merger with Comsat in 1982. Amplica had used a design program called Magic to develop its state-of-the-art low noise amplifiers and achieve commercial success.

As a result, Abronson became a



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DTA1-1880A		1000	-80
DTA182660A	18-26	10	-60
DTA182670A		100	-70
DTA182680A		1000	-80
DTA264060A	26-40	10	-60
DTA264070A		100	-70
DTA264080A		1000	-80
DTA184060A	18-40	10	-60
DTA184070A		100	-70
DTA184080A		1000	-80

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true believer in the power of design software. During the negotiation to sell Amplica to Comsat, he met Bill Childs, an employee of the Compact subsidiary. Together they teamed up to start EEsof in 1983.

EEsof focused on providing design software that targeted the inexpensive and rapidly growing personal computer, introducing their first product, the Touchstone® linear circuit simulator in 1984.[8] While the initial netlist-based text entry was similar in format to SuperCompact, the move to the PC gave Touchstone a game-changing advantage and the company quickly ate into Compact's market share.

EEsof furthered its product capability by adding links from its software to the HP8510 network analyzer. This allowed measured data to be captured directly into the analysis software. More importantly, the feature would entice those engineers dedicated to the "build and test" design method into using software. The so-called "Touchstone file" (also known as a SnP file after its set of file extensions) was originally the proprietary file format for the linear circuit simulator. The file format would become an industry standard for S-parameters (along with Y- and Z-parameters) used by circuit simulators and measurement equipment (VNAs) alike. This simple ASCII text file is now universally used to document the n-port network parameter data and noise data of linear active devices, passive filters, passive devices, or interconnect networks.

By 1985, the Compact Software subsidiary was practically bankrupt and Comsat essentially gave away the business unit's product line assets to Communications Consulting Corp. (CCC)[4] just as it had released Super-Compact PC version 3.09 to counter the growing popularity of Touchstone on the lower cost platform. CCC President, Dr. Ulrich Rohde, had deep roots in the industry, also being the Chairman of Synergy Microwave and Director with Rohde & Schwarz, the test equipment manufacturer. At the time, Rohde stated his intentions to "immediately increase the capabilities of Compact's software products and to incorporate new microwave models." The new company came with zero employees; however, Rohde immediately partnered with other technologists from around the globe and began focusing on model accuracy and new analyses.

TOOL FUNCTIONALITY GROWS AS VENDORS COMPETE

Combining circuit analysis software with test equipment data was well-suited to microwave product development in the mid-1980s. Touchstone and the HP8510 network analyzer were often paired together by engineering teams. Around this time, HP and EEsof were also tied together via a marketing relationship whereby HP sold and marketed Touchstone software on HP platforms such as the Series 200 (but not on the PC). The marketing agreement brought greater exposure for EEsof and help with entry into major defense contractors, further eroding Compact's market share. It also provided entry into the design software market for HP and would set the stage for future competition.

The challenges of developing microwave components and even the network analyzer itself had convinced HP of the growing importance of design software. An internal tool, MANTIS (Microwave Analog Topology Interactive Simulator) was developed by Jeff Meyer who used it to help develop a broadband amplifier. HP executives concluded that design software would be a natural extension of the company's strong position in the network analyzer market (and a capability the company would promote for many years to come).

Around this time, according to HP literature, "Hewlett-Packard engineers were developing advanced internally-used design tools, including its own highly-capable linear simulator that ran on the readily available workstations from the HP computer division." In 1985, several key designers from the HP 8510 team were chosen to guide the development of software for the emerging microwave and RF design marketplace. The goal was "to integrate simulation, data display, and layout tools in a way that mirrored the way engineers really worked."[8]

By 1987, the first version of the HP Microwave Design System (MDS A.01.00) was released. It had been developed in-house and comprised a linear circuit simulator with inte-

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grated schematic capture and graphical layout with back-annotation, a first for RF EDA software. MDS was offered on UNIX workstations from HP, Sun and Apollo as well on the PC (not Microsoft Windows but SCO UNIX). Schematic capture would help engineers enter their circuits graphically, thereby speeding-up design entry (for some) and providing a useful visual for circuit troubleshooting. To no surprise, the introduction of HP's MDS product soon ended the marketing relationship with EEsof, at least temporarily.

Competition between Compact, EEsof and new-entrant HP sparked considerable innovation during these years. Also driving development was the DARPA program known as MIMIC. The overall goal of this program was to provide analog microwave and mm-wave sensors, based on gallium arsenide integrated circuit technology that would improve performance, size, weight, cost and reliability for the armed services (Army, Navy and Air Force). The program targeted CAE specifically as an area for development.

This program, similar to the earlier MERA program that fueled TI's GaAs development, was announced in the fall of 1985 by Egbert Maynard, the czar of the DoD's VHSIC program.[7] In 1987's MIMIC program "Phase 0", each military branch awarded four teams between $750 K and $1 M to study the best way to develop and produce affordable, reliable, high performance MMICs. "Characterization of material and device processes and the development of computer-aided design capabilities" were specific program goals targeting design software.

The next year, the three services managed to agree on a single statement of work and selected the four teams that would move forward. In phase 1, EEsof would team with primes Hughes and GE and foundries AT&T, M/A-COM and Harris in a contract worth $50 M. EEsof would also collaborate with newly formed Cadence to develop "Smart" (simulation-able microwave artwork) libraries, which combined an electrical model of MMIC components with each component's physical layout. Compact would team up with primes Raytheon and TI along with partners General Dynamics, Norden Systems, Teledyne, Litton Airtron and Aerojet on their contract worth $68 M (HP's MDS was not part of the phase 1 awards).[10]

The infusion of money, directly and to their end-users, would help subsidize the new developments in modeling, analysis and design to manufacturing (CAD layout) required to support the complexity introduced by MMIC technology through the late 1980s and early 1990s. While HP was relatively quiet from the initial launch of its linear simulator until 1989 and the release of MDS B.01.00, Compact and EEsof were extremely busy adding and marketing capabilities that targeted the emerging MMIC market. Acquired and internally developed technologies, such as improved circuit simulation, netlist to artwork conversion, CAD with graphical interfaces, synthesis and IC model libraries were continually being added to both families of products.

Over this period, EEsof linked Touchstone to an artwork conversion tool called MiCAD, a transmission line calculator (LineCalc), circuit synthesis (E-Syn) and a version of microwave SPICE. The company also introduced ANACAT, which allowed control of the HP 8510 or equivalent Wiltron network analyzer from a PC, and sorted the resulting data into the necessary formats for use with Touchstone, Lotus 1-2-3 and dBase. The products also became available on the DEC VAX, Apollo and HP 300 series in addition to the PC.

By the middle of 1987, EEsof increased the number of components available in Touchstone, added many MMIC-based devices and was openly hinting of upcoming nodal-reduction algorithms (for speed and handling larger circuits), generalized nodal noise figure calculations, a schematic editor specifically for microwave/RF engineers and a new class of frequency-domain nonlinear simulator. The mainframe platform support, MMIC models, new analyses and emphasis on computing power indicated that the company was actively pursuing the emerging MMIC market.

In 1987, as the battle for the hearts and minds of MMIC designers raged, the cost-conscious side of the software market was being ex-

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AE313	50 ~ 2200	19	3.5	19
AE314	50 ~ 1200	22	2.3	20
AE324	50 ~ 1200	23	2.0	22
AE417	50 ~ 1200	13	3.4	24.8
AE414	50 ~ 2200	20	1.9	25
AE427	50 ~ 1200	25	2.0	24.2

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AE514	50 ~ 2200	18.5	2.6	25.2
AE617	50 ~ 1200	22	2.3	28
AE627	50 ~ 1200	19	3.8	29.6
AE618	50 ~ 1200	20.8	2.1	30.8

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AE362	50 ~ 6000	15.8	1.3	32
AE364	50 ~ 6000	14.3	1.9	35
AE374	50 ~ 6000	16.5	1.3	38
AE384	50 ~ 6000	14	1.4	39
AE366	50 ~ 1200	23	1.4	39
AE365	50 ~ 1200	15	2.5	37

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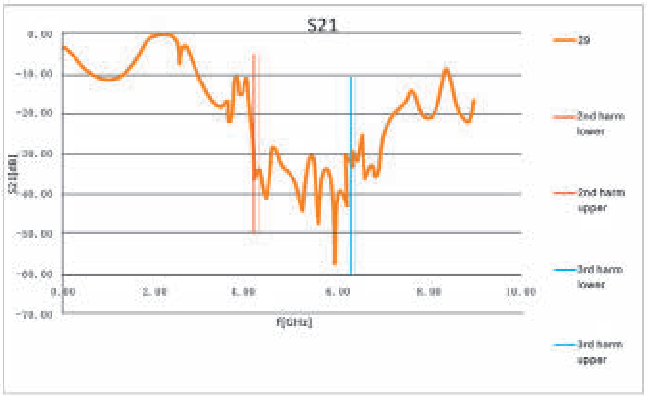

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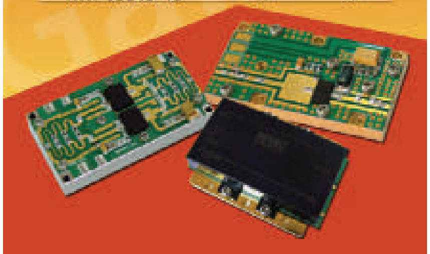
RWP03040-10	35	40

20~1000MHz products

Part Number	Gain (dB)	Psat (W)
RWP05020-10	37	20
RWP05040-10	37	40

450~870MHz products

Part Number	Gain (dB)	Psat (W)
RWP06020-10	37	20
RWP06040-10	37	40



500~2500MHz products

Part Number	Gain (dB)	Psat (W)	Size (MM)
RUP15010-10	14	10	55x30
RUP15010-11	57	10	120x80
RUP15020-10	15	20	60.4x30.2
RUP15020-11	57	20	120x80
RUP15030-10	14	30	90x50
RUP15050-10	11	50	100x50
RUP15100-10	55	100	130x60

1000~2000MHz products

Part Number	Gain (dB)	Psat (W)
RWP15020-10	26	20

2~520MHz products*

Part Number	Gain (dB)	Psat (W)
RWP02020-10	35	20
RWP02040-10	35	40
RWP02080-10	35	80
RWP02160-10	35	160

* Release scheduled 2009 Q4

2500~6000MHz products*

Part Number	Gain (dB)	Psat (W)	Size (MM)
RUP43010-10	8	10	70x35
RUP43020-10	7	20	75x35

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plored by a filter designer named Randy Rhea and his company Circuit Busters Inc. Their product Super-Star, a linear simulator with two-port and nodal capability, and random, gradient and pattern search optimization, sold for under $600 (see ***Figure 3***). In comparison, a seat of Touchstone v1.5 for the VAX mainframe was listed at a price of $13,500 in 1987. The Super-Star product would also earn a reputation for its filter synthesis capability, a feature that would define the attributes (electrical or physical) of a filter based on user-specified criteria. The Circuit Busters company would later be renamed Eagleware.

Meanwhile, under the direction of Ulrich Rohde, Compact Software was busy keeping its promise to make vast improvements to Super Compact. In 1985, according to Rohde, "both the main frame and PC versions were unstable and distributed models such as T-junctions, crosses and others were fairly inaccurate at higher frequencies." By the end of 1986, the code had been stabilized for both platforms and capabilities were being added.

In that year, the company offered synthesis capability for filters, PLL and complex matching along with microwave design, RF and communication design kits. Bi-directional control of network analyzers was available for the PC version, AUTOART circuit to layout conversion (a feature introduced during the Comsat days) was available on both platforms and the company introduced a number of new and unique analysis capabilities, including unrestricted N-dimensional nodal noise analysis for linear (and eventually nonlinear) circuits, yield optimization and user-defined model capability. Rohde was especially focused on developing the state of the art in passive model accuracy, touting this as a significant advantage over his competitors.

▲ *Fig. 3 1987 ad for SuperStar from Circuit Busters Inc. (Eagleware).*

MODELING PASSIVE ARBITRARY GEOMETRIES

RF/mW design software from EEsof, Compact, HP and Eagleware relied on netlist and schematic entry (in the case of MDS) to define the circuit topology. Parameterized distributed elements represented the transmission lines and discontinuities that defined the geometry of the physical circuit and were known (or assumed) to impact electrical performance. In general, these distributed elements were parameterized by their physical attributes which, in turn, would impact the equivalent electrical model. Artwork conversion programs were used to translate the netlist (or netlists generated from schematic) into layout for circuit visualization and mask generation.

Typically, the microwave circuit designer would progress from ideal design (wired interconnects and lumped elements) to replacing the ideal interconnects and elements with transmission lines and real element data (measured or other form); adjust the design to compensate for the change to the overall performance (via tuning or optimization); add discontinuity models to sections where transmission lines intersected and adjust the design once again. Essentially, the microwave circuit designer, like previous generations of microwave engineers, was a plumber. This time, the tool box was a library of components and the hammer was a set of parameters such as W or L.

The designer's goal was to approxi-

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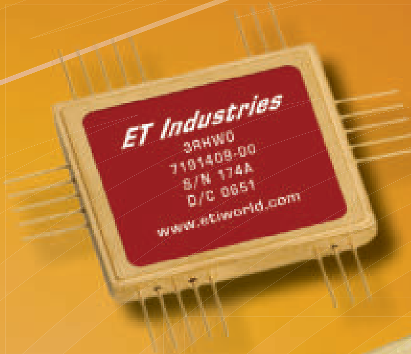

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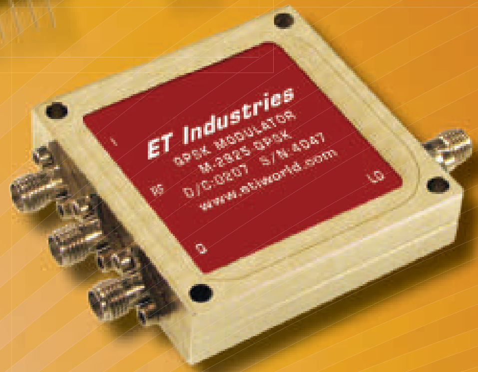

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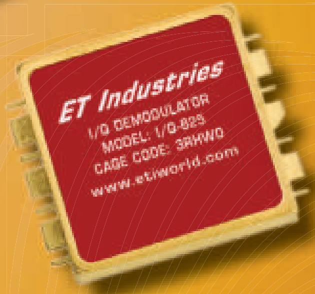

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	DC	BNC-R (Female)	
RF Power		50W max.	100W max.
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Bias Voltage		30V max.	150V max.
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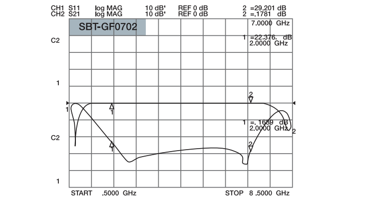

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mate the electrical performance of their circuit by aligning these individual distributed element geometries in such a way as to replicate the physical shape of the design layout. The accuracy of any circuit simulation depended on the quality of the different vendor models for distributed elements as well as the engineer's use of these models to reflect their intended physical design. Model quality and correct model use would improve over time and user experience, but was often the weak link in an accurate simulation.

Design, test and re-evaluating modeling assumptions typified hardware development during this period. With a glut of GaAs foundries, multiple design iterations were yet to be a significant problem. However, accurate modeling was most problematic for the innumerable irregular geometries being conceived, which were not analytically calculable. The inability to derive closed form solutions of Maxwell's equations under various constitutive relations of media, and boundary conditions needed to be overcome by computational numerical techniques.[11]

In the February 1986 issue of *Microwave Journal*, the cover story featured a technical article by Rolf Jansen of MCAD Software and Design Corp. (in association with Compact Software), West Germany. The article described a CAD package for layout-oriented design of single- and multi-layer MICs and MMICs up to mm-wave frequencies. The software program, known as LINMIC, incorporated analysis, sensitivity analysis and "interactive" optimization based on a spectral-domain electromagnetic technique that computed the required design data in the form of multi-dimensional look-up tables to be used in subsequent circuit design. LINMIC's EM-based models were added to the SuperCompact product and would provide a boost to its passive model accuracy, especially the multi-coupled line as verified by MIMIC team partner's Raytheon and Texas Instruments.

Through the 1970s and 1980s, a number of researchers were investigating methods to apply Maxwell's equations via computer programming to solve arbitrary geometries.

In 1975, physicist Thomas Weiland at the Technische Hochschule in Darmstadt, Germany, started working on numerical algorithms to solve the eigenvalue problem of arbitrarily shaped and filled waveguides. Weiland solved this problem by inventing the finite integration technique (FIT) for solving Maxwell's equations. Weiland left Darmstadt to work at the CERN particle-physics lab before moving on to the University of Hamburg, where he continued working on the design of accelerators and microwave components, such as cavities. Throughout this period he continued to improve and extend FIT. The resulting code later came to be called MAFIA (an acronym for solving MAxwells Equations using the Finite Integration Algorithm) and it was the first program to provide 3D simulation of particle beams moving through a cavity while under the influence of RF fields from external sources.[12] In 1983, at the Deutsches Elektronen Synchrotron (DESY) in Hamburg, he set up an international collaboration in order to develop the software package MAFIA for 3D EM and charged particle simulation. Throughout the 1980s, Weiland improved and commercialized the code, which began to get the attention of companies building RF and microwave equipment. By 1992, Weiland founded CST to commercialize MAFIA and focus on the telecoms industry.

In 1987, the *Journal* began running advertisements for a product "designed to determine the electromagnetic field and performance characteristics of high frequency microwave devices." This product, from a new company called Ansoft Corp., was called Maxwell and it could be used to analyze microwave integrated circuits, dielectric waveguides, connectors, transmission lines and cavity resonators.

The new numerical methods and the introduction of the IBM PC in 1981 led a number of university professors and researchers to start electromagnetic field simulation software companies: MAFIA (now CST), Vector Fields, IES, Infolytica and Magsoft/Cedrat. Also among the first commercial EM products was a program from Jim Rautio (a former General Electric MMIC designer) called Sonnet Software released in 1989. This

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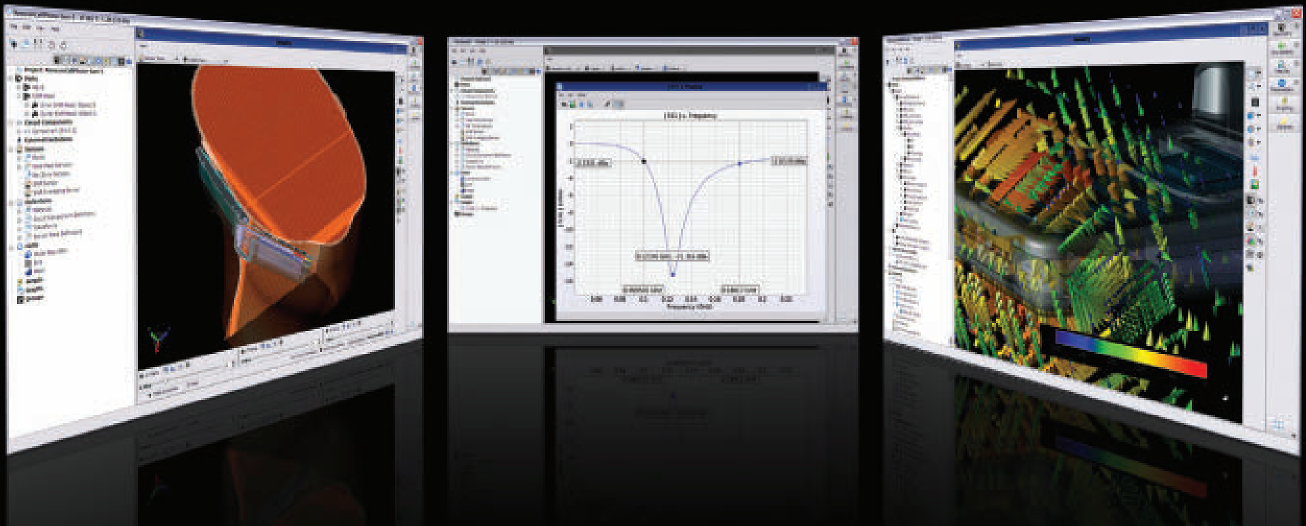

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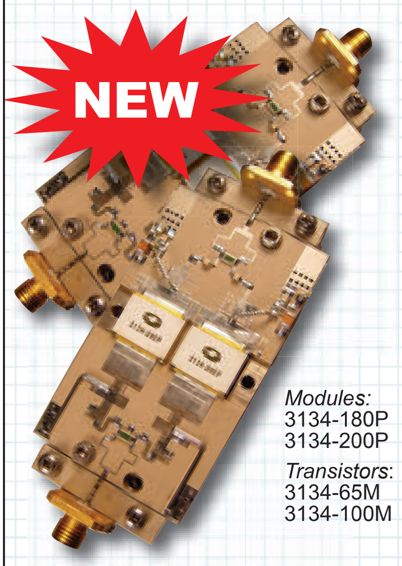

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"planar" electromagnetic simulator solved arbitrary 2 and 2.5D (planar) problems using the Method of Moments applied directly to Maxwell's Equations. Structures were defined by their geometry and the dielectric stack-up. The program subdivided the metal structure into a mesh of small subsections based on a rectangular grid and would calculate the voltage everywhere due to current on that one subsection, repeating for all the sub-sections. The simulation provided S-parameters of the structure, which could be used to validate analytic models, develop libraries, troubleshoot passive structures and eventually (with optimization) perform actual design.

NONLINEAR BEHAVIOR

Integrated microwave circuits use nonlinear components such as GaAs FETS and diodes. As a result, simulation software needs to address large-signal handling performance. Linear frequency-domain simulators, which are well suited for analyzing dispersive transmission lines, could only simulate active devices operating under small-signal conditions (such as S-parameters or small-signal linear models).

Prompted by the emergence of device models for the GaAs FET and more readily available computing power in the early 1980s, efforts began to concentrate on developing efficient simulation techniques for steady-state nonlinear circuits. Nonlinear analysis was needed in order for engineers to expand simulation to power amplifiers, oscillators, mixers and examine traditional linear circuits as they approach nonlinear behavior.

Before 1987, the commercially available tools for nonlinear analysis were SPICE (microwave versions in both Touchstone and SuperCompact) and the Volterra series expansion.[13] Researchers, many tied to academia, were investigating different approaches to high-frequency nonlinear simulation that, unlike SPICE, could address distributed transmission line models. SPICE, which had to perform a large number of computations over hundreds of thousands of cycles to achieve steady state at microwave frequencies, was unacceptably slow. The most promising candidate for an alternative nonlinear (periodic and quasi-periodic) steady-state simulator at high frequencies was known as Harmonic Balance (HB).

Harmonic balance methods are variations of Galerkin's method, first described in 1915, when applied to nonlinear circuits.[14] This method assumes a solution containing unknown coefficients, which is substituted into the governing equations and the unknown coefficients are adjusted so that the governing equations are satisfied as accurately as possible. This is known as convergence. When the assumed solution is a sum of sinusoids, the procedure is referred to as harmonic balance.

The name appeared as early as 1937 in the work of Ukrainian scientists Kryloff and Bogoliuboff. The method was developed and applied to nonlinear circuits by E.M. Baily of Stanford in 1968 and J.C. Lindenlaub 1969. In 1976, Nakhla and Vlach[15] reduced the number of variables to be optimized by partitioning the network into smaller sub-networks composed of linear or nonlinear elements. This technique, originally referred to as piecewise harmonic balance, splits the networks into linear and nonlinear portions, solving the linear portion in the frequency domain and the nonlinear portion in the time-domain. The nonlinear time-domain solution is converted into the frequency-domain via discrete or fast Fourier transform (DFT or FFT) and the spectra of the currents at the linear-nonlinear interface are compared. The continuity equation for current requires that the nonlinear currents equal the linear currents. The technique seeks a solution to this steady-state nonlinear problem by iteratively solving for a set of variables such as the voltages at the linear-nonlinear interface.

Like the plethora of EM simulators, transistor models, measurement techniques and IC processes that have evolved over time, harmonic balance has had many implementations. Each method is like a recipe, constantly being tweaked to optimize performance for the intended problem. Being an iterative solver, the challenge for scientists and programmers was to develop techniques that would achieve convergence—most rapidly, accurately and for the range of circuit problems being implemented by the RF/microwave industry.

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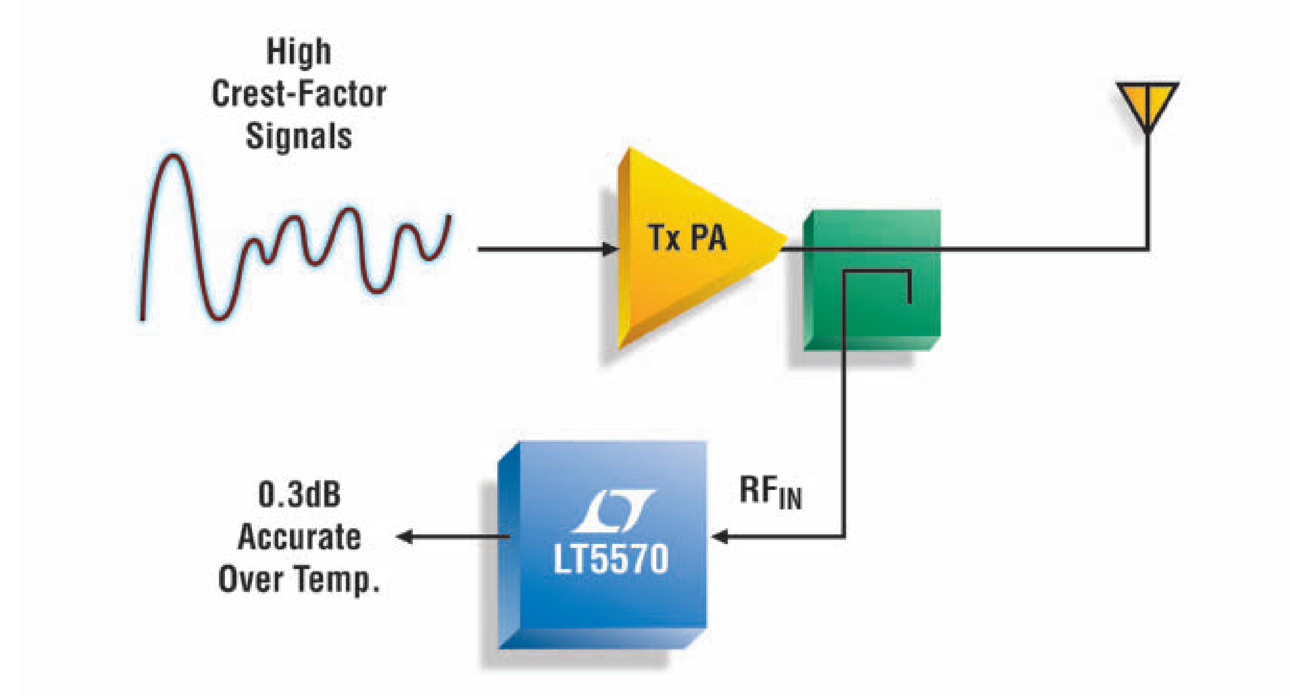

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LTC5507	100kHz – 1GHz	46dB Peak
LTC5508	600MHz – 7GHz	44dB Peak
LTC5532	600MHz – 11GHz	42dB Peak

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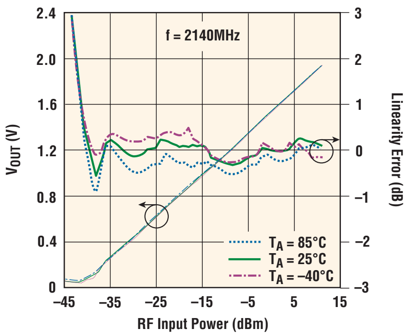

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LINEAR TECHNOLOGY

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Investigating the criteria for convergence, Hicks and Kahn developed the fixed-relaxation method (1980-1982); Kerr developed the multiple-reflection method in his 1975 paper, "A Technique for Determining the Local Oscillator Waveforms in a Microwave Mixer" (later to be shown by Hicks and Kahn to be a variation on the "p method"; Camacho-Penalosa developed an algorithm for determining the optimum p factor). Rizzoli, et al. used a state variable approach to overcome the problem of requiring the nonlinearities to be expressed explicitly as voltage-controlled current sources. While the currents and voltages at the nonlinear ports had to be evaluated for the harmonic balance equations, they need not be explicitly dependent on each other, but may be related through an alternate set of independent control variables (referred to as state-variables). Rizzoli's program, written in Fortran77, could then iterate on the state-variables (rather than the interface currents) and call the nonlinear models with time-samples of the state-variable.[15]

In October 1987, the *Microwave Journal* cover featured a new commercial simulator from Compact software called Microwave Harmonica. It was the commercialization of Rizzoli's program and Rizzoli was credited with the Microwave Harmonica mainframe implementation in the article. This program would represent the first nonlinear frequency-domain simulator to reach the market, if only by one month. By November, EEsof was marketing its netlist-based nonlinear frequency-domain simulator, Libra.

Ken Kundert, a Research Fellow for the Networks Measurements Division of HP pursuing his PhD at UC Berkeley, developed the core algorithms and code base for the microwave "harmonic balance" circuit simulator (MNS) version of MDS, HP8515b. In 1986, Kundert and UC Berkeley advisor, Alberto Sangiovanni-Vincentelli, published a paper, "Simulation of Nonlinear Circuits in the Frequency Domain," which described the spectral Newton technique as implemented in the project he developed at Berkeley called Harmonica.

▲ *Fig. 4 1987 HP MDS ad featuring J. Botka, B. Donecker, D. Rytting, J. Meyer and J. Fitzpatrick.*

Stating that the piecewise implementation of harmonic balance, which required an optimizer to solve the frequency-domain equations formulated by the technique, would result in the number of harmonics and nonlinear devices being severely limited, the authors solved the nonlinear equations with Newton's method (frequency-domain analysis of nonlinear circuits driven by multi-tone signals).[16] This approach did not require partitioning the circuit into linear and nonlinear networks and was thus known as the nodal formulation.

Nodal harmonic balance treated every node in the circuit the same way, whether it was nonlinear or not. This approach would prove more capable in solving circuits with more nonlinear devices operating under more strongly nonlinear conditions than the piecewise approach. The piecewise approach would prove to have a speed and convergence advantage where the circuit had more passive components and was only moderately nonlinear. As these techniques became commercialized, designers would become intimate with the engine settings (i.e. state variables, number of harmonics) and source conditions (i.e. power levels) to assist the simulator with convergence.

In 1989, EEsof introduced the company's nonlinear high frequency simulation tool, Libra, based on what they learned and could leverage from Kundert's work. UC of Berkeley's open source policy allowed them to study and use some parts of the actual code including the sparse matrix package. However, the Libra HB engine was based on the piecewise formulation of harmonic balance and not Kundert's nodal approach. Six months after returning to HP in 1988, Kundert's work was commercialized in the MDS HB engine and released in early 1989 (see ***Figure 4***).

Because Compact Software had trademarked the Microwave Harmonica name, Kundert changed the name of his Berkeley program from Harmonica to Spectra, which in turn was leveraged into the Spectre and SpectreRF programs (a SPICE-like transient simulator before harmonic balance was added), developed by Kundert when he joined Cadence Design Systems Inc. after leaving HP the same year as the MDS HB simulator was released. Kundert's advisor and co-author, Alberto Sangiovanni-Vincentelli, was co-founder of Cadence (as well as rival EDA vendor Synopsys). The Spectre and Spec-

TABLE I

POTENTIAL MIMIC REQUIREMENTS OF SELECTED SYSTEMS (1989)

SYSTEM	ARRAY SIZE	TOTAL SYSTEMS	TOTAL MIMICs
ATF	2,000	750	12×10^6
ATA	3,800	2,000	38×10^6
ALQ-131	64	400	128,000
ASPJ	64	750	1.44×10^6
INEWS	64	750	1.44×10^6

ATF: Advanced Tactical Fighter Aircraft
ATA: Advanced Tactical Aircraft
ALQ-131: ECM pod for Tactical Aircraft (F-16, A-10, F-11)
ASPJ: Airborne Self-protection Jammer
INEWS: Integrated Electronic Warfare System

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SM: I promised to dress up like a woman if we beat our productivity goal in 2008. We did, so here I am in all my glory!

MWJ: How does IKE Micro produce at such a high level?

SM: We have a veteran, low-turnover workforce, and a good balance of automated and manual assembly capability. Because of our 100% focus on build-to-print manufacturing, design and market issues don't get in the way of the delivery schedule.

MWJ: Are your company's assembly capabilities comprehensive?

SM: Yes, from DC to 100GHz. Our capabilities include surface mount, epoxy and solder board mount, feedthru installation, die attach, wire/ribbon bond, coil and beam lead bonding, and all the crazy RF soldering and bonding needed so our units make it through test with minimal tuning.

MWJ: What types of customers take advantage of IKE's experience and capabilities?

SM: It's a good mix. It includes the big systems companies and many of the small to mid-sized module suppliers. Many of these companies advertise with you. We do complex modules and pretty basic subassemblies. Our domestic and international customer mix is 65% defense and 35% commercial.

MWJ: What are your goals for 2009?

SM: I want to continue to produce at high levels and exceed customer expectations. More importantly, I plan to steer clear of the EE design guys, some of those guys freak me out, especially when I'm wearing this dress.

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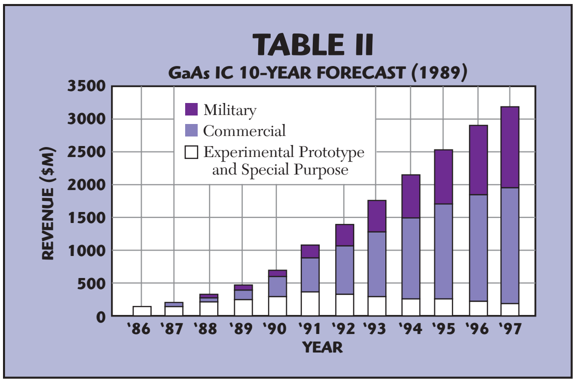


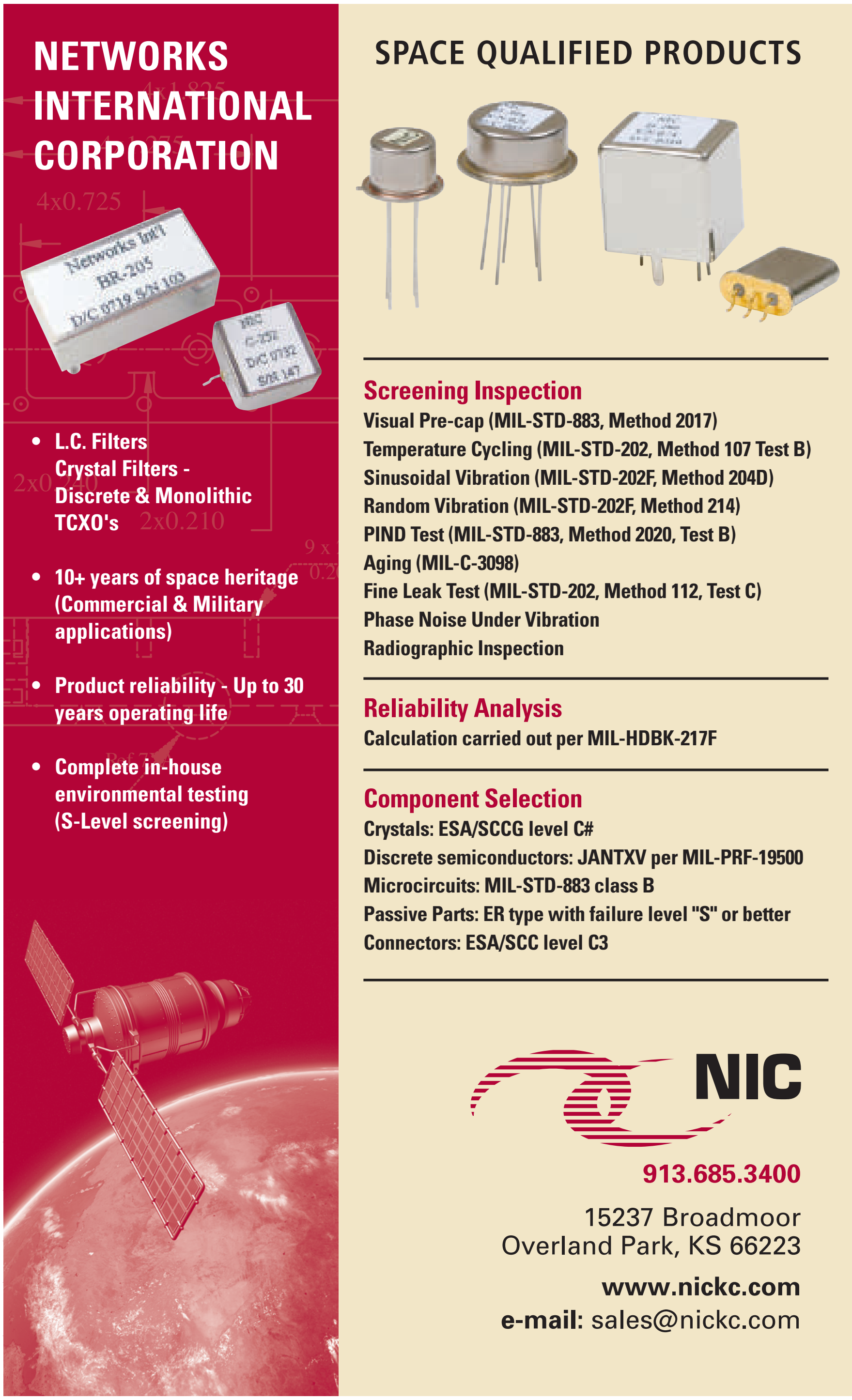
treRF simulators would help transform Cadence from a CAD company into a leading EDA company. SpectreRF and its nodal formulation would provide a distinct advantage in addressing the RFICs developed in the mid-1990s.

By the late 1980s, the RF and microwave circuit design market was being served by four major competitors—Compact, EEsof, Eagleware, and HP. The MIMIC program started in December of 1987 was well into phase 1 (the second of a four-phase program) and was providing the driving force in the development of GaAs integrated circuits and supporting CAE software. The DoD and NATO were gravely concerned that the Warsaw Pact had superior resources and was gaining a technological advantage. The recently signed INF treaty forced military planners to devise a way to stop (without using nuclear weapons) a potential large-scale Warsaw Pact assault. Despite improvements in US-Soviet relations and Congress' close scrutiny of defense spending, high-tech weapon systems based on advanced components were needed (see ***Table 1***). This threat provided the MIMIC program funds, which would take microwave design to the next level of complexity at a critical stage.

While the commercial support for advanced GaAs ICs was very limited, the DoD did project that a growing commercial demand would emerge in the 1990s, as shown in ***Table 2***. To address this need, software would once again needed to evolve. This time, the digitally-modulated RF devices such as MMICs, RFICS and multichip modules (MCM) in the emerging wireless communications market would drive the need for greater simulation capacity, more automation, new design environments, EM and system simulation along with the integration of these tools.

CONCLUSION

What were the watershed moments in design software? The development of microstrip/stripline transmission line theory, and MIC and MMIC technologies, the GaAs FET and simulation models, the adoption of S-parameters and the network analyzer, two-port linear analysis, parameterization and optimization, development of distributed transmission line models, time-shared mainframe computers, the microprocessor and PC, the development of planar and 3D electromagnetic simulation, the development of harmonic balance, krylov-subspace, transient assisted harmonic balance, circuit envelope, netlist to artwork conversion software, the schematic



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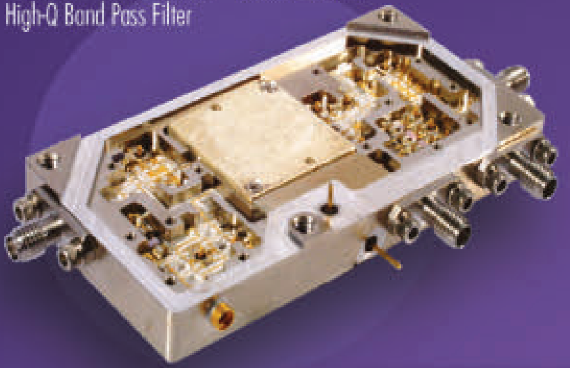

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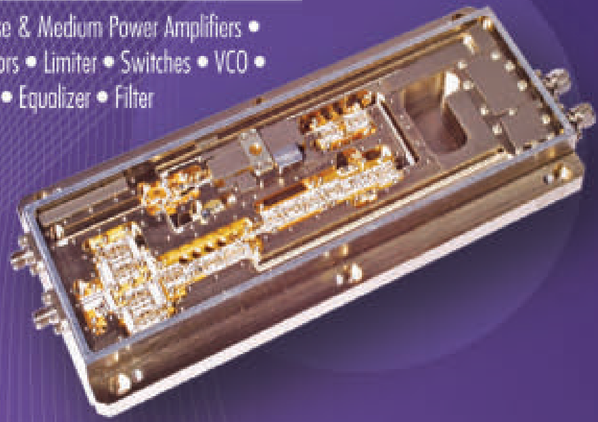

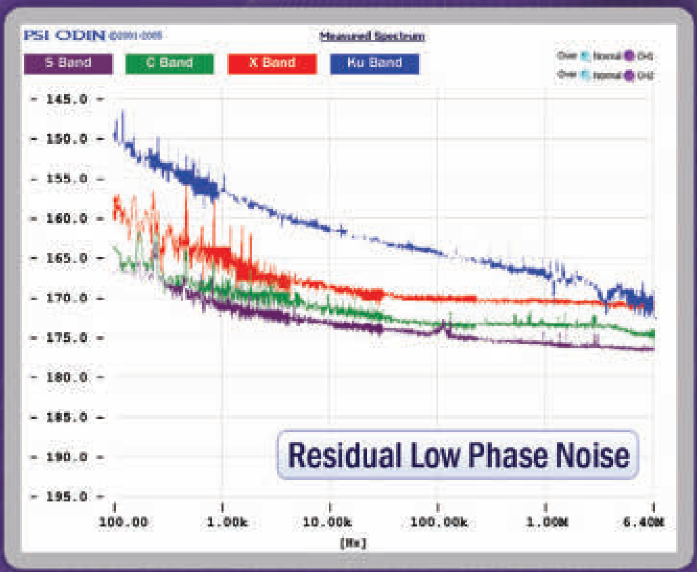

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PART II

In Part II, our story continues with contributions from the people working in CAE/EDA today. As military spending winds down and cellular technology takes off, the software market goes through some fundamental changes. HP acquires EEsof; Ansoft acquires Compact, Applied Wave Research (AWR) and Computer Simulation Technologies (CST) enter the market; The MAFET program; EM and system tools make significant gains in capability and popularity; and automated design environments (ADS, Microwave Office, Ansoft Designer, Genesys and Microwave Studio) with integrated simulators, layout, EM and more take center stage all while playing a critical role in the wireless revolution.

COMMENTS

Have some war stories from your early days of using, developing or supporting RF/microwave CAE software? We would love to hear from you. Contact the author at dvye@mwjournal.com.

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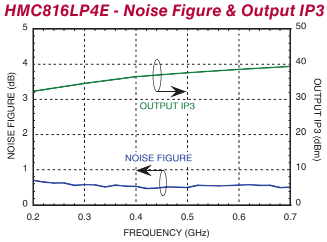

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NEW!	10 kHz to 14 GHz	Fractional-N w/ Int. Sweeper	75	200	-221 / -227	6 Hz	+5V @ 37mA +3.3V @ 136mA	LP6C	HMC702LP6CE
	10 MHz to 8 GHz	Fractional-N	70	200	-221 / -226	3 Hz	+5V @ 7mA +3.3V @ 95mA	LP4	HMC700LP4E
	80 MHz to 7 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 310mA	LP5	HMC698LP5E
	160 MHz to 7 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 310mA	LP5	HMC699LP5E
	10 MHz to 2.8 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 250mA	QS16G	HMC440QS16GE

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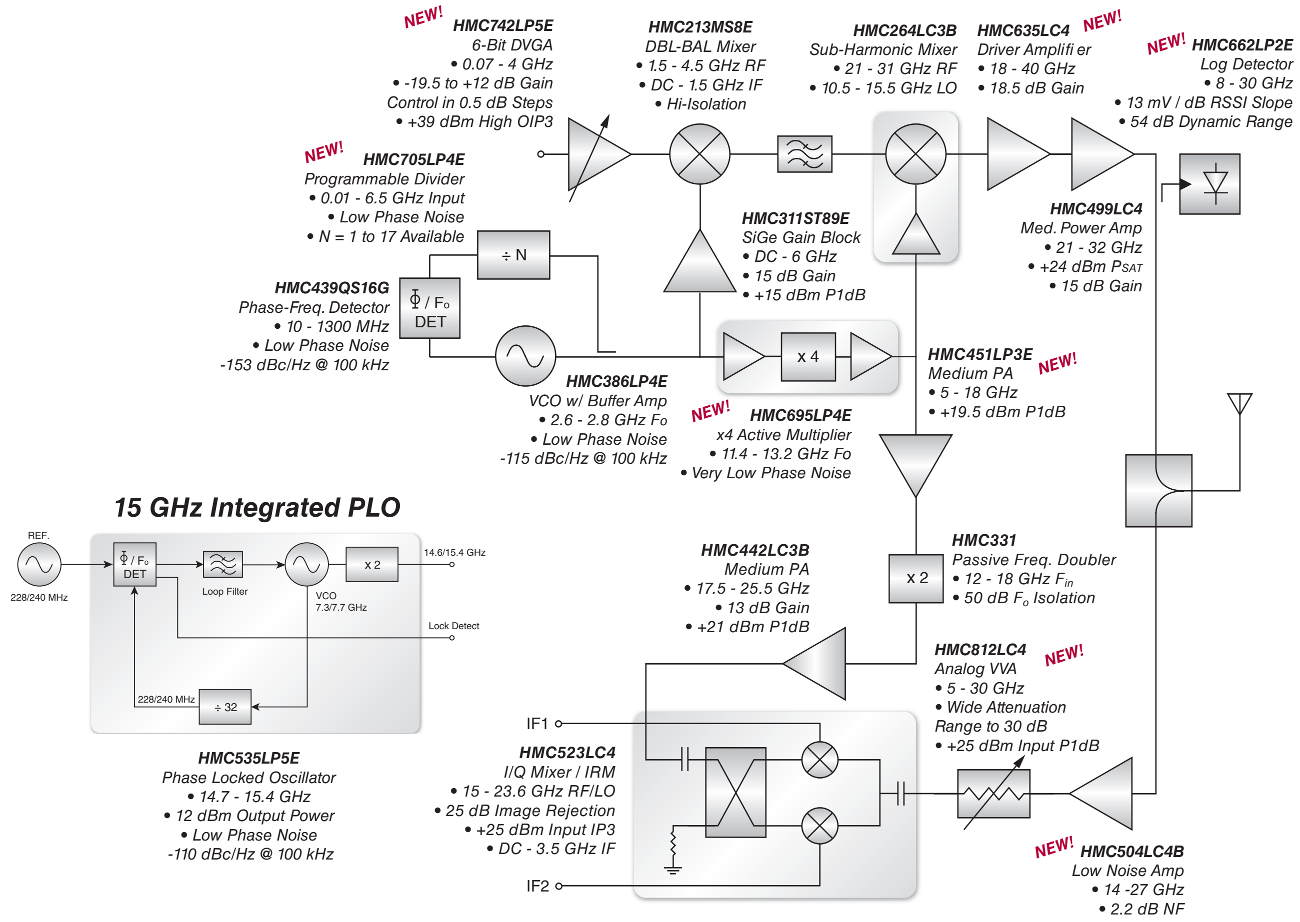

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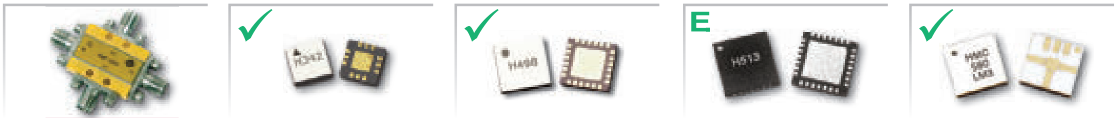

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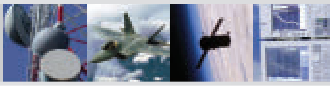

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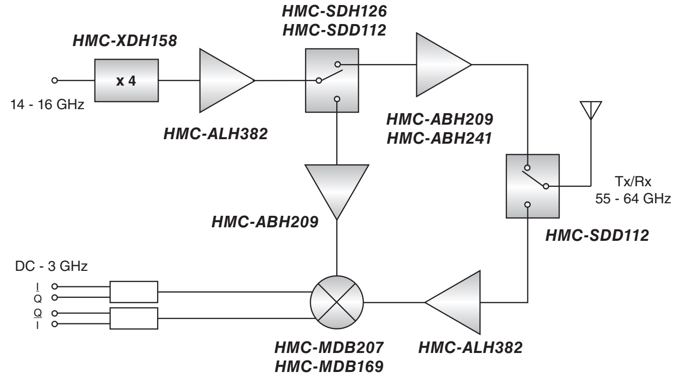
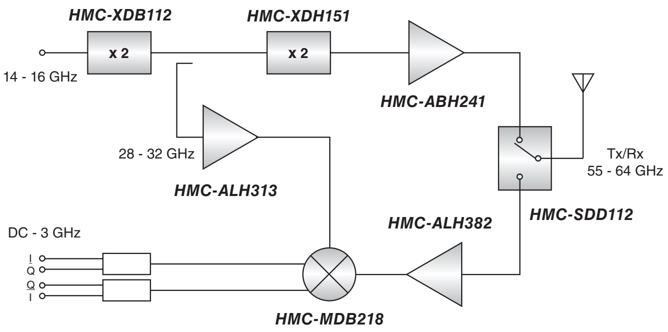


Sub-Harmonic Option for 60 GHz Chipset



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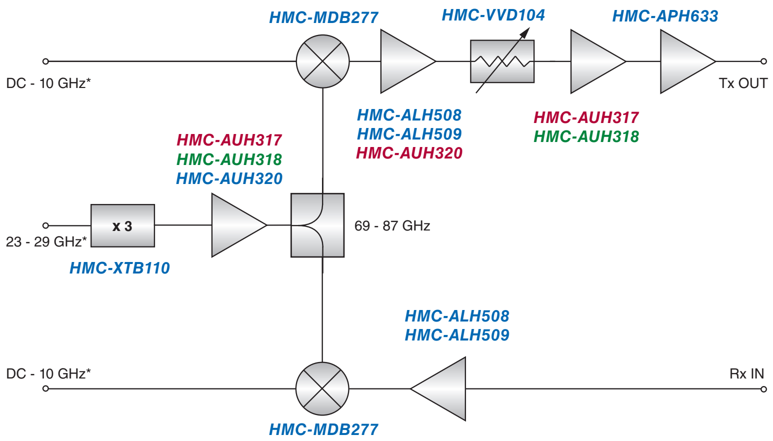

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CA01-2110	0.5-1.0	28	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111	4.0-8.0	29	1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA812-3111	8.0-12.0	27	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA1218-4111	12.0-18.0	25	1.9 MAX, 1.7 TYP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1

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Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

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CA0102-3111	0.1-2.0	28	1.6 Max, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA0106-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max, 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112	0.1-8.0	32	3.0 MAX, 1.8 TYP	+22 MIN	+32 dBm	2.0:1
CA02-3112	0.5-2.0	36	4.5 MAX, 2.5 TYP	+30 MIN	+40 dBm	2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0	22	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA618-4112	6.0-18.0	25	5.0 MAX, 3.5 TYP	+23 MIN	+33 dBm	2.0:1
CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110	2.0-18.0	30	5.0 MAX, 3.5 TYP	+20 MIN	+30 dBm	2.0:1
CA218-4112	2.0-18.0	29	5.0 MAX, 3.5 TYP	+24 MIN	+34 dBm	2.0:1

LIMITING AMPLIFIERS

Model No.	Freq (GHz)	Input Dynamic Range	Output Power Range Psat	Power Flatness dB	VSWR
CLA24-4001	2.0 - 4.0	-28 to +10 dBm	+7 to +11 dBm	+/- 1.5 MAX	2.0:1
CLA26-8001	2.0 - 6.0	-50 to +20 dBm	+14 to +18 dBm	+/- 1.5 MAX	2.0:1
CLA712-5001	7.0 - 12.4	-21 to +10 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1
CLA618-1201	6.0 - 18.0	-50 to +20 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	6.0-12.0	24	2.5 MAX, 1.5 TYP	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25	2.2 MAX, 1.6 TYP	+16 MIN	20 dB MIN	1.8:1
CA1518-4110A	15.0-18.0	30	3.0 MAX, 2.0 TYP	+18 MIN	20 dB MIN	1.85:1

LOW FREQUENCY AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

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Harris Awarded $736 M for Weather Satellite System

Harris Corp. has been awarded a 10-year, potential $736 M contract to provide a complete, end-to-end solution for the National Oceanic and Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite — Series R Ground Segment (GOES-R GS) program.

The Harris team will design, develop, deploy and operate the GOES-R ground segment, which will receive and process satellite data, and generate and distribute weather data to more than 10,000 direct users. Harris will also provide the command and control of operational satellites. The Harris team is providing a service-based, open-architecture solution that will accommodate the anticipated 40-times increase in data to be ingested, processed and distributed. The first launch of a GOES-R series satellite is scheduled for 2015.

Today's GOES satellites provide the images and time-lapse sequences familiar to most Americans because they are commonly used in television weather forecasts. The satellites are the primary tool used by NOAA to detect and track hurricanes, thunderstorms, tornadoes and other severe weather in the continental US and the western hemisphere. The next-generation GOES-R system will provide significantly improved image resolution and increase the rate of imagery coverage of earth surfaces from every 30 minutes to every five minutes in normal conditions, and every 30 seconds during periods of severe weather.

Growing Market for Active Electronically-Scanned Arrays (AESA)

In January 2007—around two-and-a-half years' back—Engalco released the first industry and market report concerning AESAs. That first report clearly showed that these types of radars already had great operational significance whilst at the same time providing substantial and growing markets for the associated transmit-receive modules (TRM) and MMICs. The AESAs Report was understandably well received and the time is now right for an update: AESAs2, recently released by Engalco.

A substantial amount of new research lies behind AESAs2, including of course the likely impacts of US Defense Secretary Richard Gates' major review. There are many changes affecting the main application segments of airborne, land-based and shipboard platforms, and an entirely new segment is included providing quantitative data on space-borne radars. Several recently announced new AESA systems are included throughout this report for each segment.

Airborne applications represent the main markets with 379 "free world" shipments in 2009 rising to 1,638 in 2015. These markets are typically two orders of magnitude above those applying to either the land-based or shipboard segments. Total "free world" market values are just over US$6 B in 2009, which more than doubles to exceed US$13 B for 2015. Throughout the report the geographic segmentations are: Europe, North America and the Rest of the "Free World" (RoW).

Engalco's research indicates that the total available markets for TRMs will approach US$1.3 B for 2009, which will grow strongly over most of the time scale. Total markets for the required MMICs, implemented in each TRM, to a large extent mirror the forecasted data for the TRMs. However, careful attention is paid to the impacts of unit prices on both TRM and MMIC market values. Unit price data, including regional and application-segment forecasts, are provided for TRMs and MMICs. The impact of new technologies such as GaN power amplifiers and SiGe BiCMOS receivers is taken into account in the data.

AESAs2 includes extensive market data charts and tables complete with commentaries and critiques, covering all application segments and geographic regions to 2015. Forecasted shipments data are included and the retrofitting of AESAs onto existing platforms represents an important feature of this report. For further information, please contact Engalco at +44 (0)1262 424 249 (GMT) or e-mail: enquiries@engalco-research.com.

Lockheed Martin to Develop Long-range Radar for US Air Force

The US Air Force has awarded Lockheed Martin a fixed-price contract for nearly $25 M to develop a prototype for the next-generation 3-Dimensional Expeditionary Long-Range Radar (3DELRR). Lockheed Martin was one of two teams placed under contract for the technical development of this new land-based radar.

The Electronic Systems Center at Hanscom Air Force Base leads the acquisition for the new radar. The Air Force plans to replace its entire TPS-75 long-range radar inventory with the 3DELRR, which will detect, identify, track and report aircraft and missiles. Following a 20-month Technical Development Phase, the Air Force has said it intends to competitively award one contract for system development in the 2011 timeframe.

"Lockheed Martin will leverage our years of experience in developing transportable long-range radars to provide our long-time Air Force customer with a radar that will meet its mission requirements," said Carl Bannar, Vice President of Lockheed Martin's radar business in Syracuse, NY. "We are honored to have been selected to continue development on 3DELRR, and intend to demonstrate that we have the best solution."

Lockheed Martin built the first next-generation long-range radar, the AN/TPS-59. There are more than 170 of the company's radars—including the TPS-59, the AN/FPS-117 and the AN/TPS-77—operating throughout the world. The radars are used in areas such as battle theaters and very remote locations; none has ever been removed from service.

Micro Systems Awarded Target Control Transponders Contract

Herley Industries Inc. announced that its Micro Systems subsidiary located in Fort Walton Beach, FL, has been awarded a production order totaling $1.5 M on a long-term production contract. The order from a major defense prime contractor represents the exercise of a contract option for target control transponders for a quantity of 15 full scale aerial target drones and a number of spare assemblies.

Wayne Armstrong, Micro Systems' President, stated, "This option award is a prime example of the type of work that is the core of our business. This long-term production contract was preceded by an extensive development effort. We are now in steady state production and expect annual orders for a number of years into the future. Our focus on timely deliveries of quality products at fair prices results in long-term partnerships with our customers."

Raytheon Awarded $14 M for Patriot Depot-level Maintenance

Raytheon Co. has been awarded $14.7 M for depot-level maintenance for US Army Patriot Air and Missile Defense Systems.

The US Army Aviation and Missile Command, Redstone Arsenal, AL, provided the additional funding under a contract previously awarded to Raytheon in June 2006. This is the fourth option bringing the value of the sole-source contract to $51.9 M. "This contract provides for third-echelon maintenance performed by Raytheon field engineers at locations in the United States and overseas," said Joseph "Skip" Garrett, Vice President and Deputy for Patriot Programs at Raytheon Integrated Defense Systems (IDS). "These services are necessary to ensure the high reliability and readiness that the Army requires."

Services under this contract include diagnostics, maintenance, repairs, modifications and technical assistance at a level higher than Patriot units are able to perform.

Raytheon IDS is the prime contractor for both domestic and international Patriot Air and Missile Defense Systems and systems integrator for Patriot Advanced Capability-3 missiles.

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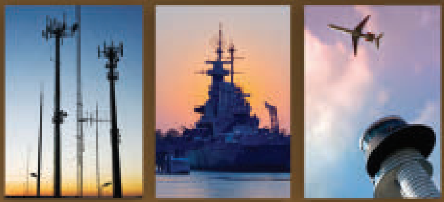

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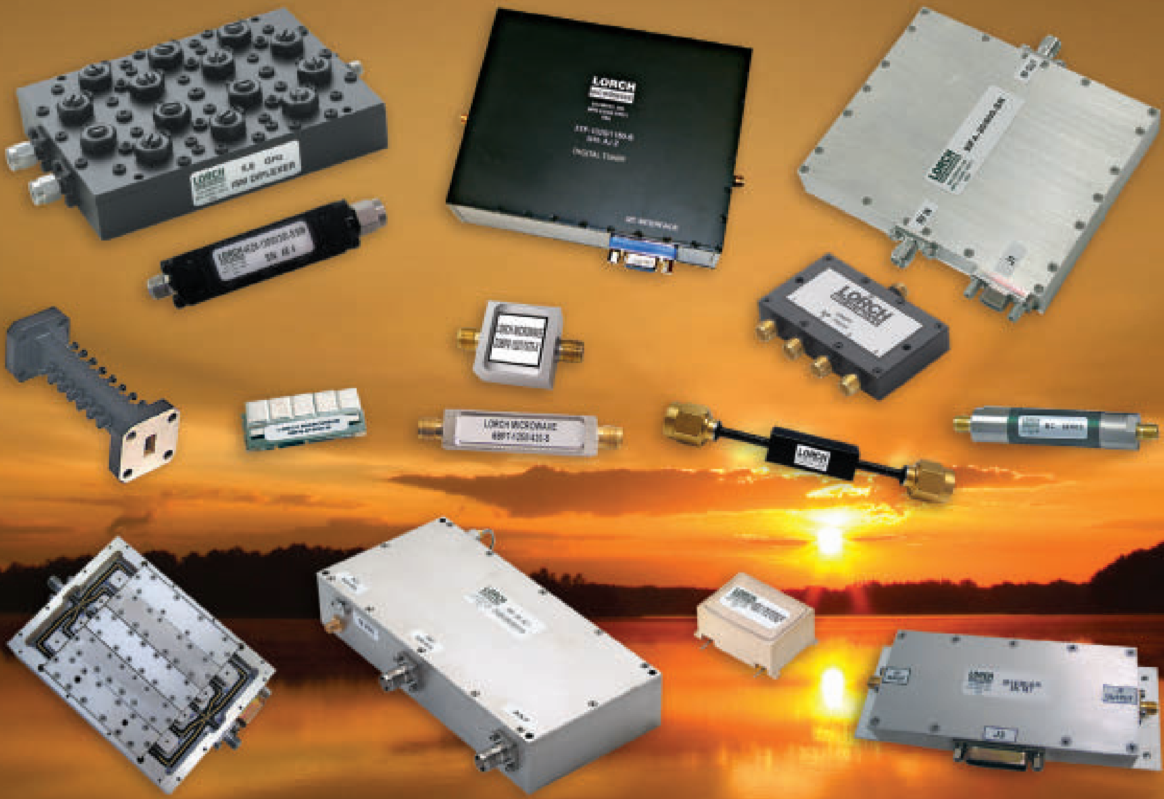

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20 - 115 MHz, minimum	≥ 40 dB @ 150 MHz & ≥ 50 dB @ 250 - 600 MHz
20 - 150 MHz, minimum	≥ 40 dB @ 200 MHz & ≥ 50 dB @ 300 - 600 MHz
20 - 220 MHz, minimum	≥ 40 dB @ 300 MHz & ≥ 50 dB @ 450 - 900 MHz
20 - 335 MHz, minimum	≥ 40 dB @ 440 MHz & ≥ 50 dB @ 660 - 1400 MHz
20 - 500 MHz, minimum	≥ 35 dB @ 670 MHz & ≥ 50 dB @ 1005 - 2000 MHz
20 - 700 MHz, minimum	≥ 40 dB @ 980 MHz & ≥ 50 dB @ 1470 - 2000 MHz
20 - 1010 MHz, minimum	≥ 35 dB @ 1400 MHz & ≥ 50 dB @ 2100 - 3000 MHz
20 - 1400 MHz, minimum	≥ 40 dB @ 2000 MHz & ≥ 50 dB @ 3000 - 4200 MHz
20 - 2000 MHz, minimum	≥ 40 dB @ 2800 MHz & ≥ 50 dB @ 4200 - 5000 MHz
20 - 3000 MHz, minimum	≥ 40 dB @ 3940 MHz & ≥ 50 dB @ 5910 - 6000 MHz

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Radar on Chip for Cars Cooperative Formed in Germany

Infineon Technologies AG, Robert Bosch GmbH, BMW Forschung und Technik GmbH, Continental AG and Daimler AG have formed the Radar on Chip for Cars (RoCC) technology cooperation project. The companies are engaged in joint research with the aim to significantly increase driving safety by making highly reliable radar systems available in all vehicle classes.

The three-year RoCC project has a budget of more than €17 M. It is supported by a financial grant of €8.3 M from the German Federal Ministry of Education and Research (BMBF), as part of the ITK2020 support programme focusing on 'Innovation Alliance in Automotive Electronics'. The German government's high-tech strategy promotes efforts made to reduce the overall number of traffic accidents, in this case by helping to introduce innovative safety solutions into the compact and small-vehicle classes as quickly as possible.

In the RoCC cooperative project, the five companies will work together to develop highly integrated, cost-optimized automotive radar sensor systems in the 76 to 81 GHz frequency range for both long-range systems (covering distances of up to 250 m) and short-range systems (covering distances between 5 cm and 20 m). Infineon Technologies is the project coordinator. Additional participants from academia include German universities in Bochum, Bremen, Erlangen-Nuremberg, Stuttgart and Ulm, the Technical University in Munich and the University of Applied Sciences in Ulm.

Short-range automotive radar sensors in use today use ultra-wideband technology at 24 GHz. This frequency, however, is licensed in Europe only up until 2013. The RoCC project aims to convert the system to the frequency range already released by the European Union of 79 GHz, and deliver systems that use these higher-frequency sensors at a cost that does not exceed today's 24 GHz systems. This presents a significant challenge to semiconductor technology, sensor design technology and in-vehicle integration that can only be tackled by a joint research project involving some of the most important companies in the automotive industry and their suppliers.

NGMN Alliance and TDIA Establish AGREEMENT

The TD Industry Association (TDIA) and the NGMN Alliance, the group focussing on the evolution of next generation mobile networks, have established a cooperation agreement to support the globally harmonized development of next generation mobile broadband technologies and services.

The TDIA and NGMN will work together to promote TD-LTE technology worldwide and ensure the development of a convergent standard for Frequency Division Duplex and Time Division Duplex-based next generation mobile networks. This will lay the foundation to extend market scale and to ensure seamless mobile broadband experience for the customer. The two bodies will widen the scope of work on chipsets and devices, system interworking, trial coordination, spectrum requirements, as well as roaming support.

Peter Meissner, operating officer of the NGMN Alliance, stated, "The aim of this agreement is to avoid fragmentation of standards, to reduce cost and market risks, and to provide truly global services and devices for the end-user."

ZigBee Alliance and ESMIG Act Smart on Metering in Europe

The ZigBee® Alliance and the European Smart Metering Industry Group (ESMIG) are working together to define interoperable communications standards for smart metering technology across the European Union. The ZigBee Alliance is a global ecosystem of companies creating wireless solutions for use in energy management, commercial and consumer applications, and ESMIG is the organization for smart metering in Europe. The ZigBee Smart Energy public application profile is the first open standard to be endorsed by ESMIG.

ESMIG members determined that the ZigBee Alliance and its ZigBee Smart Energy provide a solid, open standards approach to smart metering communication. ESMIG provides impartial expertise to key stakeholders including EU institutions, EU Member State governments, authorities, regulators, electric, gas and water utility providers on all aspects related to Smart Metering.

The two organizations will collaborate and identify where ZigBee Smart Energy can be rolled out across the 27 Member States of the EU. They will evaluate ways to maximize the benefits of a standardized smart metering program for consumers, utility service providers and the environment.

"The ZigBee Alliance is both a valuable and experienced partner who can provide ESMIG with expertise and solutions for smart metering in Europe," said Howard Porter, Managing Director at ESMIG. "ESMIG believes that a handful of proven and open standards, like ZigBee Smart Energy, will play a key role in EU smart metering projects because they deliver the most value for all parties, and allow utility service providers with flexibility in choosing standards that fit their specific requirements."

Indra and Cisco Work on Defence and Security Innovation

Spain's Indra and Cisco have signed an international agreement to collaborate in the research and development of new technologies and solutions for the security and defence industries. The Memorandum of Understanding (MoU)will allow both companies to strengthen their positions in markets with high growth potential over the next few years and will initially focus on technology areas such as wireless networks, mobility, mobile data centres, Cisco TelePresence™ and IP video surveillance.

Under the terms of the MoU, the companies may also, in the future, extend their collaboration into other public and private sector market segments, such as healthcare and intelligent urbanisation, where both companies already have extensive experience and a track record of innovation.

"Working with Indra is particularly timely given the growing trend towards cross-border collaboration in today's defence and security bodies," said Chris Dedicoat, President of Cisco's European Markets. "These 'borderless' organisations need robust network systems, with the intelligence to make them secure and allow them to support collaboration across functional, geographic and interorganisational divides."

Alcatel-Lucent Opens Alternative Energy lab

Alcatel-Lucent has announced the operational launch of the first alternative energy laboratory and pilot site in the world dedicated to the telecoms sector. Located on its Bell Labs research site in Villarceaux, France, this station forms part of an Alternative Energy strategic programme launched by the company to respond to the growing demand from wireless operators for energy-autonomous and green wireless networking equipment that can provide advanced communications capabilities even in remote areas with no access to commercial power grids.

This programme builds on Alcatel-Lucent's recent innovations to create more energy efficient wireless networks and leverage its experience deploying more than 300 radio sites powered by alternative energy sources. The goal is to develop a mass-produced alternative energy solution capable of being deployed to more than 100,000 wireless base station sites through 2012.

The team staffing this lab will research technologies that will enable operators serving developed areas to retrofit existing base stations with alternative energy solutions, consequently cutting down on their carbon emission and reducing their network operating costs while protecting the environment.

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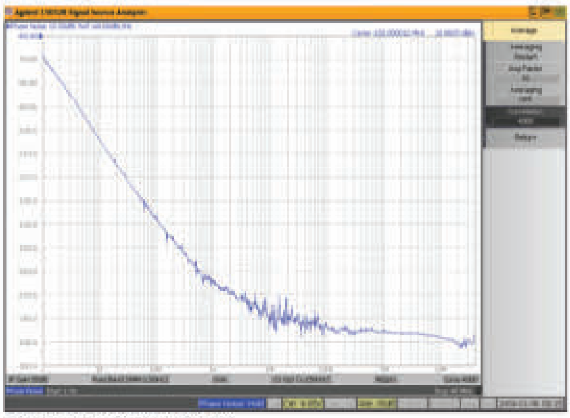

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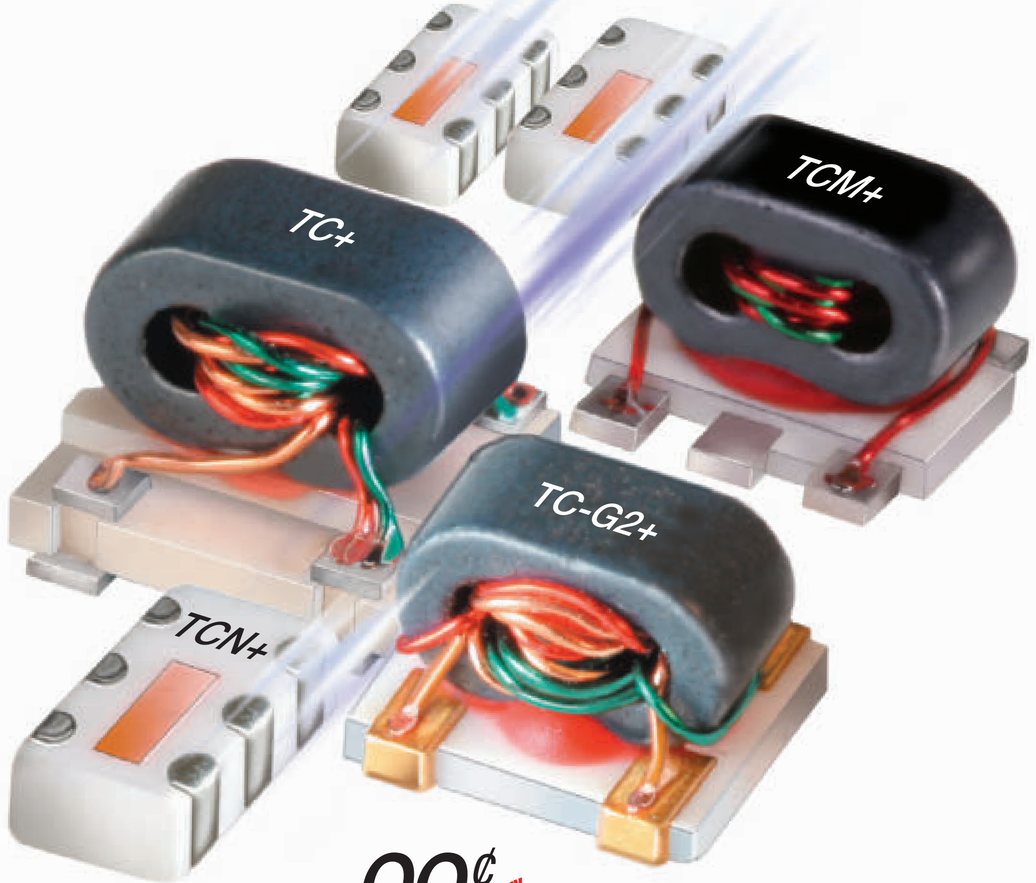

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3G and 4G Product Expansion

Mobile phone operators are now looking beyond the handset to fuel further growth. They foresee a broad range of consumer electronics devices as vehicles for 3G and 4G wireless service access. The new Strategy Analytics Connected Home Device Strategies report, "Beyond the Handset—Wireless Consumer Electronics: US Market Forecast," identifies up to 20 new device segments in which 3G and 4G wireless technologies will be embedded, and which operators could support with data and media services. The new range of embedded CE devices will create a market of 100 million installed devices for wireless operators in the US by 2014. By the end of 2009, more than half of the 8.4 million consumer electronics devices installed and enabled for 3G and 4G will be consumer notebook PCs. This entire device population of 3G and 4G enabled products will nearly double to 16.6 million in 2010, and continue to expand toward 101 million by 2014. According to Peter King, Director, Consumer Home Device Strategies at Strategy Analytics, "Beyond notebooks, Strategy Analytics expects other portable devices, such as Mobile Internet Devices and game consoles to add 3G and 4G wireless network capabilities."

"Wireless operators stand to benefit from future expansion in portable digital media device markets," notes David Mercer, Vice President, Digital Consumer Practice. "They must now pay closer attention to developing innovative multi-device business models. The majority of today's wireless service plans are poorly adapted to the need for unlimited data access across multiple consumer devices." This Strategy Analytics report also concludes that today's 3G technologies will dominate the consumer electronics device market in the near term. LTE and WiMAX will begin to have an impact in 2013 and beyond, as service availability expands and key price points are reached.

TriQuint and Win Tighten Grip on GaAs Foundry Market

The latest Strategy Analytics report, "Squeezing Out the Competition: TriQuint Semiconductor and Win Semiconductors Extend GaAs Foundry Leadership," reports that TriQuint Semiconductor and Win Semiconductors continue to squeeze out the competition, increasing their collective share of the GaAs (gallium arsenide) foundry market from 67 percent in 2007 to 77 percent in 2008.

TriQuint held onto the top spot in 2008, benefiting from commercial opportunities as well as engagements in the US defense and aerospace industries. Win Semiconductors is by far the largest pure-play GaAs foundry, pushing TriQuint hard for the number one spot in 2008, with only one percentage point separating the two companies in overall market share.

"Strategy Analytics estimates that the total market for GaAs foundry grew 27 percent year-on-year in 2008 and was worth $311 M," noted Asif Anwar at Strategy Analytics. "The market for GaAs foundry services will continue to grow as dual-sourcing and fabless strategies become more prominent in the GaAs industry."

"Start-up companies and research institutes targeting niche and emerging markets may be finding that the tapeout costs of 'cheap silicon' are too expensive in the current downturn," observed Stephen Entwistle, VP of the Strategic Technologies Practice. "This offers an additional opportunity for GaAs foundries to leverage the lower costs and higher performance capabilities offered by GaAs processes."

Ultra Low Cost Handset Surge in China and India

Ultra low-cost handsets (ULCH)—those selling for $35 or less—will determine the success of operators and vendors in emerging markets, according to "ULCH—A Key to Success for Vendors and Operators in Emerging Markets," a report from the Strategy Analytics Emerging Markets Communications Strategies service. More than half of the 300 million ULCH expected to be sold in 2013 will go to emerging markets, with China and India playing a crucial role in driving the growth.

Between 2007 and 2013, the ULCH share of global handset sales will triple, as operators try to attract new users. "Emerging markets have a huge untapped population," says Rahul Gupta, Manager, Emerging Markets, and author of the report. "But it's a population with limited spending power. A low-cost handset has to be part of the strategy of any operator or handset vendor trying to get a piece of this market."

"The most important issue for operators seeking to benefit from low-cost handset development is to choose suppliers who have global scale in purchasing, product design and brand," added Chris Ambrosio, Executive Director of the Strategy Analytics Global Wireless Practice.

This report also points out that low-cost alone is not sufficient; the need to provide a limited set of rich applications, such as embedded gaming and FM radio, along with the expansion of distribution and service networks into rural areas, compounds the challenges that operators and device vendors have in developing ULCH offerings.

CE Products and Handsets Drive Wi-Fi Chipset Growth

While mobile PCs and portable consumer electronic (CE) devices comprised the lion's share of Wi-Fi chipset shipments in 2008, mobile handsets and stationary CE categories are driving the market growth, reports In-Stat.

In 2008, Wi-Fi chipsets in mobile handsets grew by more than 51 percent. By 2010, In-Stat anticipates that this category will exceed 20 percent of the total Wi-Fi chipset market.

"A new segment of Digital Media Adapters (DMA), over-the-top devices, is also generating a lot of attention," says Victoria Fodale, In-Stat Analyst. "Over-the-top devices access third-party home entertainment services that are delivered across a broadband network with no affiliation to a specific broadband operator. These devices include Apple TV, the Netflix player by Roku and the Blockbuster/2Wire Streaming MediaPoint box."

Recent research by In-Stat found the following:

- Total Wi-Fi chipset revenue will pass $4 B by 2012.
- The Apple iPhone garnered a lot of attention in the handset category, but Nokia and HTC led in Wi-Fi-enabled handset volumes.
- The strong success of new netbook devices is boosting growth in the computing segment.
- 802.11n will surpass 802.11g in the stationary CE embedded chipset segment in 2010.
- New Bluetooth 3.0 specification uses 802.11g technology for the physical layer, which could open up a new market for Wi-Fi chipset suppliers.

Recent In-Stat research, "Global Wi-Fi Chipset Forecast and Analysis: 2007 to 2013," covers the worldwide market for Wi-Fi chipsets. It includes:

- Forecasts of WLAN chipset units and revenue by market segment and by technology
- Segmentation for mobile PCs, including notebook PCs, netbooks, ultra mobile PCs (UMPC) and mobile Internet devices (MID)
- Segmentation for portable CE, including handheld games, digital still/video cameras, IP network cameras, personal digital assistants (PDA) and personal media players (PMP)
- Segmentation for mobile handsets
- Segmentation for networking equipment, including routers, gateways and access points (AP)
- Segmentation for stationary CE, including gaming consoles, Blu-ray players/recorders, digital televisions (DTV), media adapter/player/receivers, networked attached storage, personal video recorders (PVR), printers and multi-function peripherals (MFP), personal video recorders (PVR) and set-top boxes (STB)
- Segmentation by technology, including 802.11g, 802.11a/g and draft n/802.11n
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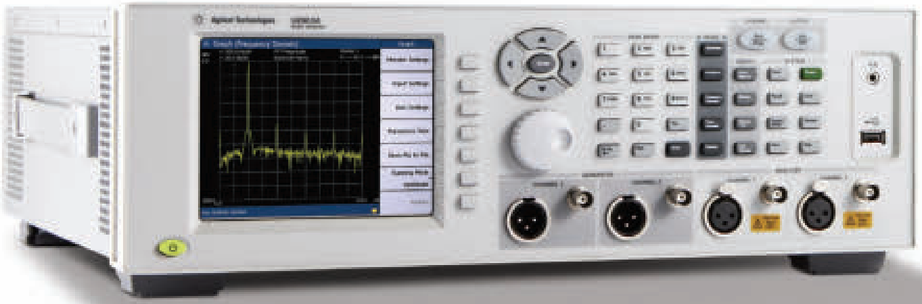

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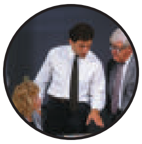

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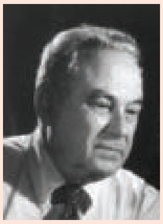

William Cuming, who helped start Emerson & Cuming in 1948, died of pneumonia on May 28 in Boston, MA. Born in New York City, Cuming earned a degree in mechanical engineering from the Stevens Institute of Technology in 1942 and an MBA from Harvard University in 1947. Along with Cherry Emerson, he started Emerson & Cuming, a company that designed epoxy resins and coatings to protect components. The company eventually employed more than 700 people. Cuming and Emerson sold their company to W.R. Grace in 1978. After the sale of Emerson & Cuming, he launched a new technologies company called Cuming Corp., a supplier of flotation and insulation materials to the offshore oil and gas industry. A sister company, Cuming Microwave Corp., manufactures radar-absorbing materials and microwave materials for the electronics and aerospace industries. A World War II veteran, Cuming was 88 years old.

INDUSTRY NEWS

■ **Skyworks Solutions Inc.**, an innovator of high reliability analog and mixed signal semiconductors enabling a broad range of end markets, announced its acquisition of **Axiom Microdevices**, a volume supplier of CMOS-based power amplifiers for mobile phones. Terms of the acquisition were not disclosed and will have no significant impact to Skyworks' operating expenses. Accordingly, the company expects the transaction to be earnings per share neutral in fiscal year 2009 and accretive thereafter.

■ **Curtis Industries**, a division of Powers Holdings Inc., and a Milwaukee manufacturer of electronic EMI filters and wire interconnect terminal blocks, acquired the **Filter Networks**, Salisbury, MD brand of EMI filters and filtered connectors.

■ **Valpey Fisher Corp.** and **Kernco** announced that the two companies are collaborating on technology, marketing and manufacturing products that address the satellite communications business.

■ **Remtec Inc.**, a manufacturer of metallized ceramic substrates and packages with Plated Copper on Thick Film Technology (PCTF®), and **Microwave Packaging Technology Inc.** (MPT), Anaheim, CA, a leader in the design, test and assembly of microwave modules and components, have announced a strategic alliance to integrate their core competencies. By combining these capabilities, Remtec and MPT establish a single, reliable source for the design, test and manufacture of advanced microwave and millimeter-wave packages and modules built with PCTF technology.

■ **Freescale Semiconductor** announced that it has partnered with **Flextronics** to create a high performance reference design for the Enterprise WLAN access point market. Based on Freescale's PowerQUICC® II Pro MPC8377E processor, the IEEE® 802.11N access point reference design offers a comprehensive, production-ready solution that scales from 400 to 800 MHz and speeds time-to-market.

■ **Agilent Technologies Inc.** announced that **Simplay Labs**, Shanghai, China, has selected Agilent's HDMI test solution for source, sink and cable certification at its new test center. This purchase continues the long-term relationship between Simplay Labs and Agilent to further develop devices for HDMI standards. The test center at Simplay Labs is designed to promote industry-wide interoperability among products using HDMI and High-bandwidth Digital Content Protection (HDCP).

■ **WIN Semiconductors** announced the availability of a set of design kits for its PP25 family of 0.25 µm optical gate PHEMT technologies for use with Advanced Design System (ADS) EDA software from **Agilent Technologies**. The WIN PP25-00 kit also supports a complete ADS front-to-back end MMIC design flow with scalable devices, native design rule checker (DRC) and latest layout capabilities in ADS 2009, which is the latest release from Agilent EEsof.

■ **Modelithics** and **Auriga Measurement Systems** announced the placement of an Auriga AU4750 pulsed IV measurement system at Modelithics. Modelithics is now integrating the AU4750 into its overall transistor characterization and modeling strategy.

■ **AWR** announced that users of AWR's Microwave Office design software now have access to XML library data for a broad array of microwave amplifiers from **TriQuint Semiconductor Inc.**'s San Jose design center (formerly WJ Communications). The devices include packaged gain-blocks, field effect transistors (FET) and heterojunction bipolar transistor (HBT) amplifiers.

■ The US Department of Defense (DoD), through the Defense Microelectronics Activity (DMEA), has granted **Tahoe RF Semiconductor Inc.**, a fabless RFIC company and Wireless Electronic Design Services (EDS) provider, accreditation as a Microelectronics Trusted IC Supplier for the DoD and all other US Government customers. The DoD requires that all Mission Assurance Category I systems employ only Trusted IC service(s) to fabricate its custom designed ICs.

■ **Aeroflex** announced its IFF-45TS avionics test set has received official certification from the US Department of Defense (DoD) International AIMS Program Office. The IFF-45TS test set is now AIMS certified to perform testing and validation on identification, friend or foe (IFF) Mode 4 and 5 transponders and interrogators. In addition, the IFF-45TS will perform testing on DME/TACAN interrogators.

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DCO1198-8	1198.4 - 1198.7	0.5 - 7.5	+8 @ 30 mA	-116	[illegible]
DCO170340-5	**1700 - 3400**	**0.5 - 24**	**+5 @ 24 mA**	**-90**	[illegible]
DCO200400-5 **DCO200400-3**	**2000 - 4000**	**0.5 - 18**	**+5 @ 35 mA** **+3 @ 35 mA**	**-90** **-89**	**0.3 x [illegible]**
DCO300600-5 **DCO300600-3**	**3000 - 6000**	**0.5 - 18**	**+5 @ 35 mA** **+3 @ 35 mA**	**-80** **-78**	**0.3 x 0.3 x 0.1**
DCO400800-5 **DCO400800-3**	**4000 - 8000**	**0.5 - 18**	**+5 @ 35 mA** **+3 @ 35 mA**	**-78** **-76**	**0.3 x 0.3 x 0.1**
DCO432493-5 DCO432493-3	4325 - 4950	0.5 - 11	+5 @ 17 mA +3 @ 17 mA	-88 -86	0.3 x 0.3 x 0.1
DCO473542-5 DCO473542-3	4730 - 5420	0.5 - 22	+5 @ 20 mA +3 @ 20 mA	-88 -86	0.3 x 0.3 x 0.1
DCO490517-5 DCO490517-3	4900 - 5175	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 0.1
DCO495550-5 DCO495550-3	4950 - 5500	0.5 - 12	+5 @ 22 mA +3 @ 22 mA	-87 -85	0.3 x 0.3 x 0.1
DCO608634-5 DCO608634-3	6080 - 6340	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-86 -84	0.3 x 0.3 x 0.1
DCO615712-5 DCO615712-3	6150 - 7120	0.5 - 18	+5 @ 22 mA +3 @ 22 mA	-85 -83	0.3 x 0.3 x 0.1
DXO Series					
DXO810900-5 DXO810900-3	8100 - 8800	0.5 - 16	+5 @ 22 mA +3 @ 22 mA	-82 -80	0.3 x 0.3 x 0.1
DXO900965-5 DXO900965-3	9000 - 9650	0.5 - 16	+5 @ 22 mA +3 @ 22 mA	-80 -78	0.3 x 0.3 x 0.1

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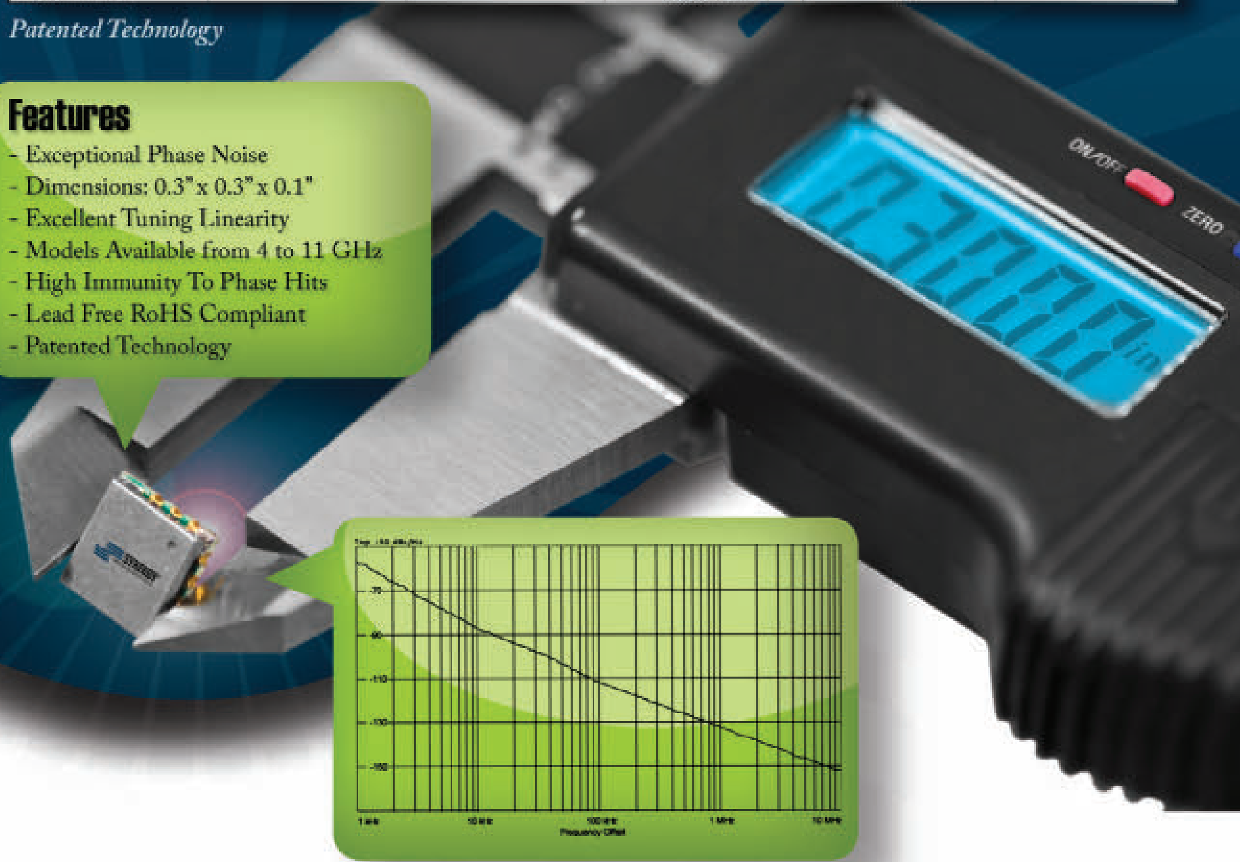

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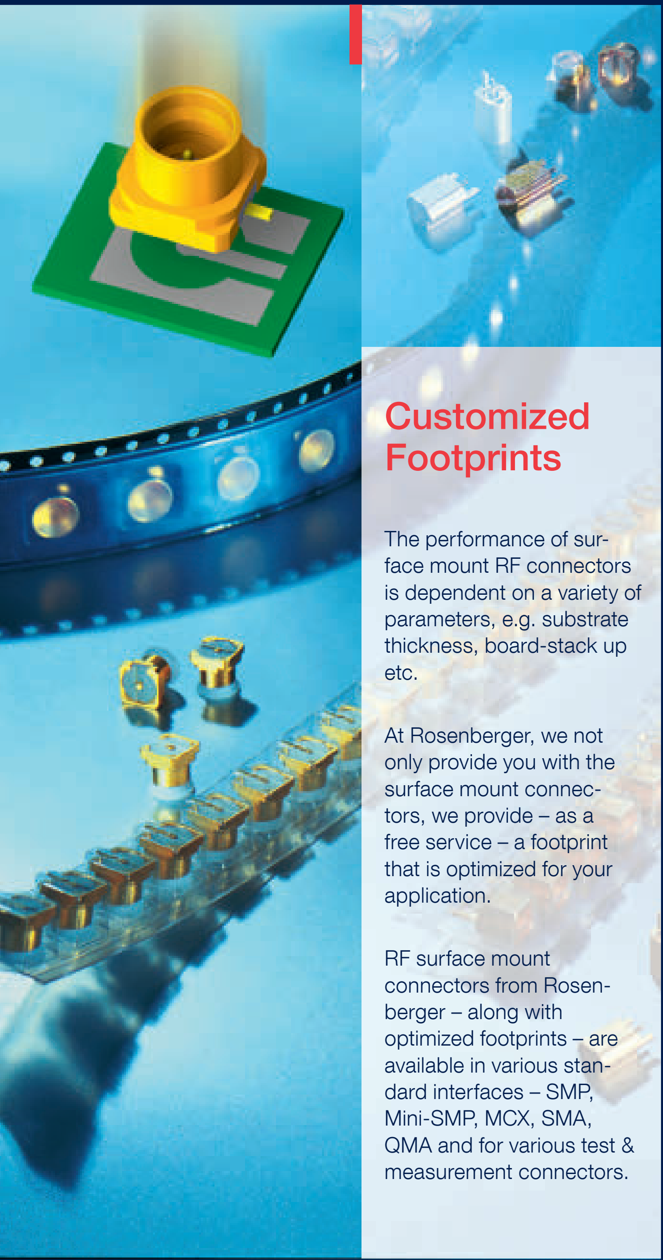

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■ **Richardson Electronics Ltd.** announced that it has been named "Distributor of the Year" by **Microsemi Corp.**'s Power Products Group. This distinction, presented annually by the Microsemi Sales and Marketing teams, goes to the distributor who has consistently shown exemplary design, sales and logistics support to Microsemi's global customer base.

CONTRACTS

■ **Comtech Telecommunications Corp.** announced that its Maryland-based subsidiary, Comtech Mobile Datacom Corp., received orders totaling $6 M under its Movement Tracking System, or MTS contract, with the US Army. Total orders received to date against the $605.1 M MTS contract increased to $535.2 M.

■ **TriQuint Semiconductor**, an RF products manufacturer and foundry services provider, announced that it has been awarded leadership of Phase III of a multi-year gallium nitride (GaN) research and development contract by the Army Research Laboratory (ARL). The contract, funded by the Defense Advanced Research Projects Agency (DARPA), was awarded based on TriQuint surpassing Phase II goals. The overall program is designed to develop new high power, wideband GaN amplifiers for a range of defense applications.

■ **Micro Systems Inc.**, a wholly owned subsidiary of Herley Industries Inc., has achieved a significant milestone on the Korea Medium Range Surface to Air Missile (KMSAM) program. Working as a key team member with Composite Engineering Inc. (CEi) of Sacramento, CA, the company has integrated its MONTAGE ground control station with the CEi developed BQM-167i high performance aerial target. In early May, 2009, the Korean missile successfully engaged the target system and the target aircraft was recovered normally.

■ **RF Micro Devices Inc.** (RFMD) announced that the company has been selected by a smartphone manufacturer to supply its RF2815 GPS LNA module for use in a soon to be released CDMA smartphone. This new smartphone is expected to launch in the second half of calendar 2009 in North America. The feature-rich, dual-band CDMA device will be manufactured by the Taiwan-based smartphone manufacturer and will feature a leading open source mobile operating system.

NEW MARKET ENTRY

■ **RFaxis** is a provider of RF chips, specifically designed to address the critical path needs of the burgeoning wireless market. Founded in 2007 and based in Irvine, CA, the company's game changing technologies hope to redefine and simplify RF integration with single chip solutions that deliver both high performance and cost efficiency. Leveraging BiCMOS technologies, along with its own innovative approach and technology, RFaxis has developed an RF front-end integrated circuit. Now, design engineers will

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AMF-3B-00500100-13-33P	0.5-1	43	1.5	1.3	2:1	33	1700
AMF-4D-00500200-25-33P	0.5-2	40	2	2.5	2:1/2.3:1	33	1400
AMF-4B-00800250-50-34P	0.8-2.5	40	3	5	2:1/2.3:1	34	2700
AMF-3B-01000200-35-30P	1-2	30	1	3.5	1.8:1	30	900
AMF-3B-01000200-20-33P	1-2	35	1	2	1.5:1	33	1200
AMF-5D-01000200-15-33P	1-2	50	1.5	1.5	2:1/2.3:1	33	1500
AMF-3B-01000200-50-40P	1-2	35	3	5	2.2:1/3:1	40	4100
AMF-3D-01000400-45-30P	1-4	28	1.5	4.5	2:1/2.3:1	30	800
AMF-4D-01000400-35-30P	1-4	39	1.5	3.5	2:1/2.3:1	30	900
AMF-4D-01000800-85-30P	1-8	28	2	8.5	2.2:1	30	1100
AMF-4D-00400600-50-30P	0.4-6	34	2	5	2:1/2.3:1	30	650
AMF-3B-02000400-20-30P	2-4	35	1	2	2:1	30	950
AMF-4B-02000400-15-33P	2-4	50	1.5	1.5	2:1	33	1600
AMF-5B-02000600-70-33P	2-6	34	2	7	2:1	33	2200
AMF-4B-02000600-70-37P	2-6	35	2	7	2:1/2.8:1	37	4800
AMF-4B-02000800-80-36P	2-8	40	2.5	8	2:1/2.8:1	36	4800
AMF-3B-02001800-30-30P	2-18	35	2	3	2.2:1	30	2000
AMF-3B-02001800-60-32P	2-18	35	2.5	6	2:1/2.3:1	32	4500
AMF-3B-02002000-60-30P	2-20	40	2.5	6	2:1/2.5:1	30	4500
AMF-5B-04000800-60-30P	4-8	33	1.5	6	2:1	30	1400
AMF-4B-04000800-50-33P	4-8	36	1	5	2:1	33	1500
AMF-6B-06001800-80-33P	6-18	35	2.5	8	2.1:1/2.2:1	33	3500
AMF-2B-06001800-65-35P	6-18	45	3	6.5	2.1:1/2.2:1	35	6500
AMF-6B-06001800-120-40P	6-18	43	5	12	2:1/2.3:1	40	12,500

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PERSONNEL

■ Park Electrochemical Corp. announced the appointment of **Patrick Crowley** as Vice President of Research and Development. In this position, Crowley will be responsible for the company's global research and development activities. Crowley had previously been President of Nelco Products Pte. Ltd. in Singapore.

■ Crane Aerospace & Electronics, a segment of Crane Co., has announced the appointment of **Simon Abel** as Director of Sales, Standard Power for the Electronics Group. Abel will be responsible for the Field Sales organization and for driving sales in current and emerging markets. Abel joined Crane in 1988, opening a sales office in the United Kingdom to serve the European market.

▲ Simon Abel

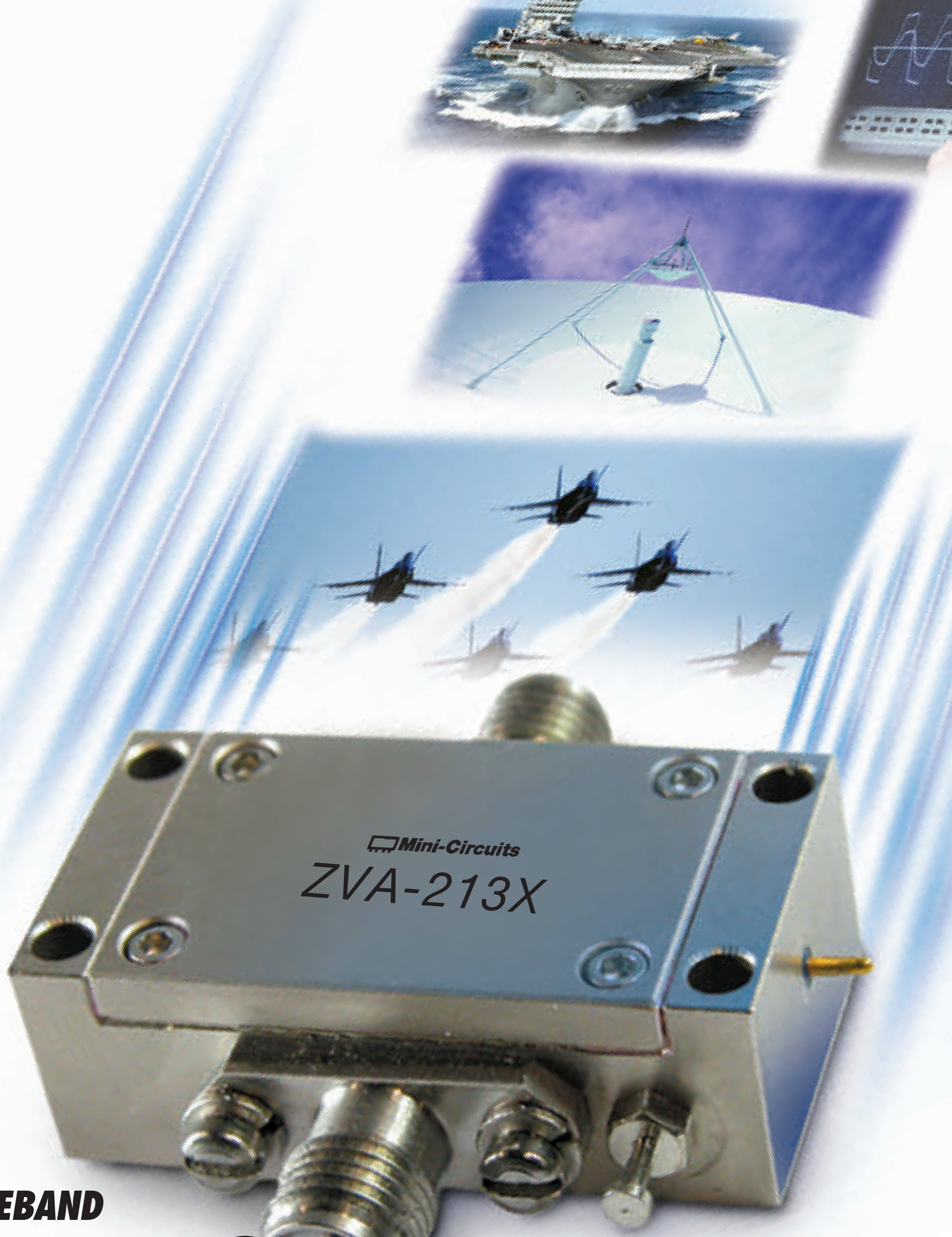
■ TRAK Microwave Corp., a Smiths Interconnect business, appointed **Keith Morrison** as Director, Business Development for Integrated Microwave Assemblies (IMA). Morrison joins TRAK Microwave from Avnet Inc., where his last position was Business Development Manager. Morrison earned his BSEE from the University of South Florida, and brings to TRAK Microwave a successful 23-year career in the RF/microwave industry, with proven skills in both technical and sales responsibilities.

▲ Keith Morrison

■ Centellax has added three sales positions to its US sales team. **Perry King**, Regional Sales Manager–US Components, comes to Centellax with over 20 years of technical sales experience. He has previously worked with Inphi, Iterra Communications and Anadigics. **Rob Crowe**, Regional Sales Manager–East Coast Test Products, has previously worked for LeCroy, Yokogawa and Fluke. He has 30+ years experience in sales and account management. **Cindy McMillan**, Regional Sales Manager–California Test Products, has more than 15 years experience. She brings a wealth of knowledge from her previous engineering positions at Delco Systems, TRW and Hewlett-Packard.

REP APPOINTMENTS

■ **Greenray Industries** has chosen **Akon Electronics India** (A.E.I.) to exclusively represent them in India. A.E.I.'s sales office is in the ideal location of Bangalore. A.E.I. is a division of Akon Inc. USA, who has successfully been conducting business in India for over a decade. In 1994, Akon USA established a full microwave manufacturing facility and sales office (Akon Electronics India) in New Delhi to better serve the Indian Defense Market. A.E.I. has since expanded its sales offices to Bangalore and Hyderabad.



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ZVA-183+	0.7-18	26	+24	3.0	895.00
ZVA-213+	0.8-21	26	+24	3.0	995.00

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ENHANCEMENT OF MICROSTRIP STEPPED-IMPEDANCE LOW-PASS FILTERS USING FRACTAL-SHAPES

Microstrip stepped-impedance low-pass filters using fractal shapes, such as Koch islands and Sierpinski carpets, are proposed for the first time. Conventional stepped-impedance low-pass filters are very popular, due to their ease of implementation in either microstrip or coplanar technology. However, to achieve a low-pass filter with high stopband performance, techniques such as increasing the high- to low-impedance ratio will degrade the passband performance because of sharp current discontinuities in the high-low steps. By proper design, the sharp current discontinuities can be smoothed by constructing the low-impedance sections with fractal-shaped geometries, thus the passband performance of the microstrip stepped-impedance low-pass filters is enhanced greatly. To verify the proposed method, low-pass filter prototypes, constructed with different fractal-shapes of different iteration orders, are designed, fabricated and measured, and the results show that the maximum return loss level is greatly reduced, either using Koch or Sierpinski fractals, while the other performance parameters are not changed.

A compact and high performance microwave low-pass filter (LPF) is highly desirable to suppress harmonics in wireless communication systems, such as satellite and mobile communication systems. One of the conventional filters used is the stepped-impedance low-pass filter, mainly because of its ease of fabrication in either microstrip or coplanar technology. The filter is normally composed of alternating low and high impedance regions, where the change in impedance is controlled by the line width of the strip. In order to achieve a high degree of attenuation in the stopband, it is necessary to increase the order of the filter or obtain a large high to low impedance ratio (Z_h / Z_l).[1,2] However, if the filter order is increased, the size of the entire circuit will be larger, and if the impedance ratio is large enough, the passband performance will be degraded because of the sharp current discontinuities in the high-low steps.

To enhance the passband performance for a low-pass filter with a large impedance ratio, electromagnetic bandgap (EBG) structures are used.[3-6] However, since the frequency se-

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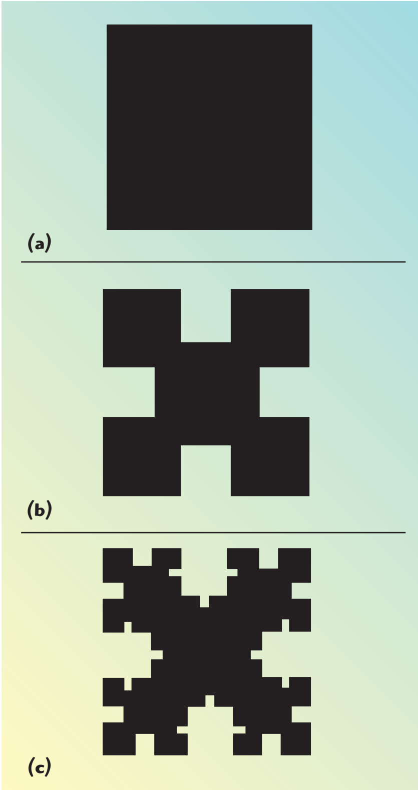
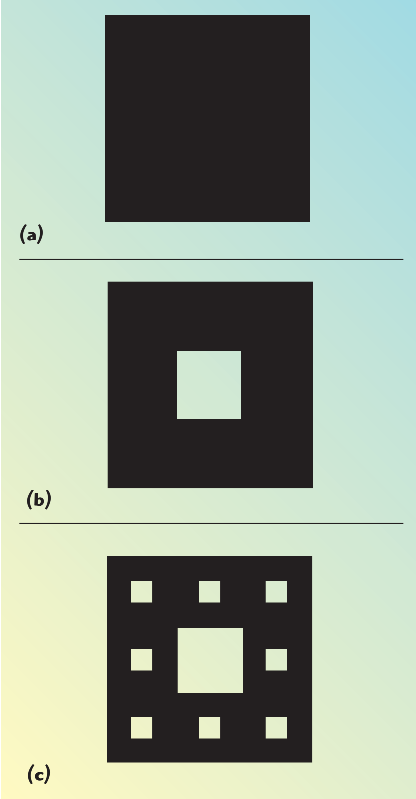
lective properties of electromagnetic bandgap structures are based on the well-known Bragg effect, their period scales with the signal wavelength, and hence the dimensions of the structure might be too high (in certain applications) to achieve the desired rejection levels. Furthermore, this kind of structure cannot be attached to a metal plane. Since microwave components are always enclosed in a metal box to shield radiation to or from other microwave components, the use of electromagnetic bandgap structures will cause enclosure difficulties. High performance microstrip stepped-impedance low-pass filters with lumped elements have been proposed;[7,8] however, the use of lumped elements raises fabrication difficulties and manufacturing repeatability is difficult to maintain.

Recently, fractal-shaped coupled-line microstrip bandpass filters[9] and stepped-impedance transformers[10] have been proposed. Because of the weak current discontinuities of the fractal-shaped geometry in the passband, fractal-shaped bandpass filters and stepped-impedance transformers have achieved high performances. Based on these reports, fractal-shaped microstrip stepped-impedance low-pass filters were proposed for the first time by the authors,[11] and some preliminary results were discussed, such as the simulation and experimental results of the Koch fractal-shaped microstrip stepped-impedance low-pass filters. However, the general characteristics of the fractal-shaped low-pass filters were not mentioned, and the reasons for the passband enhancement abilities of the fractal-shaped low-pass filters were also not discussed. In this article, an in-depth insight to the behavior of the general fractal-shaped microstrip stepped-impedance low-pass filters is provided, and the reasons for the passband enhancement abilities of the fractal-shaped low-pass filters are discussed through the simulated current distributions of the structures. The main properties of fractal geometries, such as the Koch islands and Sierpinski carpets, are reviewed and the design procedure of the fractal-shaped microstrip stepped-impedance low-pass filters is presented. The simulation and measurement results for the designed microstrip stepped-impedance low-pass filters are given. A detailed analysis of the reasons for the passband enhancement abilities of the fractal-shaped low-pass filters is also presented. Through the current distributions of the low-pass filters based on the simulation results, it will be demonstrated that, with the use of the fractal-shaped geometries, the current discontinuities in the passband caused by the high-low impedance steps are reduced greatly, and the resultant passband performance is thus enhanced, while the stopband performance remains virtually unchanged.



▲ *Fig. 1 Koch fractal island shape whose iteration factor is 1/4 (a) iteration order 0, (b) iteration order 1, (c) iteration order 2.*



▲ *Fig. 2 Sierpinski fractal carpet shape whose iteration factor is 1/3 (a) iteration order 0, (b) iteration order 1, (c) iteration order 2.*

FRACTAL GEOMETRIES AND THEIR APPLICATION ON MICROSTRIP STEPPED-IMPEDANCE LOW-PASS FILTERS

Koch and Sierpinski Fractal Geometries

Nowadays, fractal theory is widely applied to microwave engineering, such as in circuit designs,[9-12] in antenna designs,[13,14] and in frequency selective surface designs.[15,16] The classical fractal geometries are Koch and Sierpinski fractal geometries, which are named after the Dutch mathematician Helge von Koch and Polish mathematician Sierpinski, respectively. The other fractal shapes are mainly derived from these two shapes, so the general behavior of the fractal-shaped microwave components can be derived from the behavior of the components that employ these two fractal geometries. No matter which kinds of fractal shapes are used, they are characterized by two factors: The iteration factor (fractal factor) and the iteration order. The iteration factor represents the construction law of fractal geometry generation and the iteration order depicts how many iteration processes are carried out. For a conventional square, it has numerous fractal shapes. ***Figure 1*** shows the generation process of a Koch island whose iteration factor is 1/4, and ***Figure 2*** shows the generation process of a Sierpinski carpet whose iteration factor is 1/3. Increasing the iteration order of the fractal geometry infinitely would produce the ideal fractal structure that shows self-similarity. The multiband and wideband properties of the fractal antennas are a consequence of its self similarity. In this article, the fractal-shaped structures are applied to the design of microstrip stepped-impedance low-pass filters, and it will

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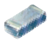

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TABLE I

PHYSICAL PARAMETERS OF THE CONVENTIONAL MICROSTRIP STEPPED-IMPEDANCE LOW-PASS FILTER

i	Z (Ω)	*w* (mm)	*l* (mm)
1	15	11.22	2.06
2	120	0.45	8.54
3	15	11.22	7.70
4	120	0.45	11.65
5	15	11.22	5.64
6	120	0.45	3.1

be demonstrated that the sharp current discontinuities of the high-low microstrip steps can be greatly smoothed, when the low-impedance microstrip-lines are made with fractal shapes.

TABLE II

SUMMARY OF RESULTS

F	Iter	Simulation Results				
		MRL	CF	SL	2H-IL	2H-F
K0, S0	0	-19.8	234	14.53	-1.75	8.45
Koch	1	-26.2	238	14.17	-2.00	7.95
	2	NULL	237	14.05	-2.98	7.80
Sierpinski	1	-26.4	235	14.2	-2.86	8.35
	2	-30.35	238	14.0	-2.91	8.3
F	**Iter**	**Experiment Results**				
		MRL	**CF**	**SL**	**2H-IL**	**2H-F**
K0, S0	0	-17.8	234	14.45	-2.12	8.60
Koch	1	-23.2	243	14.12	-2.76	7.65
	2	-28.6	236	14.0	-2.65	7.95
Sierpinski	1	-23.87	233	14.3	-2.72	8.25
	2	-28.8	235	13.75	-2.77	8.3

Design of the Fractal-shaped Microstrip Stepped-impedance Low-pass Filters

Based on the construction law of the Koch islands and Sierpinski carpets mentioned above, the fractal-shaped stepped-impedance low-pass filters were designed in microstrip technology. The specifications are given by the cut-off frequency (f_c = 2.5 GHz), filter order (sixth-order) and frequency response (maximally flat Butterworth). The design of the structure is a two-step process.

First, the conventional layout of the filter is obtained according to the standard procedure. To this end, the characteristic impedances of the high and low impedance sections have been set to Z_h = 120 Ω and Z_l = 15 Ω, respectively. From these values, the electrical length of each transmission line section has been obtained following the standard design formulas.[1] By using a commercial transmission line calculator (Agilent LineCalc), the geometry of the filter has been determined for a Rogers RT/Duroid 5880 substrate with a thickness h = 0.78 mm and a dielectric constant ϵ = 2.2. To provide space for the connectors, 50 Ω access lines have been cascaded at the input and output ports. The physical parameters of the designed conventional microstrip stepped-impedance low-pass filters are listed in ***Table 1***, where i is the filter section number, Z is the impedance of the section, and w and l are the width and length of the microstrip line, respectively.

The second step consists of constructing the low-impedance sections, where the conductor strip width is substantial, as Koch islands and Sierpinski carpets of different iteration numbers, to enhance the passband of the filter. The iteration orders of the fractals are limited to two because of manufacturing tolerance. Thus, the Koch and Sierpinski fractal-shaped microstrip stepped-impedance low-pass filters with different iteration orders are determined.

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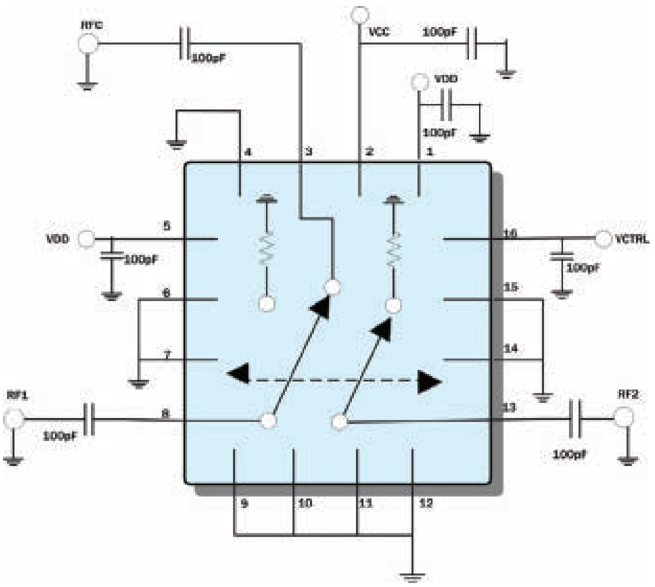
RF3023	10 to 3000	30	0.2 to 0.4	25	GPIO	SC70	July 09
RF3024	10 to 3000	30	0.2 to 0.4	>50	GPIO	SC70	July 09
RF3025	10 to 6000	25	0.5 to 0.6	>50	GPIO	QFN 3 x 3	July 09



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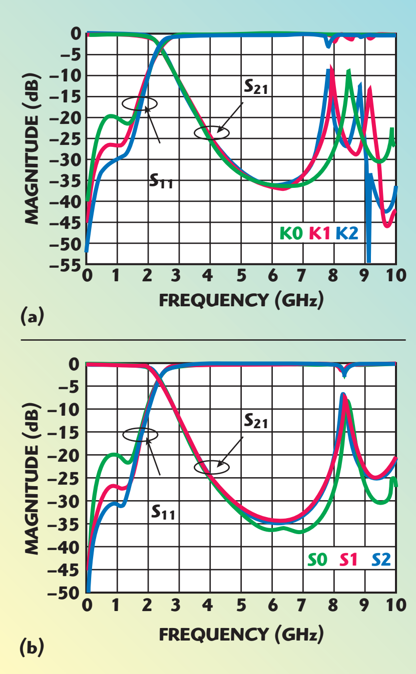
RESULTS AND ANALYSIS

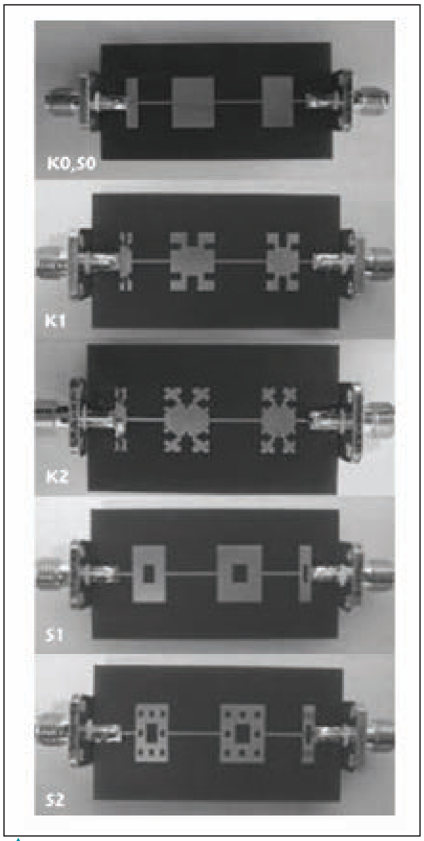
Simulation Results

The designed Koch and Sierpinski fractal-shaped microstrip stepped-impedance low-pass filters with different iteration orders are simulated using the finite-element-method (FEM)-based software Ansoft HFSS 10.0; the simulated frequency responses are shown in ***Figure 3***.

As can be seen, the two kinds of fractal-shaped low-pass filters show great passband performance enhancement abilities. The simulation results of these filters are summarized in ***Table 2***, where F is the fractal shape, Iter is the iteration number, MRL is the maximum return loss in the passband in dB, CF is the cut-off frequency in GHz, SL is the selectivity[17] in dB/Hz, 2H-IL is the second harmonic insertion loss in dB and 2H-F is the operating frequency corresponding to 2H-IL. The maximum return-loss level of the passband of the Koch fractal-shaped microstrip stepped-impedance low-pass filters decreased from -19.8 dB for K0, to a value below -30 dB for K2, and the maximum return-loss level of the passband of the Sierpinski fractal-



▲ *Fig. 3 Simulated response of fractal-shaped stepped-impedance low-pass filters with different iteration orders; (a) Koch and (b) Sierpinski.*



▲ *Fig. 4 Prototypes of the Koch and Sierpinski fractal-shaped microstrip stepped-impedance low-pass filters.*

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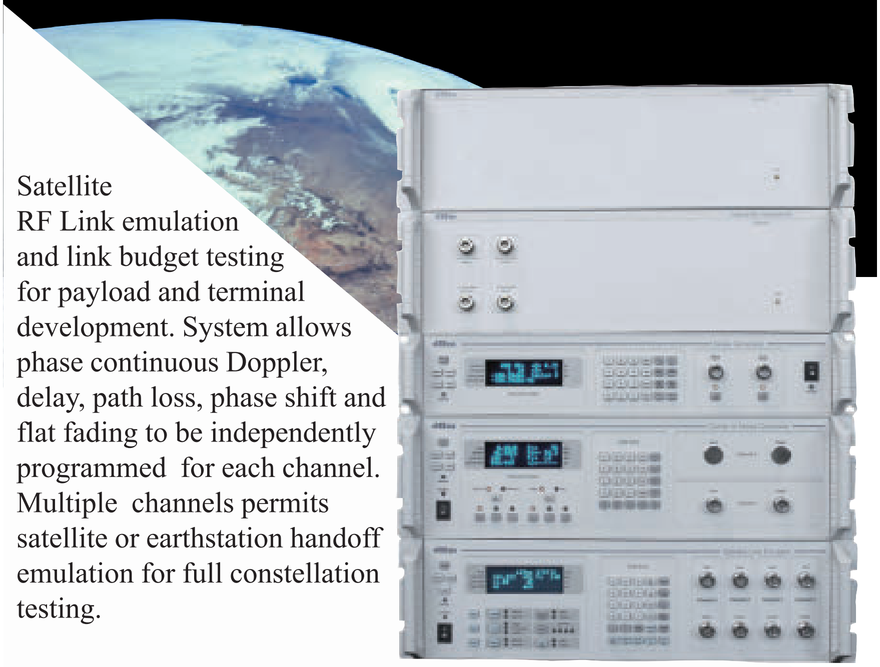

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CBL-3FT-SMSM+	SMA	3	1.5	27	72.95
CBL-4FT-SMSM+	SMA	4	1.6	27	75.95
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CBL-2FT-SMNM+	SMA to N-Type	2	1.1	27	99.95
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CBL-6FT-SMNM+	SMA to N-Type	6	3.0	27	114.95
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CBL-25FT-NMNM+	N-Type	25	11.7	27	199.95
		Female to Male			
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CBL-6FT-SFNM+	SMA-F to N-M	6	3.0	27	146.95
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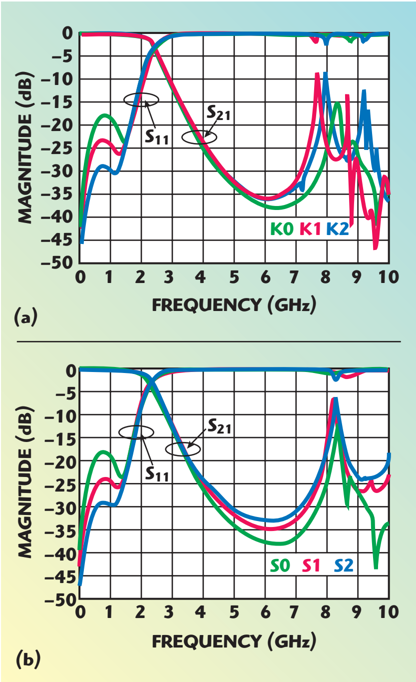
shaped microstrip stepped-impedance low-pass filters is decreased from -19.8 dB for S0, to -30.35 dB for S2. It is also observed that the higher the iteration order, the lower the maximum return-loss level becomes. Nevertheless, these results reveal that the proposed technique is very promising for the design of microstrip stepped-impedance low-pass filters with improved passband. Because the sharp current discontinuities in the high-low steps are smoothed by the fractal shapes, and the performance of the stopband is decided by these current discontinuities, the stopband performance of the fractal-shaped microstrip low-pass filters all degraded a little. However, the degenerations have not changed the overall performance of the low-pass filters.

Measurement Results

The final fractal-shaped microstrip stepped-impedance low-pass filters were fabricated and the prototypes are shown in ***Figure 4***. All prototypes were measured using a HP8720ET vector network analyzer, and the measured frequency responses are shown in ***Figure 5***. As can be seen, the fractal-shaped low-impedance sections have zigzag/forklike width distributions of great complexity along the structure with the aim to suppress the sharp current discontinuities caused by high-low steps at their resonant frequency. It is not difficult to see the essence of the passband enhancement abilities of the fractal-shaped microstrip stepped-impedance low-pass filters, which is reducing the sharp current discontinuities in the high-low steps by smoothing the strip width variations. The measured frequency response agreed well with the simulated frequency response with slight discrepancies. The slight discrepancies between simulation and measurement are due to tolerances that are inherent to the fabrication process and are especially critical as a consequence of the small fractal dimensions and narrow strips for the high impedance sections. The experiment results of these filters are summarized in Table 2. The maximum return loss level of the passband of the Koch fractal-shaped low-pass filter is reduced from



▲ *Fig. 5 Measured response of fractal-shaped stepped-impedance low-pass filters with different iteration orders; (a) Koch and (b) Sierpinski.*

Electrical Specifications

Frequency Range GHz	Phase Error Vs Frequency MAX	Attenuation Error MAX	Insertion Loss Max	V.S.W.R MAX
0.5-2.0	±10.0°	±1.5dB	13.0dB	1.70:1
1.0-3.0	±10.0°	±1.5dB	13.0dB	1.70:1
2.0-6.0	±10.0°	±1.5dB	12.0dB	1.90:1
6.0-18.0	±10.0°	±1.5dB	12.0dB	1.90:1
12.0-22.0	±15.0°	±3.50dB	17.0dB	2.20:1
2.0-18.0	±22.0°	±3.00dB	16.0dB	2.20:1

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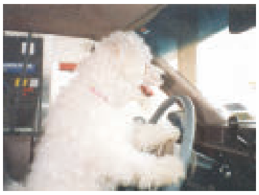

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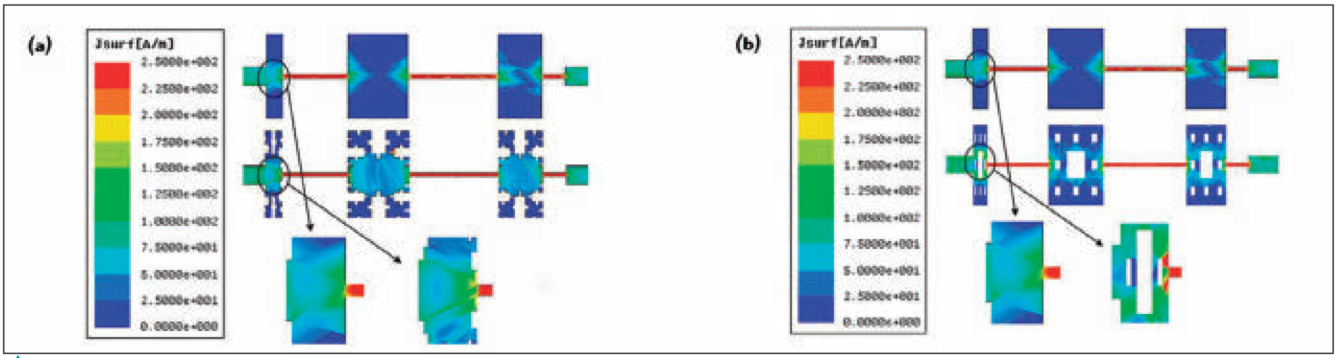

▲ *Fig. 6 Current distribution of the fractal-shaped microstrip stepped-impedance low-pass filter at 0.8 GHz; (a) Koch and (b) Sierpinski.*

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-17.8 to -28.6 dB, and the maximum return loss level of the passband of the Sierpinski fractal-shaped low-pass filter is reduced from -17.8 to -28.8 dB. Although the stopband performance is degraded a little, it seems that the iteration order has no relation to the performance degeneration.

Analysis

In order to have a direct view of the current discontinuities smoothing effect of the fractal shapes on the microstrip stepped-impedance low-pass filters, the characteristics of the fractal-shaped microstrip stepped-impedance low-pass filters were analyzed, based on the simulation results using Ansoft HFSS 10. ***Figure 6*** shows the current distributions of the designed microstrip low-pass filters employing Koch and Sierpinski fractal-shapes, when operating at 0.8 GHz. The current discontinuities of the conventional microstrip stepped-impedance low-pass filter are very strong, especially at the edges of the high-low-steps and in the middle of the low-impedance sections, resulting in high reflection loss levels. For the fractal-shaped microstrip stepped-impedance low-pass filters, such as K2 and S2, the current discontinuities are smoothed mainly due to the gradual changes in the strips at the high-low steps of the fractal-shaped microstripline, so low reflection loss levels are provided.

CONCLUSION

It has been demonstrated that the passband performance of a microstrip stepped-impedance low-pass filter can be improved by merely constructing the low impedance sections with fractal shapes, such as Koch and Sierpinski fractal shapes. By properly increasing the iteration order of the fractal shapes, it has

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LZY-2+	500-1000	46	+45	+45.8	8.0	+54	28	8.0	1995	1895
ZHL-5W-2G+	800-2000	45	+37	+38	8.0	+44	24	2.0	995	945
ZHL-10W-2G+	800-2000	43	+40	+41	7.0	+50	24	5.0	1295	1220
ZHL-16W-43+	1800-4000	45	+41	+42	6.0	+47	28	4.3	1595	1545
• ZHL-20W-13	20-1000	50	+41	+43	3.5	+50	24	2.8	1395	1320
ZHL-30W-252+	700-2500	50	+44	+46	5.5	+52	28	6.3	2995	2920
• ZHL-50W-52	50-500	50	+46	+48	6.0	+55	24	9.3	1395	1320
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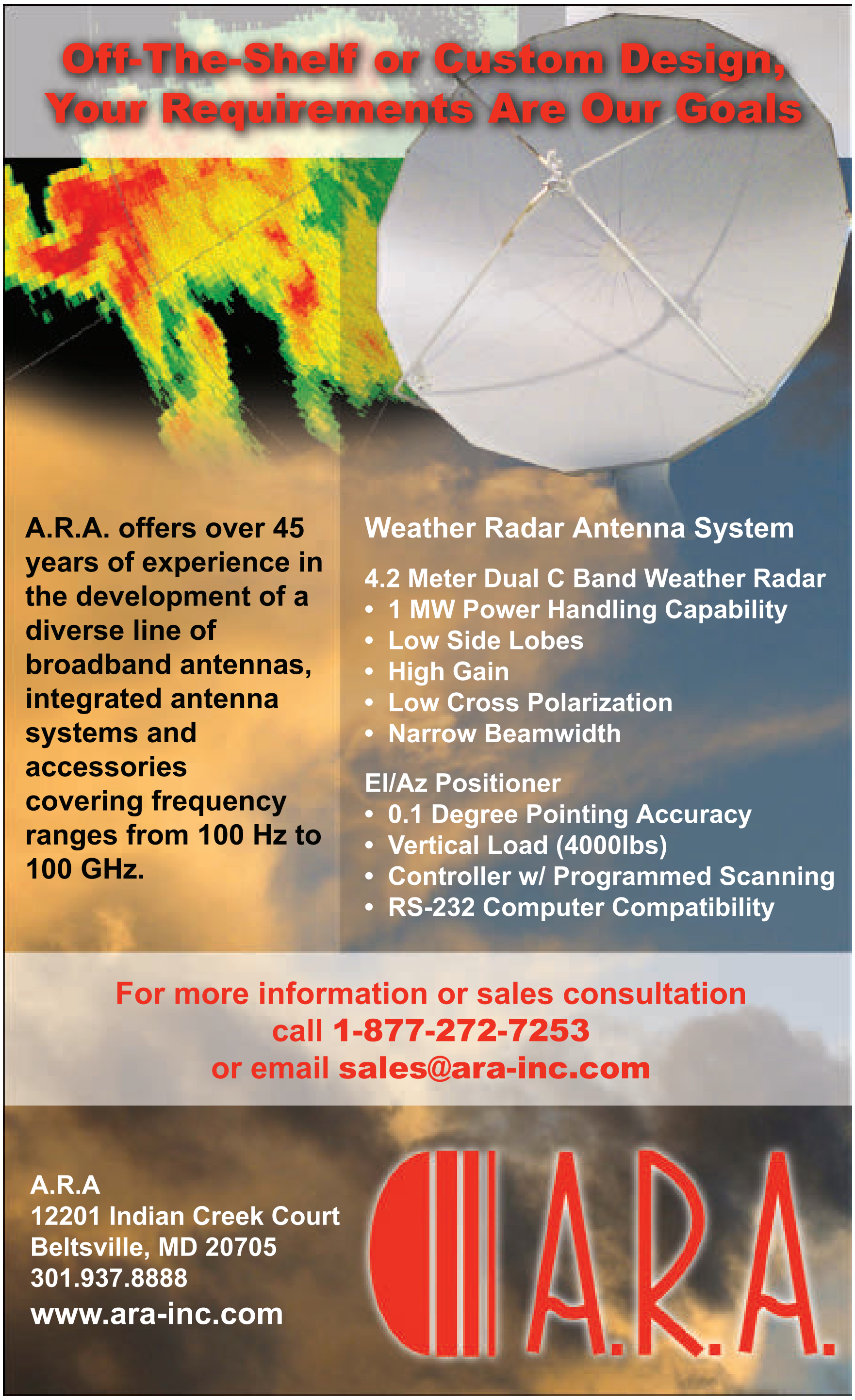
been experimentally found that the maximum return-loss level of the filter can be greatly reduced, with no major effect on the stopband. The main advantages of this technique are: (1) no extra area is added; (2) the stopband is virtually unaltered; (3) no lumped elements are added; and (4) the conventional design methodology of the filter holds. To the best of our knowledge, this is the simplest approach for the passband enhancement of the microstrip stepped-impedance low-pass filter reported so far. The idea can be applied to other technologies such as coplanar-waveguide, stripline, etc. ■

ACKNOWLEDGMENTS

This work has been supported by the National High Technology Development Program (863) of China under contracts 2003AA005044. The authors are also indebted to the 206th Institute of CWI Group for fabrication and measurement support.



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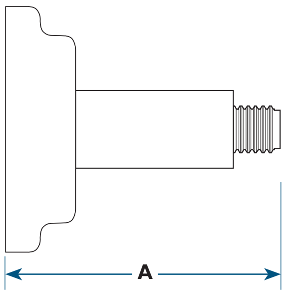

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A Modified Low Insertion Loss Dual-mode Filter Using Meander Spur-lines

A novel dual-mode filter with meander spur-lines is designed, fabricated and examined in this article. The meander spur-lines provide current distribution distortions and a size reduction of approximately 36 percent is obtained at the same resonant frequency, compared to a conventional dual-mode bandpass filter. Also, the proposed filter exhibits low insertion loss because there are no coupling gaps for the I/O ports. The measured minimum insertion loss within the passband of this filter is -0.9 dB including the SMA connector losses.

Compared to traditional microstrip filters, the dual-mode patch resonator shows attractive features such as its sharp band rejection and compact size. In general, the dual-mode operation consists of two degenerate modes, which are excited by asymmetrical feed lines and some perturbation element(s) on the patch resonators. Moreover, in order to improve the coupling between the resonator and the input/output (I/O) ports, a pair of coupling gaps was adopted widely to enlarge the interface between the feed lines and the patch resonator.[1-3] However, the pair of coupling gaps causes more etching uncertainties and insertion loss of the patch resonator than those with only one coupling gap or without a gap.[4,5] On the other hand, some methods to reduce the filter's size are presented. For example, Sung reported that spur-lines etched in a patch resonator are an effective way to make a compact dual-mode filter.[6]

Based on previous research on spur-lines,[4,7] a square-patch dual-mode bandpass filter (BPF) with a novel feeding scheme and meander spur-lines is proposed in this article. By introducing two spur-lines on both sides opposite to the feed lines and removing the gaps on the feed lines, a compact and lower insertion loss dual-mode filter is designed. Its transmission performance and current distribution results are discussed. The design method is also verified by measurements.

DUAL-MODE BANDPASS FILTER DESIGN

The basic structure of the proposed dual-mode BPF is shown in ***Figure 1***, where the dimensions are in millimeters. This filter is composed of one square-patch resonator with a pair of orthogonal slots and I/O feed lines. A pair of meander spur-lines is etched in the patch resonator to perturb the fields of the patch resonator. Compared to a straight spur-

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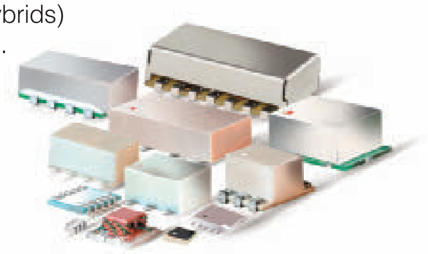

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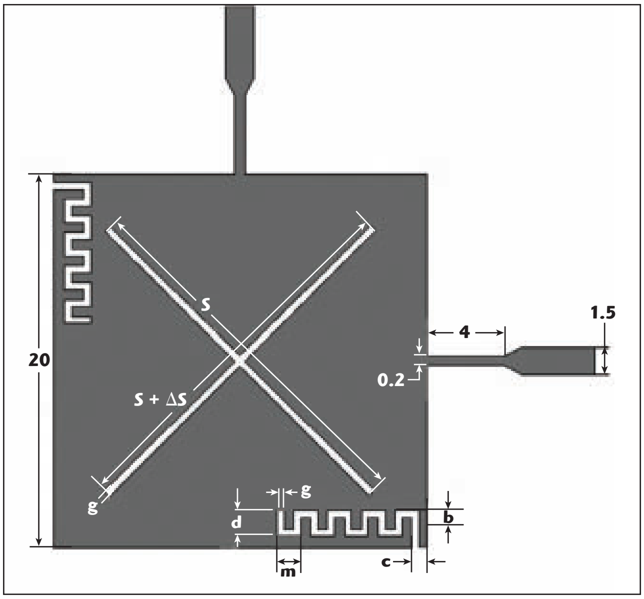
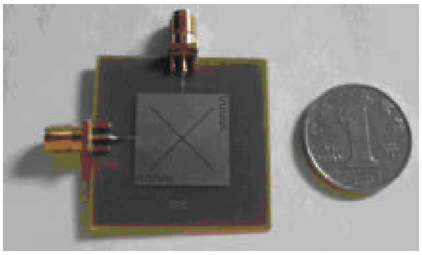
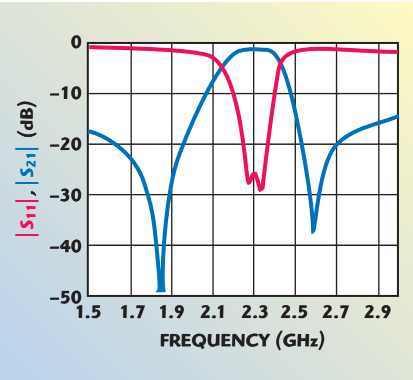


▲ *Fig. 1 Configuration of the proposed filter.*



▲ *Fig. 2 Photograph of the designed bandpass filter.*



▲ *Fig. 3 Measured performance of the proposed filter.*

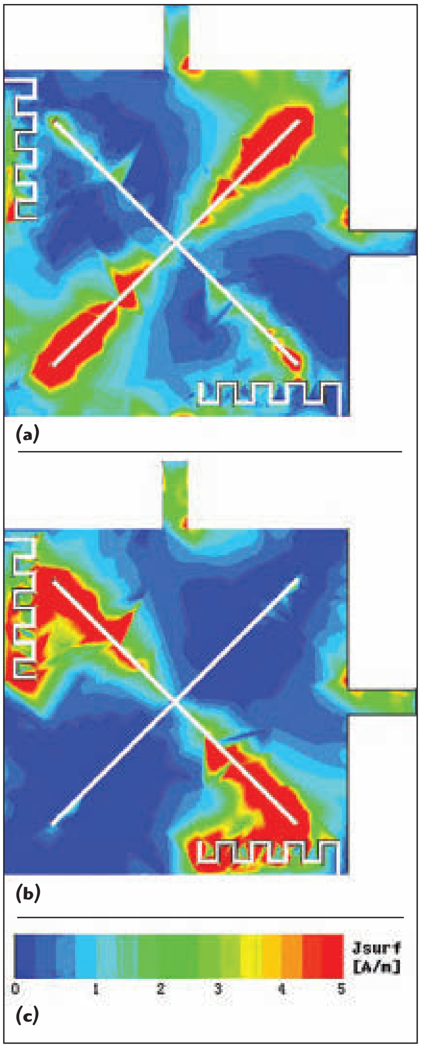
line,[6] a meander spur-line provides more slow-wave effect and occupies a smaller circuit area.[7] Without coupling gaps in the I/O ports, a low insertion loss performance is obtained. In order to perturb two degenerate modes, the two slot lengths are not equal and the two feed lines are orthogonal.

The side length of the patch is designed to be 20 mm and the feed lines are connected to a 50 Ω microstrip line. The slot's length and width are indicated by S and g, respectively. The difference in length between the two slots is ΔS. The physical dimensions of the meander spur-line are described by b, c, d, g and m. The proposed filter is fabricated on a substrate with a relative permittivity ε_r = 4.5 and a thickness of 0.8 mm. The center operating frequency is designed to be 2.3 GHz. The physical parameters are chosen as follows: S = 20 mm, g = 0.3 mm, b = 2 mm, c = 0.4 mm, m = 1.3 mm, d = 1.4 mm and ΔS = 0.2 mm. A size reduction of approximately 36 percent is obtained at the same resonant frequency, compared to a conventional dual-mode bandpass filter.[6] A photograph of the designed dual-mode bandpass filter is shown in ***Figure 2***.

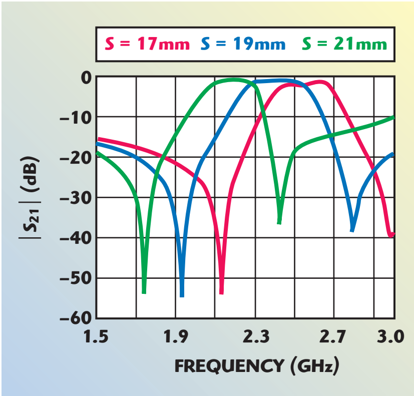
RESULTS AND DISCUSSION

Figure 3 shows the measured transmission performances of the designed dual-mode BPF; the measurement was obtained using a HP8722 network analyzer. A center frequency of 2.3 GHz and a 3 dB bandwidth of 23 percent are measured. Note that the two degenerate modes are located at 2.27 and 2.33 GHz, respectively. There are two transmission zeros on both sides of the passband, providing a sharp rejection and selectivity. They are -49.4 and -37.8 dB at the frequencies of 1.85 and 2.58 GHz, respectively. Furthermore, the insertion loss is better than -1.5 dB from 2.22 to 2.40 GHz and the return loss is better than -25 dB from 2.25 to 2.35 GHz. The minimum insertion loss is -0.9 dB at 2.26 GHz including SMA connector loss.

The simulated current distribution at the resonant frequency is shown in ***Figure 4***, which is obtained by a commercial full-wave EM simulator, Ansoft HFSS. One port is driven by current in orthogonal phase while the other port is terminated in a 50 Ω microstrip line. Two degenerate modes, related to mode TM_{010} and TM_{100}, can be observed. Note that the high current density distributions (red area) are



▲ *Fig. 4 Simulated current distribution at the resonant frequency; (a) phase = 0° and (b) phase = 90°.*



▲ *Fig. 5 Simulated insertion loss for different slot lengths.*

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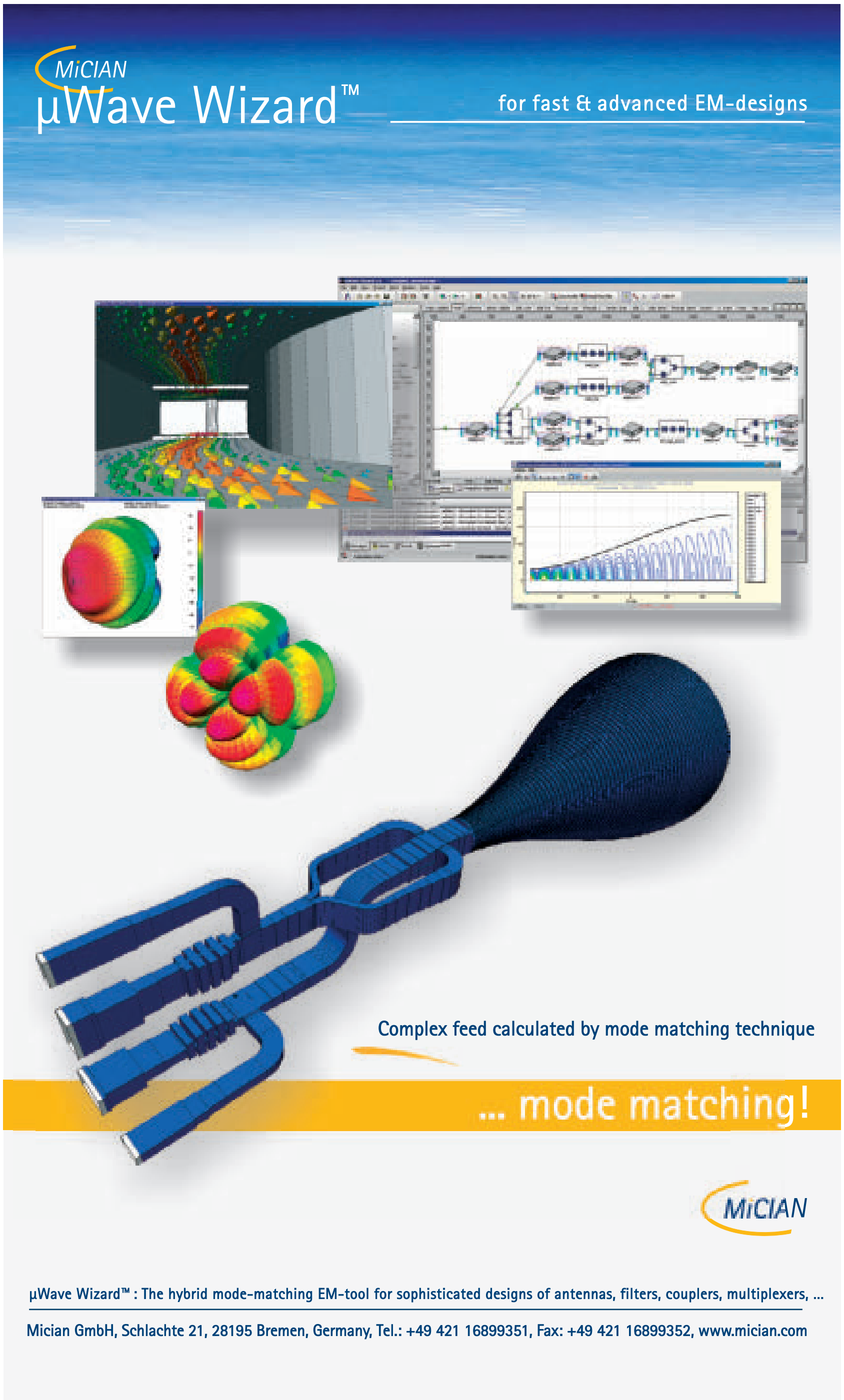
located around the ends of the slots. It is interesting to see that the current density distribution is distorted by the meander spur-line, which yields the current flow rerouting.

Simulated insertion loss performances of the proposed filter with different slot lengths are presented in ***Figure 5***. The center operating frequencies of the filter are approximately 2.17, 2.38 and 2.56 GHz for S = 17 mm, 19 mm and 21 mm, respectively. The center operating frequency is changed by 18 percent. Therefore, the simulated results show that the passband can be adjusted greatly by the slot length. Correspondingly, the transmission zeros are obviously controlled by this physical parameter.

CONCLUSION

In this article, a dual-mode square-patch filter with meandered spur-lines is introduced and verified by measurements. Compared to a traditional dual-mode square patch filter, the proposed filter provides a 36 percent size reduction with a lower insertion loss of -0.9 dB. Interestingly, it is found that the current density distribution can be distorted by meander spur-lines, which yields the current flow rerouting. This compact dual-mode BPF with low insertion loss has a good prospect in microstrip circuit applications. ■



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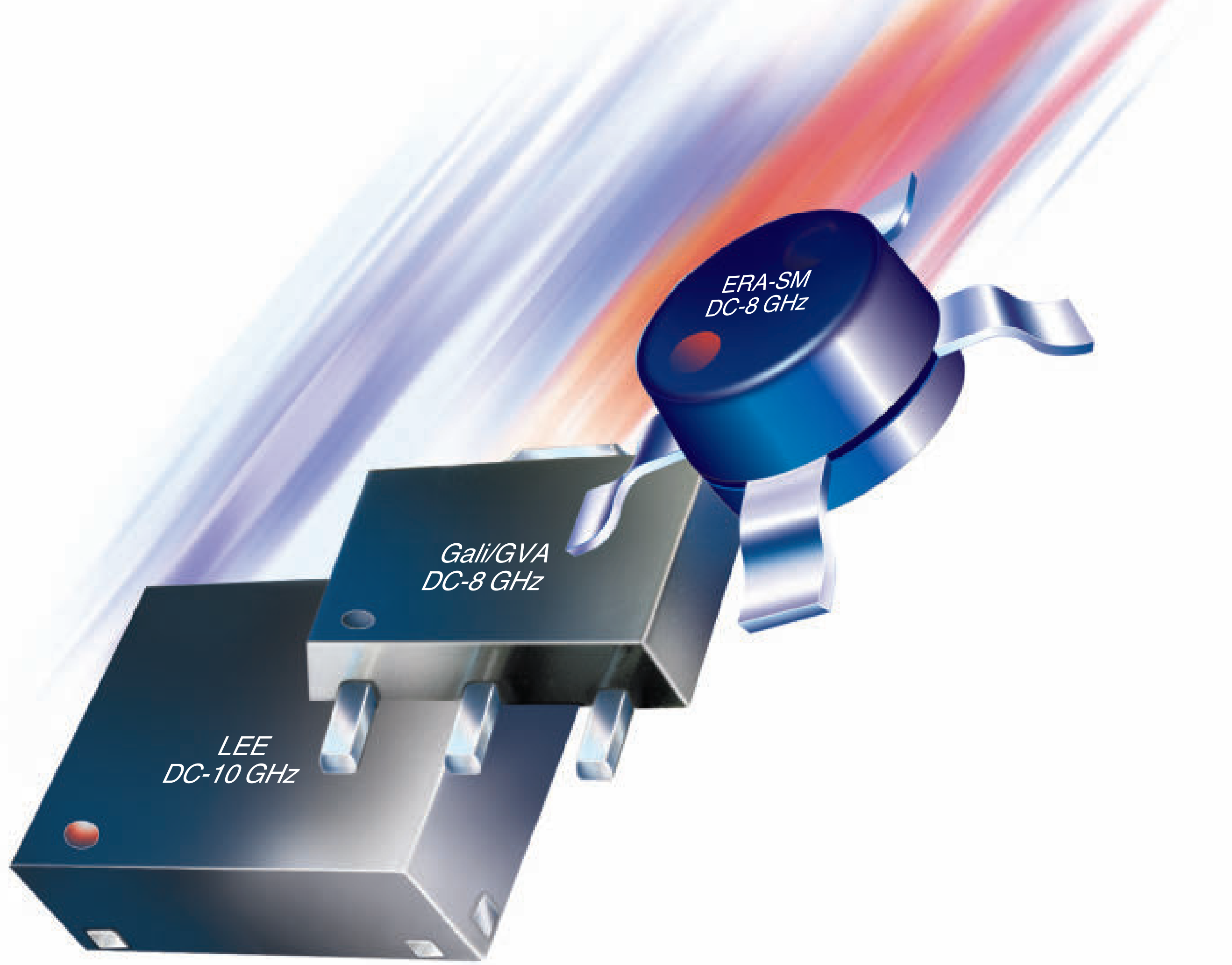

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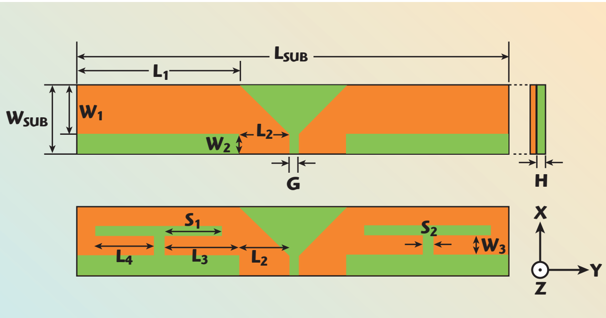
DESIGN OF A DUAL-BAND PLANAR DIPOLE ANTENNA FOR WLAN APPLICATIONS

In this article, a dipole antenna is designed to operate in the 2.4 and 5.2 GHz WLAN bands. A novel T-shape slit is embedded in the dipole antenna to achieve dual-band operation for WLAN applications, and to avoid increasing the area of the antenna. The antenna has the dimensions of 7 × 43.96 × 0.8 mm and good radiation characteristics. The fabricated antenna has a dual-band bandwidth covering 2.23 to 2.62 GHz and 4.84 to 5.38 GHz. The effects of the antenna parameters (S_1, S_2 and L_3) on the operating band are studied by using various lengths of the T-shape slit.

There has recently been much research on broadband and multi-band antennas for various wireless communication systems. The IEEE has issued regulations for the wireless local area network (WLAN, 802.11a/b) since 1999. The development of WLAN has already reached maturity and has become fairly universal. The development of antennas used on mobile communication devices is extremely important. The advantages of the printed dipole antenna[1,2] include low profile, light weight and low cost. Furthermore, it is very suitable for installation in notebook computers. A dipole antenna was reported[2] where an embedded U-shaped slot in the two rectangular arms produced two additional dipole arms. These two dipole arms enable the dipole antenna to generate a lower and a higher frequency resonance. Similarly, a different shaped slot, embedded in the dipole antenna, can produce two additional dipole arms.[3,4] Two designs[5,6] of monopole antennas consist of two strips with the same width and different length. These strips can generate different operating frequency bands.



▲ *Fig. 1 Proposed WLAN antenna geometry.*

In this article, a rectangular dipole antenna is demonstrated, where two embedded T-shape slits generate a new resonant mode to achieve dual-band operation from 2.23 to 2.62 and 4.84 to 5.38 GHz for WLAN applications. The proposed antenna is fed with a 50 Ω mini coaxial line. The advantages of the proposed antenna include small size, low cost, easy fabrication. It is very suitable for installation in a notebook computer, Personal Digital Assistant (PDA) and other mobile communication devices. Detail design steps and experimental results for the designs are studied and investigated in this article.

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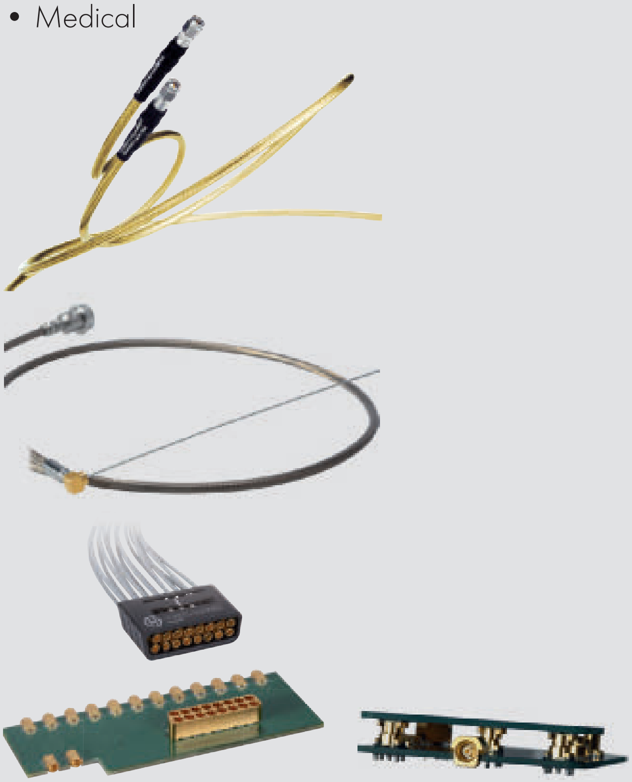

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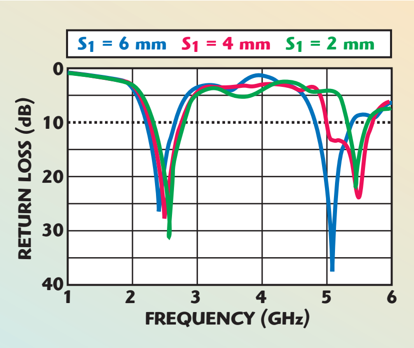
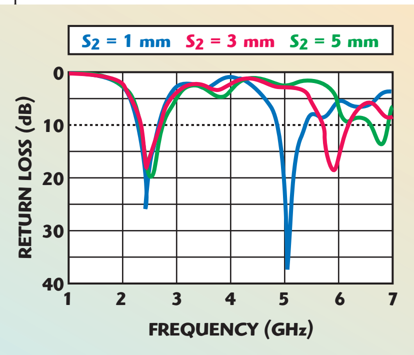
ANTENNA DESIGN

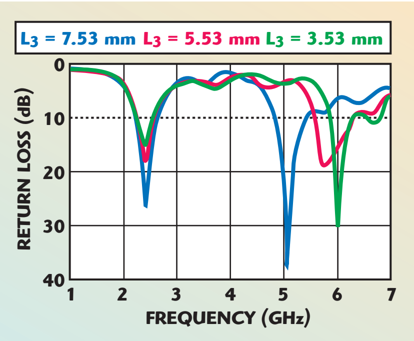
The configuration of the proposed antenna is shown in ***Figure 1***, with dimensions of W_{sub} = 7 mm, L_{sub} = 43.96 mm and H = 0.8 mm. The proposed dual-band dipole antenna is printed on an FR4 substrate with a relative dielectric constant ε_r = 4.4 and a thickness H = 0.8 mm. The proposed antenna is fed in the middle of the structure and connected to a 50 Ω mini coaxial line. The basis of the antenna structure is two rectangular arms with dimensions of W_1 = 5 mm and L_1 = 16.53 mm. The horizontal design, a T-shape slit, is embedded in each arm of the rectangular dipole antenna to generate a new resonant mode at 5.2 GHz. Combining the 2.4 GHz band of the rectangular dipole antenna and the 5.2 GHz band newly generated meets the requirements of WLAN systems.



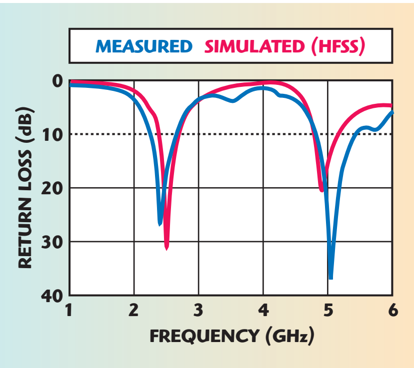
▲ *Fig. 2 Measured return loss for different* S_1.



▲ *Fig. 3 Measured return loss for different* S_2.



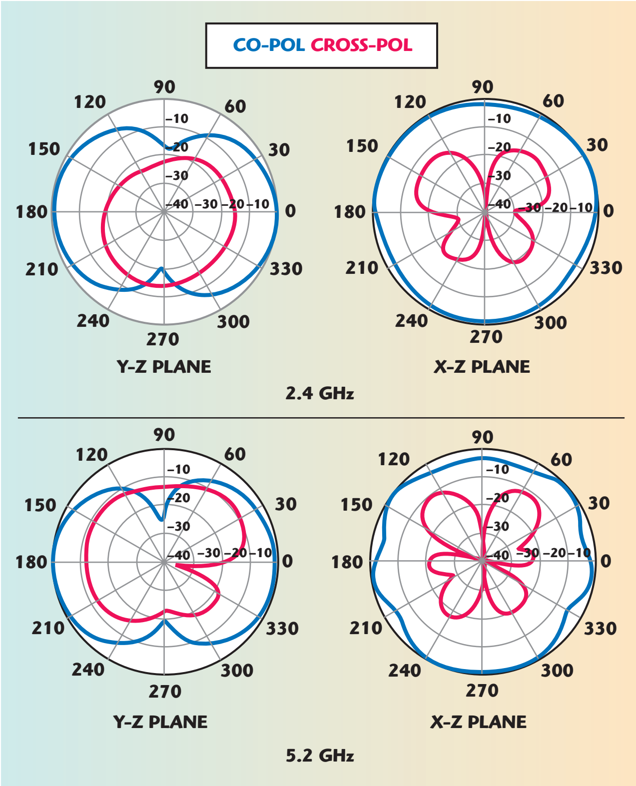
▲ *Fig. 4 Measured return loss for different* L_3.



▲ *Fig. 5 Measured and simulated return loss of the proposed antenna.*

EXPERIMENTAL RESULTS AND DISCUSSION

In this section, dipole antennas with various parameters (S_1, S_2 and L_3) were constructed and studied to demonstrate the performances of the proposed design. The simulated results are obtained with Ansoft High Frequency Simulation Software (HFSS). ***Figure 2*** shows the measured return losses of different slit lengths S_1 with other dimensions: G = 0.9 mm, L_1 = 16.53 mm, L_2 = 5 mm, L_3 = 5 mm, L_4 = 6 mm, W_1 = 5.mm, W_2 = 2 mm, W_3 = 2.mm and S_2 = 1 mm. The resonance characteristics of these antennas are listed in ***Table 1***. When S_1 decreases, the



▲ *Fig. 6 Measured radiation patterns in the y-z and x-z planes for the proposed antenna.*

TABLE I

RESONANCE CHARACTERISTICS FOR DIFFERENT S_1 LENGTHS

S_1 (mm)	1st Resonant Frequency (GHz)	1st Bandwidth (%)	2nd Resonant Frequency (GHz)	2nd Bandwidth (%)
6	2.41	16.6	5.05	11.49
4	2.49	17.27	5.44	12.5
2	2.55	16.08	5.41	5.55

TABLE II

RESONANCE CHARACTERISTICS FOR DIFFERENT S_2 LENGTHS

S_2 (mm)	1st Resonant Frequency (GHz)	1st Bandwidth (%)	2nd Resonant Frequency (GHz)	2nd Bandwidth (%)
1	2.41	16.6	5.05	11.49
3	2.44	14.75	5.89	9.51
5	2.5	17.6	6.77	5.16

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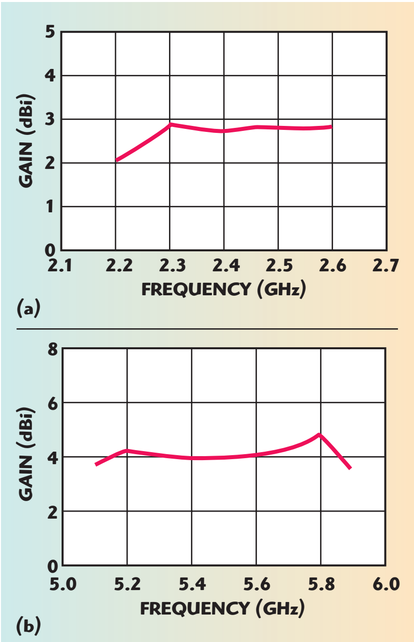
lower frequency is slightly shifted up from 2.43 to 2.54 GHz, and the higher frequency is markedly shifted up from 5.05 to 5.41 GHz. The measured return losses for various slit lengths S_2 are shown in ***Figure 3*** with S_1 = 6 mm. The resonance characteristics of these antennas are listed in ***Table 2***. The higher resonance frequency is markedly shifted up from 5.05 to 6.76 GHz when S_2 is increased. ***Figure 4*** shows the measured return losses for different lengths L_3, with S_1 = 6 mm and S_2 = 1 mm. When L_3 decreases, the higher frequency is markedly shifted up from 5.05 to 5.98 GHz. It can be found that the length L_3 determines the higher frequency, which is approximately a quarter of a guided wavelength. The related results are also listed in ***Table 3***. ***Figure 5*** shows the measured and simulated return losses of the proposed antenna, with S_1 = 6 mm, S_2 = 1 mm and L_3 = 7.53 mm. The small frequency shift between the measured and simulated results is caused by the manufacturing tolerances.

The far-field radiation patterns were measured and calibrated in a STUT anechoic chamber. ***Figure 6*** shows the measured radiation patterns at 2.4 and 5.2 GHz in both the x-z and y-z planes. Since the feed line is located parallel to the y-axis, the y-z plane radiation pattern of the proposed antenna has nulls in +y-direction and -y-direction. It is noted that the radiation pattern in the x-z plane of the antenna is with omni-directional radiation characteristics. ***Figure 7*** shows the measured antenna peak gain against frequency. The antenna gain is 2.77

TABLE III

RESONANCE CHARACTERISTICS FOR DIFFERENT L_3 LENGTHS

L_3 (mm)	1st Resonant Frequency (GHz)	1st Bandwidth (%)	2nd Resonant Frequency (GHz)	2nd Bandwidth (%)
7.53	2.41	16.6	5.05	11.49
5.53	2.41	14.11	5.75	13.04
3.53	2.41	12.03	5.98	6.85



▲ *Fig. 7 Measured antenna gain at (a) 2.4 GHz and (b) 5.2 GHz.*

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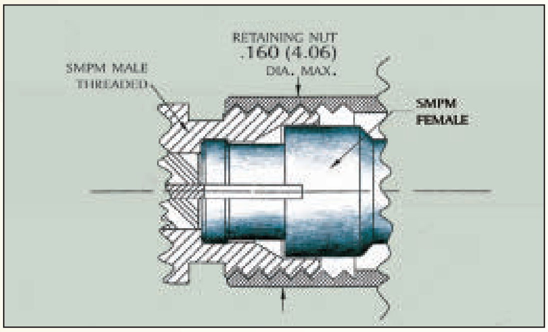

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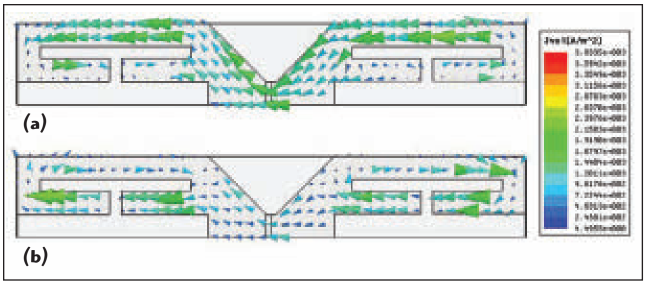

▲ *Fig. 8 Simulated surface current distribution at (a) f = 2.4 GHz and (b) f = 5.2 GHz for the proposed antenna.*

dBi at 2.4 GHz and 4.18 dBi at 5.2 GHz. ***Figure 8*** shows the simulated surface current at 2.4 and 5.2 GHz for the proposed antenna. It can be observed that these currents circulate in two current paths in this structure.

CONCLUSION

The antenna proposed in this article supports a dual-band operation at 2.23 to 2.62 GHz and 4.84 to 5.38 GHz for WLAN applications, with good radiation characteristics in both operating WLAN bands. The proposed antenna has a simple structure, low profile and small dimensions. Therefore, it will be an attractive candidate for WLAN applications and is very suitable for installation in notebook computers, PDAs and other portable devices. ■

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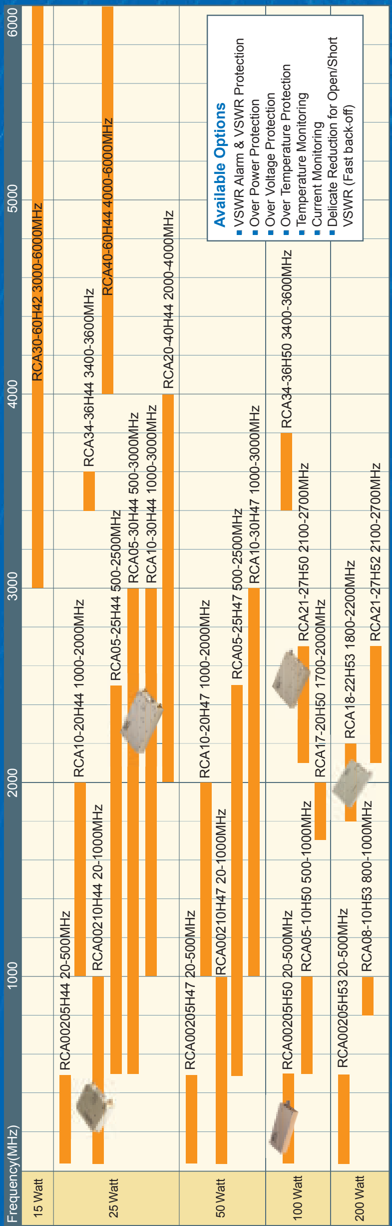

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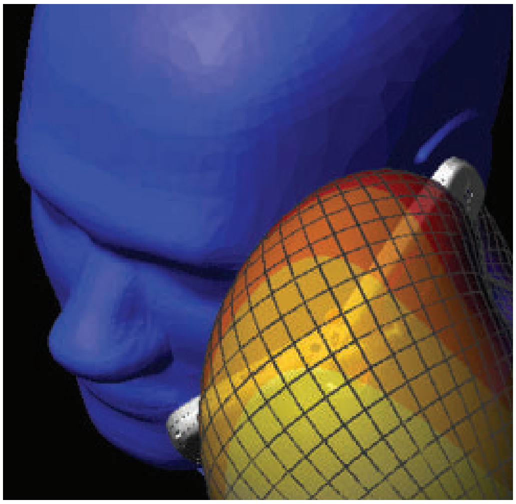

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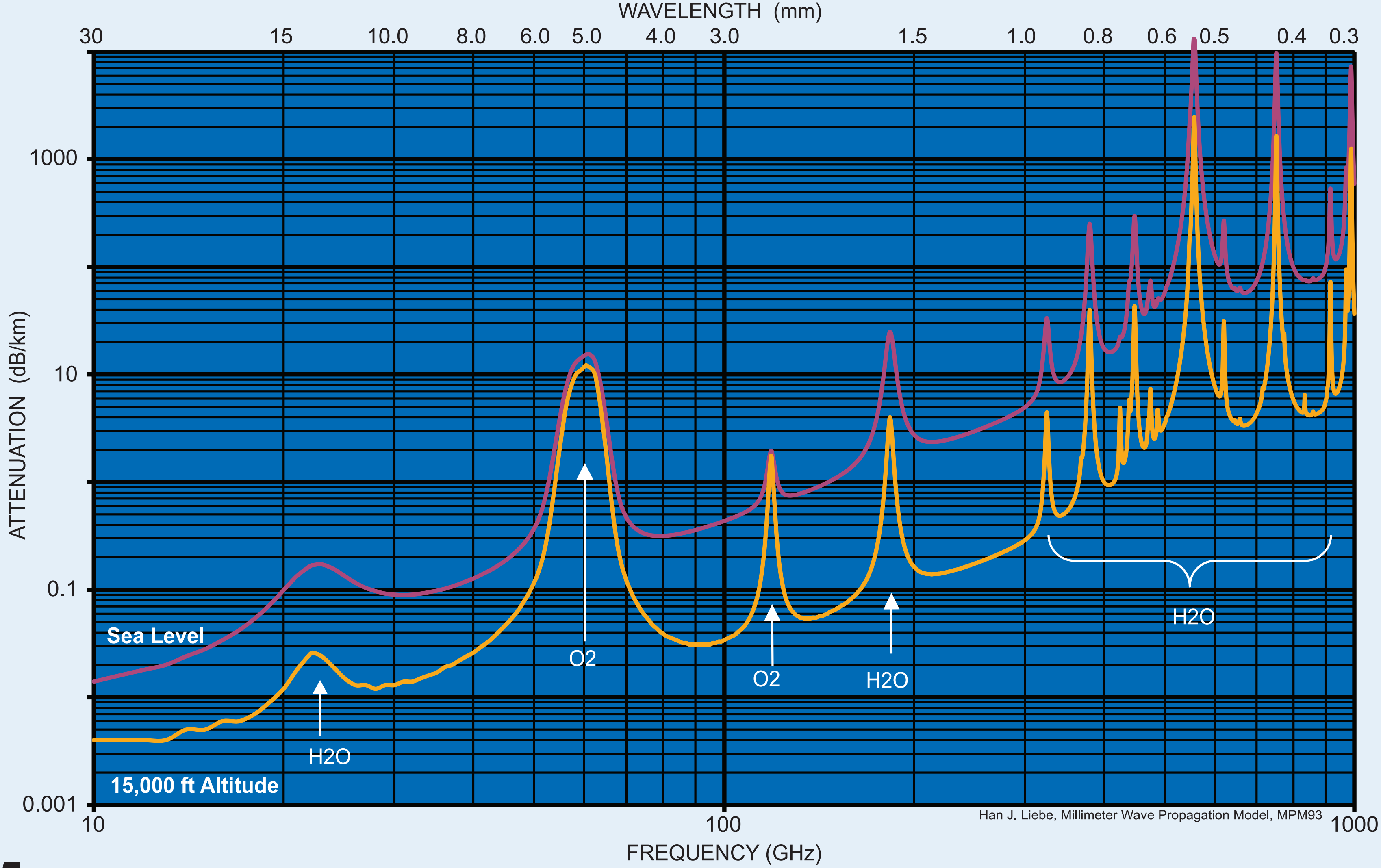

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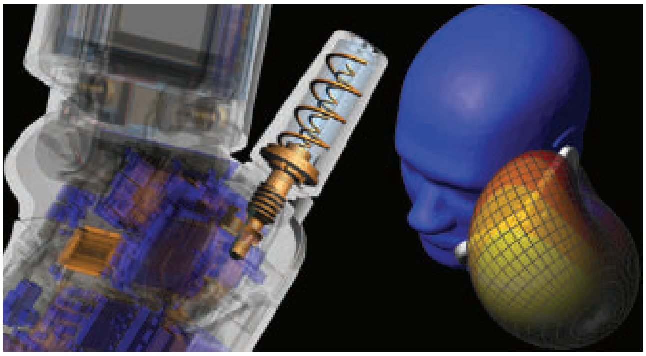

▲ *Fig. 1 Detailed image of a cell phone (left) and far-field radiation from a cell phone in the proximity of the SAM head (right).*

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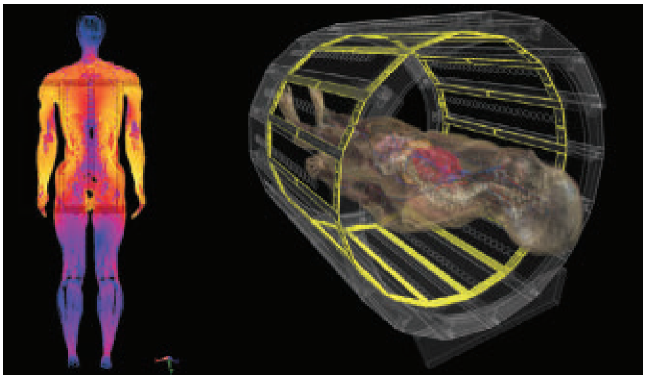
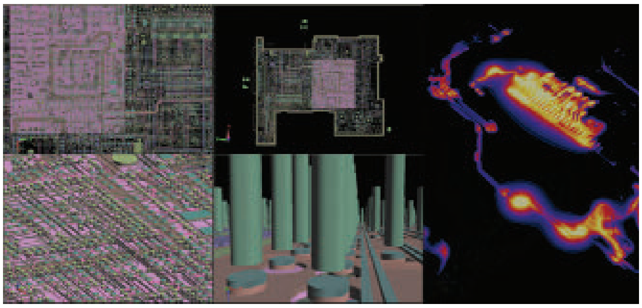


▲ *Fig. 2 Computed SAR distribution of the human body inside a MRI coil (left) and birdcage model loaded with anatomical adult male phantom in SEMCAD X (right).*



▲ *Fig. 3 PCB layout imported from ODB++ (CAD model and Netlist) as well as the simulated current distribution on the digital line of the 20 layer PCB board.*

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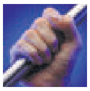

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can be extracted with a dedicated material Genetic Algorithm-based optimization routine to a stable combination of Drude-Lorenz-Debye, while the accuracy of the model can be controlled in the optimization routine.

The optical material definition includes the Kerr-effect (linear intensity dependence of the relative permittivity or permeability) and Raman-scattering, describing the scattering of light at phonons (lattice vibrations). Optical waveguides, filters, photonic crystals, nano-particles and plasmonic resonant structures can be optimized using a framework of four advanced optimization methods based on Genetic Algorithms, Particle Optimization and Bracketing Techniques. ***Figure 4*** shows a typical example using the SEMCAD X OPTICS solution.

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In addition to the established low frequency applications such as power lines (see ***Figure 5***), the user can apply the entire range of SEMCAD X's posable anatomical high-resolution full body human/animal models for radio frequency ablation in cancer treatment as well as various other biomedical applications.

MICROWAVES

SEMCAD X µWAVE is an advanced EM full-wave solution for fast and accurate design of microwave devices. A set of different time-domain solvers centered on the standard FDTD method are available: FDTD, FIT/C-FDTD, ADI-FDTD and FIT/C-ADI-FDTD. The ability to use conformal mesh FIT/C-FDTD results in a coarser spatial resolution that nonetheless produces accurate results, while reducing substantially the computational effort. Also, the ADI-FDTD solver is well suited to highly over-discretized simulation setups, as well as for simulations at very low frequencies.

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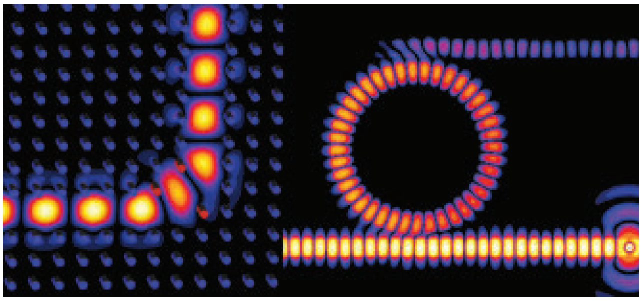
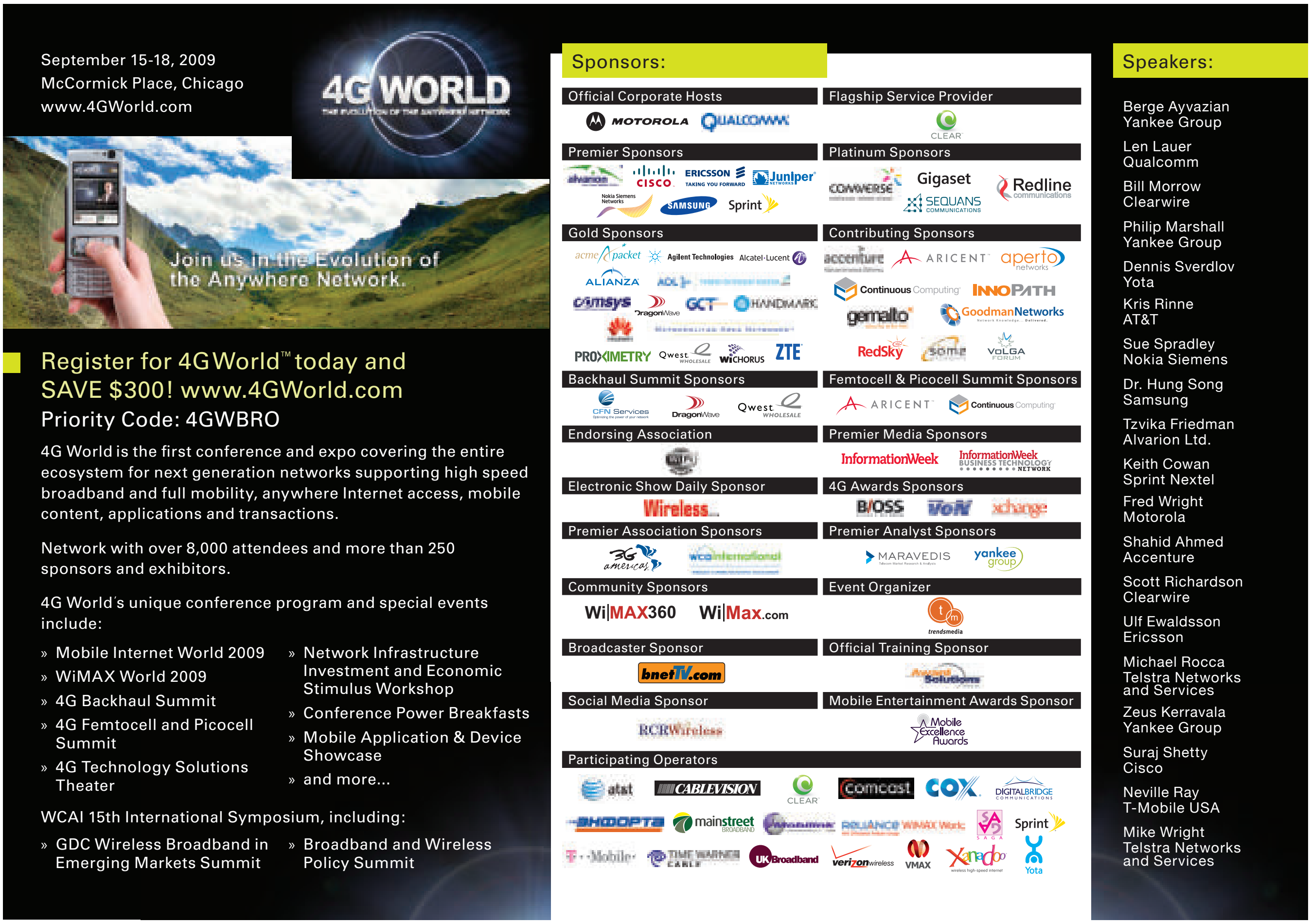


▲ *Fig. 4 Field distribution of an optimized 90° optical waveguide bend (left) and an add/drop ring coupler for optical filtering at 550 nm (right).*



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PLD	30-130 MHz	P.L. Crystal	-95	-115	-140	-155	-155	-	100 MHz	13
PLD-1C	130-1000 MHz	P.L. Mult. Crystal	-80	-100	-120	-130	-135	-	560 MHz	13
BCO	.100-16.5 GHz	P.L. Single Loop	-65	-75	-80	-90	-115	-	16.35 GHz	13
VFS	1-14 GHz	Multiple Freq. Dual Loop	-60	-75	-110	-115	-115	-	12.5 GHz	13
DLCRO	.8-26 GHz	P.L. CRO Dual Loop	-60	-85	-110	-115	-115	-138	10 GHz	13
PLDRO	2-40 GHz	P.L. DRO Single/Dual	-60	-80	-110	-115	-120	-145	10 GHz	13
CP	.8-3.2 GHz	P.L. CRO Single Loop	-80	-110	-120	-130	-130	-140	2 GHz	13
CPM	4-15 GHz	P.L. Mult. Single Loop	-60	-90	-105	-110	-115	-130	12 GHz	13
ETCO	.1-24 GHz	Voltage Tuned CRO	-	-	-70	-100	-120	-130	2-4 GHz*	13

* Octave band.

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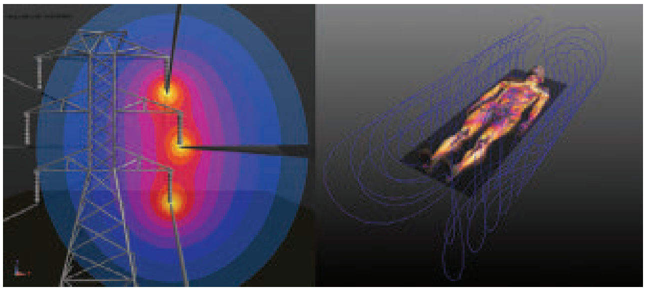
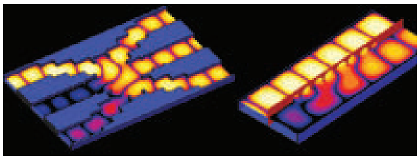


▲ *Fig. 5 H-field distribution along a power line (left) and Electro-Quasi-Static solution of the induced currents in a human phantom inside a gradient z-coil of a MRI system (right).*

is achievable with the OGL-based 3D QTech rendering engine, which has been developed in-house. Fully parameterized modeling can perform simulations of statistically distributed parameter values in addition to the advanced optimization routines available. ***Figure 6*** shows typical examples using the SEMCAD X μWAVE solution.



▲ *Fig. 6 Field distribution inside a six-port waveguide coupler (left) and inside a circular multi-aperture narrow-wall waveguide coupler (right).*

ADDITIONAL FEATURES

Listed above are the application specific features, but SEMCAD X V14 *Aletsch* also has numerous new features that are solution independent. These include:

- Next generation GUI
- New CAD importer
- Multi-view model window and perspective camera for better visualization and handling of most complex models
- Optimizer 3: full redesign and reintegration of SEMCAD's optimization platform to integrate all solvers and distribute an optimization using multiple machines on the network
- New posable human and animal body models in SEMCAD X POP
- Doubling of the computation power when using new NVIDIA GPU & Acceleware hardware solutions
- Titled lumped elements and edge sources
- Extended material handling functionality, extension of the materials database
- True 64 bit support for simulations > 1 BCells

CONCLUSION

The new SEMCAD X V14 *Aletsch* release builds on the existing and established strengths of the SEMCAD X to offer a novel suite of solutions that have been tailored to specific applications. It offers scope and flexibility to address the wide variety of challenges that engineers typically encounter.

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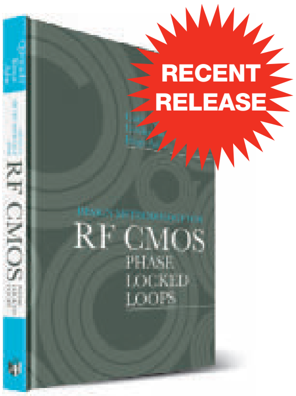

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Guillermo Bistué, Íñigo Adin, and Carlos Quemada

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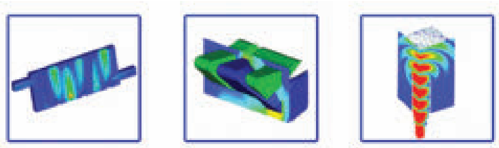

3D FEM ANALYSIS SOFTWARE FOR SOLVING COMPLEX PROBLEMS

EXECUTIVE INTERVIEW SERIES

MWJ SPEAKS WITH JOHN DEFORD, DIRECTOR OF ENGINEERING, AWR.
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Electromagnetic (EM) analysis software has evolved from its traditional place as a back-end verification tool to a necessity throughout the design flow. However, this role can impede the design flow if it requires designers to spend precious time performing file conversions, transfers, and other minutiae, or slow it to a crawl when tackling large planar or arbitrary three-dimensional (3D) problems. AWR, a company founded by microwave engineers who have experienced first-hand the complex issues that are part and parcel of high frequency design, has addressed this issue with its AXIEM™ 3D planar EM simulator, which can process upwards of a million unknowns at very high speed. The company has now expanded these capabilities to include a full 3D finite element method (FEM) EM analysis with its Analyst™ 3D FEM EM acquisition. Analyst technology is unique among 3D EM tools because it can efficiently use clusters of computers in parallel employing both spectral and domain decomposition techniques. Together these proprietary algorithms produce an orders-of-magnitude reduction in computational time while improving results. The complexity of the problems Analyst can solve are limited only by the computational resources available to the designer and not the abilities of the software itself.

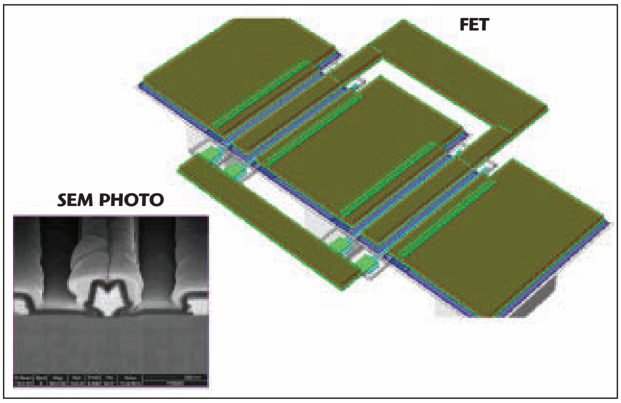

Fig. 1 SEM photo reveals the arbitrary 3D features of a FET making the Analyst FEM solver a good fit.

Even relatively straight-forward geometries presented to a 3D FEM EM solver can contain many thousands of coupled equations (see ***Figure 1***). While the solutions to these are necessary, a single computer's processing time and

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memory requirements for such calculations rapidly becomes a bottleneck in the design process; it is sometimes not even possible to solve problems above a certain size and complexity. To mitigate these limitations, multiple processors must be employed in parallel and problems must be solved using spectral and domain decomposition. To understand the latter two techniques, it is necessary to describe the unique characteristics of each one.

SPECTRAL & DOMAIN DECOMPOSITION

When solving a problem over a range of frequencies using spectral decomposition, a subset of the frequency domain is sent to each processor, which solves the design within a portion of the spectrum assigned by the software. The processors communicate only when they collectively present their results to the user after performing their tasks, which cuts overall computation time by a factor of nX, where n is the number of processors available. For example, if 10 processors are available to the user, a problem can be solved in one tenth the time by sending one tenth of the spectrum to each processor, instead of processing the entire spectrum on one processor and serially solving one frequency after another. Spectral decomposition is neither new nor difficult to implement and is commonly employed by EM tools from many vendors, including AWR's own AXIEM method of moments (MoM) solver. However, its implementation within Analyst is in conjunction with the much more complex and powerful approach of domain decomposition, providing unique benefits in terms of capacity and memory utilization.

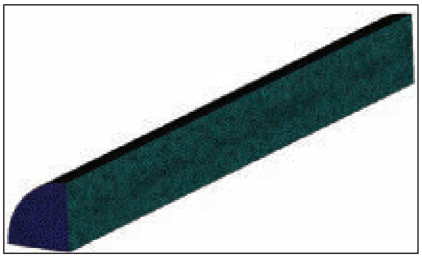
Spectral decomposition works well if each processor can handle its designated portion of the spectrum on its own. However, if one processor alone cannot solve one frequency and spectral decomposition is the only technique available, the problem cannot be solved. The answer lies in domain decomposition, which can overcome the hardware-limitation of spectral decomposition. Domain decomposition grows the possibilities of what can be solved by subdividing the finite element mesh among as many processors as are available to the user. Domain decomposition and its complementary nature to spectral decomposition are unique to the Analyst 3D FEM EM tool and have been developed and refined over 10 years, with funding from the US Department of Energy, by AWR's Analyst design team.

Somewhat less efficient than spectral decomposition, domain decomposition provides not quite an nX reduction in computation time given that all processors must communicate with each other when working on the same frequency. Consequently, domain decomposition provides a 60 to 80 percent efficiency in reducing computation time over each additional process, rather than spectral decomposition's typical near-linear scaling with the number of processors. In the 10 processor example mentioned above, a fraction of the overall mesh is sent to each processor and all 10 work on a single frequency/frequency spectrum together. This makes it possible for Analyst to solve problems of nearly unlimited size, bounded only by the number of processors available. Up until this point, "large" has been described in terms of a problem's component count and wavelengths; however, a problem can likewise be large as dictated by numerical complexity versus physical complexity (see ***Figure 2***). Here a physically simple waveguide structure is shown with a highly refined mesh as a very precise calculation for phase was desired for comparison to an analytic formula. The result is a "large" number of unknowns and a numerically challenging calculation.

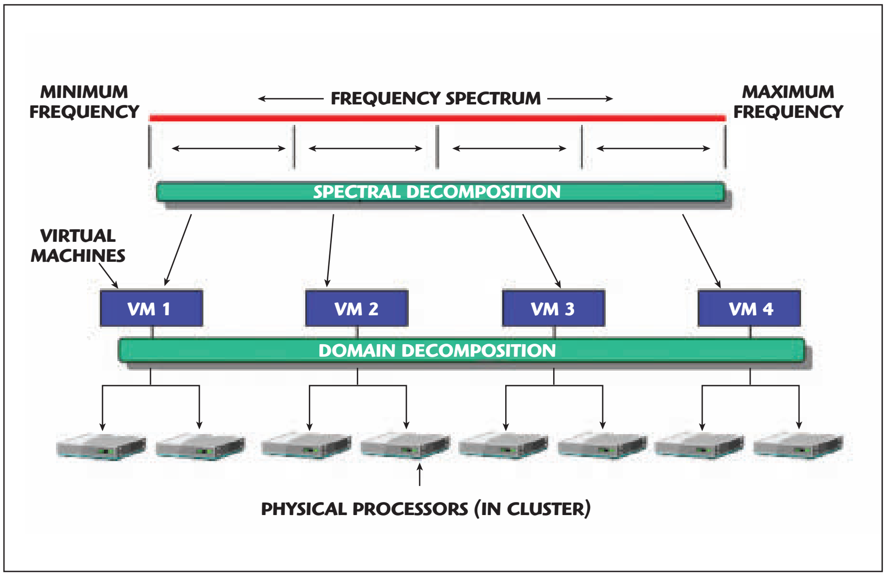
Whether large is defined in terms of physical design complexity or numerical accuracy required, Analyst can solve large problems and do so efficiently. The Analyst 3D FEM EM engine further boasts resource optimization heuristics that automatically determine the optimum number of processors to use for a given problem at a given frequency. If the problem is too large to fit on one processor but fits on two, communication time is reduced because the software has reduced the number of processors to its optimal number—and two processors do not need to communicate nearly as frequently as 10. This unique combination of spectral and domain decomposition is illustrated in ***Figure 3*** and uniquely available within the Analyst tool.

MMIC EXAMPLE

As the F_t of process technology pushes into the low THz range, MMIC design at mm-wave frequencies looks much less like distributed-design-on-a-chip. As such, the



▲ *Fig. 2 Analyst and analytic transmission phase agree to four decimal places of accuracy for this circular waveguide.*



▲ *Fig. 3 Analyst's complementary utilization of spectral and domain decomposition makes it possible to solve complex problems accurately.*

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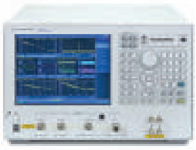

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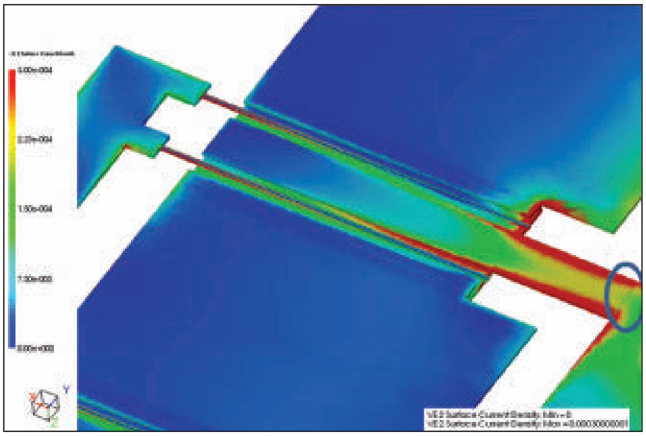

▲ *Fig. 4 Results from Analyst for a 3D PHEMT FET at 60 GHz show the distributive nature of the current in the gate, drain and source. The circled area shows a region of high current density.*

metal on the FET now needs to be extracted separately and understood apart from the intrinsic device. Given the complex cross-sectional structure of the gate, mesa-etched epitaxial layers, and metallization effects at mm-wave (see Figure 1), 3D FEM becomes necessary as it gives greater insight into the interplay of metal and device than a 3D planar EM simulation alone. In this example (courtesy of WIN Semiconductor), a four-fingered PHEMT device is analyzed at mm-wave frequencies to reveal the impact of the the 3D nature of not only the trapezoidal vias but also the arched airbridge and stepped metal that shorts the source and drain stripes, as shown in ***Figure 4***. The circled feature is actually a high current area due to a step in the metal in the z-direction.

CONCLUSION

Analyst transcends the limitations of conventional 3D FEM EM solvers in three ways. First, it was designed from its inception to efficiently perform calculations in parallel using computer clusters rather than a single computer, regardless of how many processors it employs. Second, it optimally and automatically employs the minimum number of processors required to solve a problem because too many processors employed inefficiently can actually increase computational time. Finally, by using spectral and domain decomposition, Analyst can exploit the benefits of both while minimizing their shortcomings. The result is computational times orders of magnitude faster than conventional tools when solving very large problems, the ability to solve large problems with highly accurate results, and the ability to scale linearly to accommodate problems of virtually any size the user demands.

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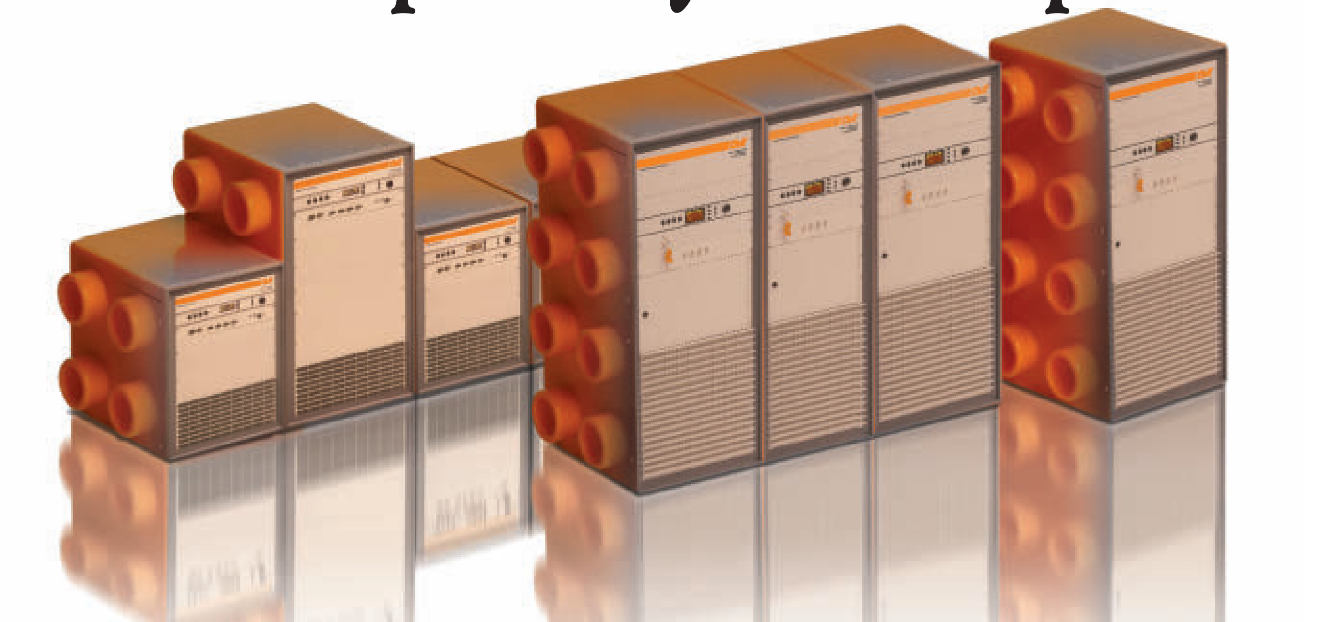

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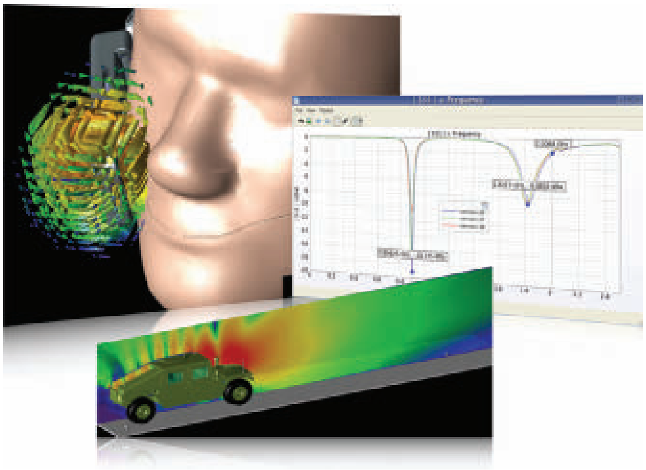

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EM simulation has become increasingly important in the design and analysis of antennas, microwave circuits, scattering and photonics, etc. In addition, manufacturers, regulatory bodies and the general public share a common concern over the effects of RF radiation from cell phones, implanted medical transmitters and MRI systems on humans. As RF energy is deposited in the tissue, heating can occur. Measuring the rate at which RF energy is absorbed is known as the specific absorption rate (SAR) and is defined as the power absorbed per mass of tissue (watts per kilogram). Because live human heads cannot be safely instrumented for these measurements, computational methods are used to estimate the SAR in actual human heads. For product designers, it has become standard practice to calculate the SAR of new devices to ensure that they generate a level below the limits set by the IEEE and other regulatory bodies. EM simulation is at the heart of these calculations.

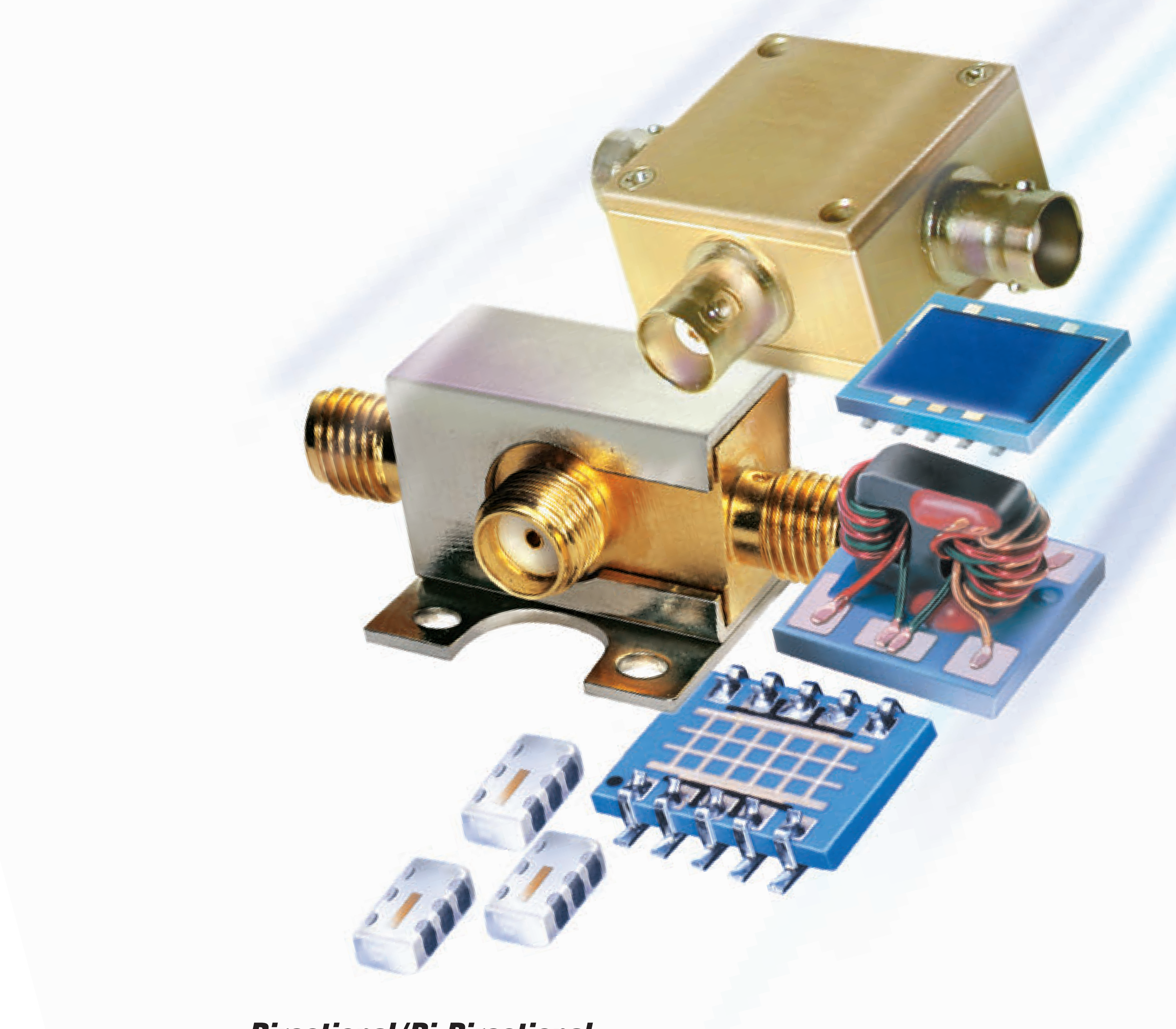
The finite-difference time domain (FDTD) modeling technique is a differential formulation that allows users to divide the model space into very small cells, which provides excellent resolution of tissue structures in the human body and makes it ideally suited for SAR calculations. Remcom's XFdtd® is an FDTD-based 3D electromagnetic solver that is used by manufacturers of cell phones, implantable RF transmitters and MRI devices to compute SAR values generated by their new products.

The company has just recently announced the release of XFdtd 7.0 (XF7), which addresses biological EM analysis as well as antenna design and analysis, microwave circuit design and other EM simulation applications. The principle enhancements of XF7 focus on providing a simplified and streamlined user interface and several unique time-saving features, ubiquitous parameterization, more accurate and efficient meshing, and dynamic interactive data processing (graphs). All these features target engineering productivity, speed and accurate results.

INTERFACE AND WORKFLOW

An intuitive and easy to operate user interface helps designers set up problems more efficiently with less time spent learning the tool's capabilities. The developers of XF7 put

REMCOM INC.
State College Park, PA



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LTCC COUPLER FAMILY

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IF/RF MICROWAVE COMPONENTS

396 Rev F

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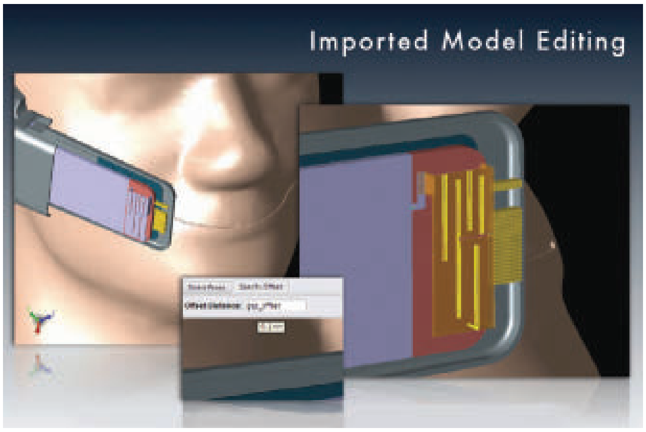
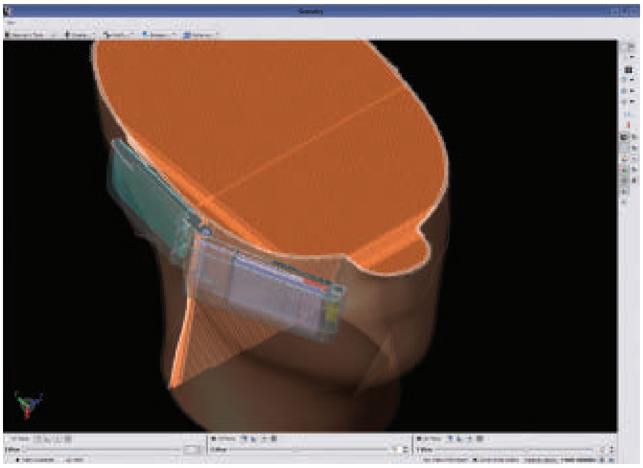
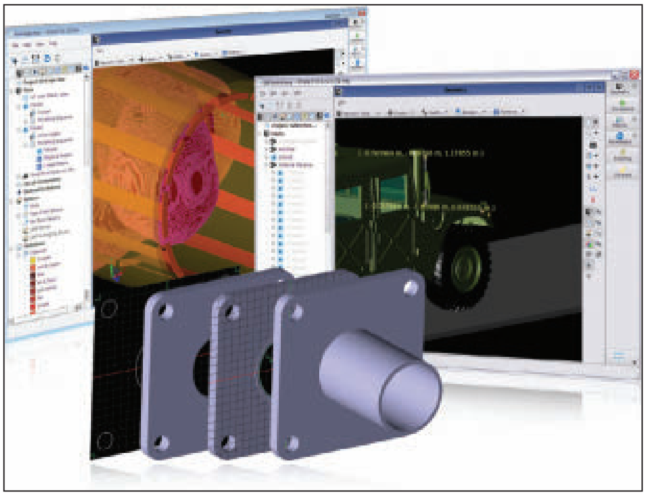


▲ *Fig. 1 Parameterized features on imported models.*



▲ *Fig. 2 Meshing example of cell phone and head.*



▲ *Fig. 3 Modeling examples.*

considerable effort into making their interface simple and clutter-free. Key features include a customizable project tree, context sensitive tools display (to reduce the number of irrelevant toolbar buttons during various stages of design entry or data-processing), in-line editors to eliminate obstructed views and menu-embedded controls instead of pop-up dialogs.

As projects are entered in XF7, each model, component, sensor, waveform, material or shared definition will indicate if it is invalid—or if anything it depends upon is invalid—and why. The interface checks for errors in real-time to ensure the validity of simulations and provides thorough feedback to troubleshoot difficulties. To eliminate redundancies in the workflow, XF7 multiplies productivity by allowing the reuse of almost anything. Any project can be turned into a template, most parts of the project can be stored in a shared library, and any simulation can be saved and the results easily accessed for comparison purposes.

Smaller features like these can save the user anywhere between five and 30 minutes each time they are used. The new Hierarchy Import can save hours when frequently updating CAD files by allowing the user to set up the hierarchy, material assignments and meshing priority only once. XF7 preserves this information each time a new version of the file is imported. Workflow efficiency is further addressed with the new complete result history.

SETTING UP THE MODEL

The new modeling engine in XF7 supports complicated models built from the ground up or imported from CAD files, which in turn can be edited (see ***Figure 1***). Modeling operations are broken down into step-by-step procedures, keeping the interface simple and the tasks easy to understand. Modeling operations are chained together on each object, creating an editable history for each model in the project.

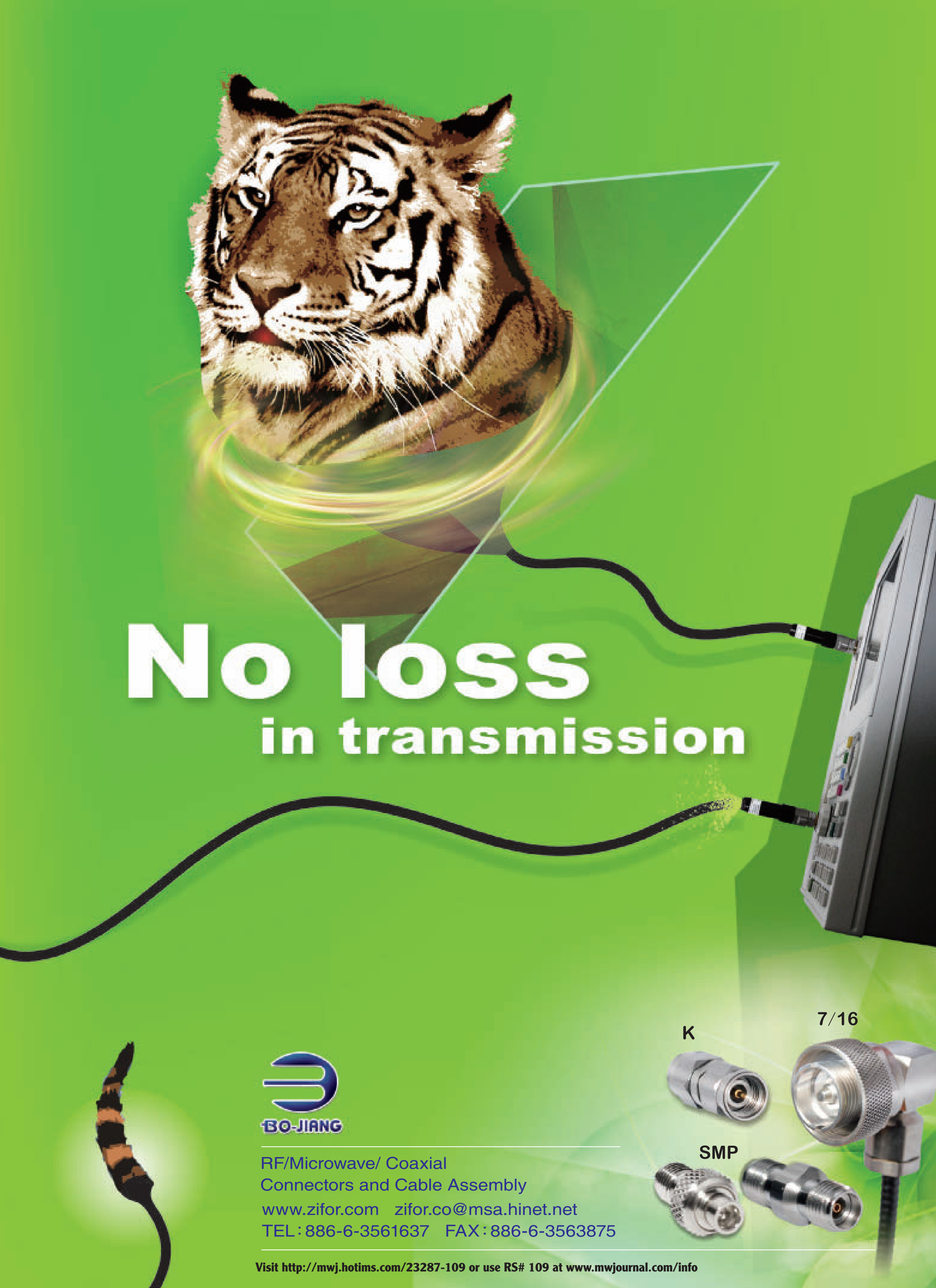
The starting point for creating models in XF7 is the powerful 2D Sketcher. Intuitive grid/object snapping and a constraint system allow for quick creation of complex shapes. XF7 keeps track of all the operations performed while creating a model, allowing users to go back and edit the original sketch and those changes will be propagated through the rest of the modeling history.

Using parameters in geometric modeling is a real time saver. In XF7, parameters can be assigned to parts, components, waveforms, materials and just about everything else in the project. Entire assemblies based on the same parameter can be modified by changing one value and parameter sweep simulations can be run automatically. Mathematical expressions can be used in place of basic parameters, and each parameter can be defined as an expression or as a scripted function.

Nearly everything in the application can be controlled and accessed through a powerful scripting API. The XF7 scripting API enables the same level of user control as the GUI. Modeling functions, result data, grid and mesh operations and even creating and running simulations can all be controlled by scripts.

MESHING

Remcom claims to have improved the product's already fast meshing engine by an order of magnitude in the latest release (see ***Figure 2***). Meshes that previously would have been too large to view can now be created and inspected in a fraction of the time on a desktop computer. XF7 intelligently updates the mesh only when and where it is required, allowing users to create the most accurate and efficient mesh with fewer interruptions. XF7 can automatically detect small details on your model, and adjust the grid automatically to provide the most detail where it is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needed. This ensures that any project will have the smallest mesh necessary to perform an accurate simulation.

RESULTS AND PLOTS

This results history allows quick and easy access to past results. The Results Browser in XF7 is completely customizable, allowing users to find results based on user-selected characteristics (see ***Figure 3***). Access to past results will likely result in data becoming quite large. The filtering and searching tools in the Results Browser provide ready access to all this data in a few mouse clicks. Results from other projects or past simulations can be added to graphs, viewed in 3D, post-processed, or exported to text files. And it all starts from the same place, the Results Browser. There are fewer windows to go through and no complicated folder structures to navigate.

The graphing tool within the new product supports plotting of results as they are computed. The results are automatically updated as new data becomes available and the graphing engine within the tool has been sped up significantly.

Field visualization is an important capability of any EM simulation tool. XF7 allows users to save fields on any point, surface, or volume in the project. Sensors are used to capture fields and can be attached to points, surfaces or even volumes. Each sensor saves only the requested fields allowing users to save only as much output data as needed. Far-zone sensors are drawn around the geometry, allowing visualization of the angles being saved. And when viewing far-zone result data, all the post-processing controls are integrated with the field viewing controls. Near-zone sensors can be attached to geometric parts allowing the sensor to move along with the part's movements. Near-zone sensors can also be assigned to a plane, rectangular shape, or a volumetric box. Each sensor can save a different set of fields, and at different time intervals.

PLATFORM AND VERSIONS

XF7 is the first EM simulation package in the industry to run natively on Windows, Mac OS X and Linux. This ensures a consistent experience across platforms and a smooth, easy transition for those in mixed platform environments.

There are two versions of XFdtd available: XFdtd Pro and XFdtd Bio-Pro. Both include the following:

- Pro-Analysis or Bio-Pro Analysis Module (32- or 64-bit)
- Geometric Modeler and Postprocessor (32- or 64-bit)
- Shared Memory (MPM) Multiprocessor for XFdtd Analysis Modules at eight cores
- 3D CAD Import Modules (Pro E, STEP, IGES, Inventor, Catia, Unigraphics, Solidworks, Parasolids, other)

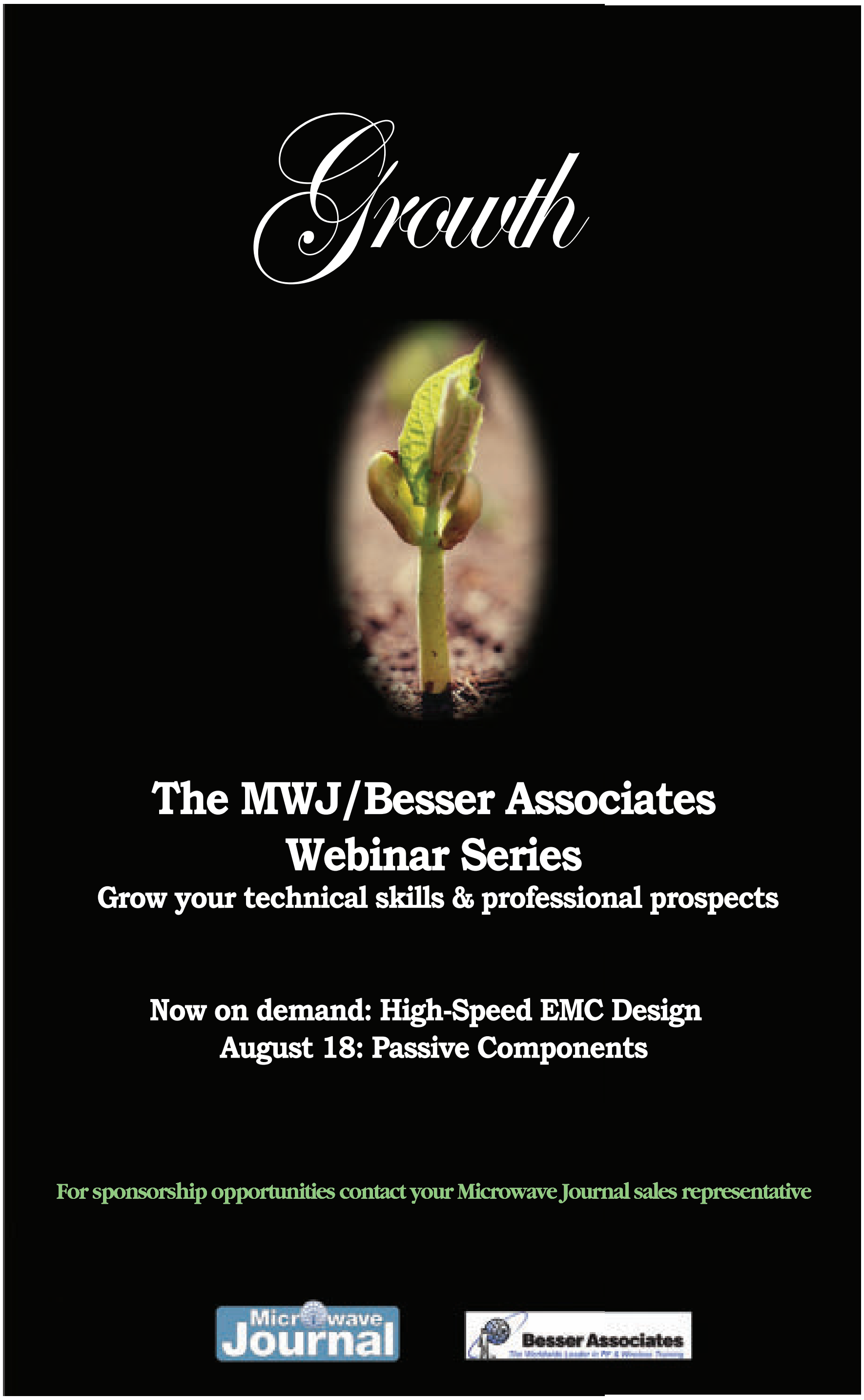
XFdtd Bio-Pro includes these additional capabilities:

- SAR capability
- Hi-Fidelity Female and Male Human Body Meshes

Additional acceleration capability is available including GPU hardware acceleration and MPI distributed memory.

Remcom Inc.,
State College Park, PA
(888) 7-REMCOM,
www.remcom.com.

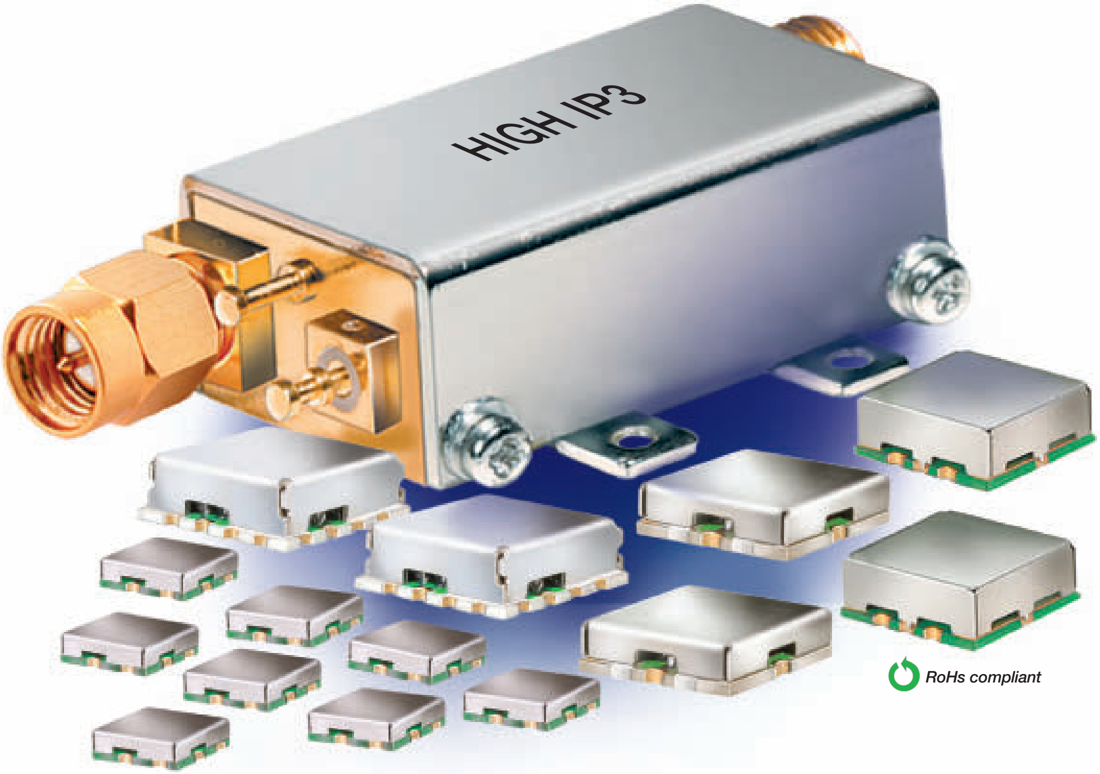
RS No. 301



Constant Impedance

VVAs

10 to 3000 MHz



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Voltage Variable Attenuators (VVAs) deliver as high as 40 dB attenuation control over the 10 MHz through 3.0 GHz range. Offered in both 50 and 75 Ω models these surface-mount and coaxial low-cost VVAs require no external components and maintain a good impedance match over the entire frequency and attenuation range, typically 20 dB return loss at input and output ports. These high performance units offer insertion loss as low as 1.5 dB, typical IP3 performance as high as +56 dBm, and minimal phase variation low as 7°. Mini-Circuits VVAs are enclosed in shielded surface-mount cases as small as 0.3" x 0.3" x 0.1". Coaxial models are available with unibody case with SMA connectors. Applications include automatic-level-control (ALC) circuits, gain and power level control, and leveling in feedforward amplifiers. Visit the Mini-Circuits website at www.minicircuits.com for comprehensive performance data, circuit layouts, environmental specifications and real-time price and availability.

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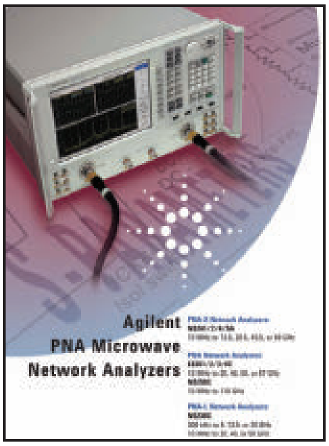


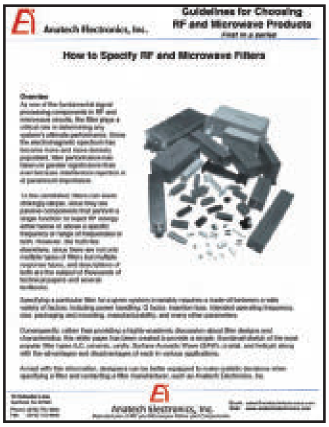
PNA-X Brochure

VENDORVIEW

Agilent now offers a new 32-page brochure that describes in detail the PNA-X premier-performance microwave network analyzers' applications, measurement functions, and the latest in calibration technology. The PNA-X provides the widest range of measurement applications in a single connection with breakthrough speed, accuracy, and performance compared to traditional microwave network analyzers. This brochure is available at www.agilent.com/find/pnax.

Agilent Technologies Inc.,
Santa Clara, CA (800) 829-4444, www.agilent.com.

RS No. 310



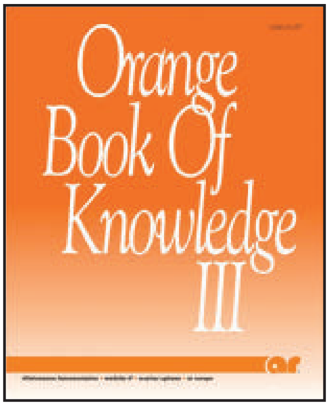
RF and Microwave Filters Guide

VENDORVIEW

This recently released "How To Specify RF and Microwave Filters" is the first in what will become a series of useful guides for technicians, engineers, installers, and others who use electromagnetic filters to solve interference problems. This guide describes cavity, ceramic, crystal, helical, lumped element (LC) and SAW filters, and illustrates their advantages and disadvantages for specific applications to make the process of filters much easier.

Anatech Electronics Inc.,
Garfield, NJ (973) 772-4242, www.anatechelectronics.com.

RS No. 311



AR's Orange Book of Knowledge

VENDORVIEW

The third edition of AR's "Orange Book of Knowledge" is now available. The book contains articles and application notes on a wide range of topics and applications including "Custom Pulses Made Easy" to a reference guide for coaxial connectors and cables. Contact your local AR sales associate for a copy.

AR RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181, www.ar-worldwide.com.

RS No. 320

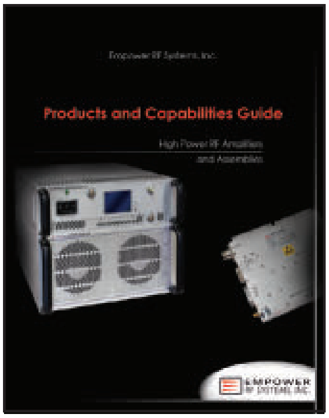
Cable Assemblies Brochure

VENDORVIEW

Electronic Assembly Manufacturing Inc. (EAM), an RF/microwave coaxial cable assembly supplier, has recently announced the release of its "RF & Microwave Cable Assemblies" brochure. The six-page brochure features an array of products, broken down by cable type. The seven cable types include flexible, hand formable, LMR®, semi-rigid, low loss, RG and corrugated. Typical VSWR is included.

Electronic Assembly Manufacturing Inc., Methuen, MA
(978) 374-6840, www.eamcableassemblies.com.

RS No. 312

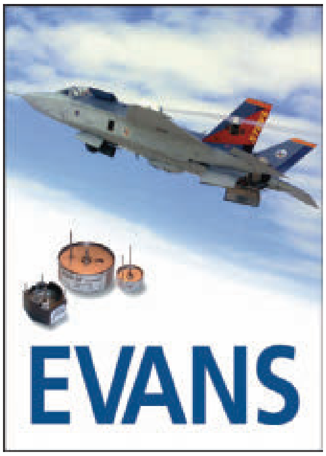


RF Amplifiers Catalog

Empower presents its updated Products and Capabilities Guide. This brochure is a comprehensive overview of the company's capabilities and a listing of its most popular amplifier products. With products that cover from 150 kHz to 6 GHz and an extensive library of building block designs, there is an array of catalog standard and semi-custom solutions available to consider. This brochure will be especially useful for buyers, sales reps and engineers.

Empower RF Systems Inc.,
Inglewood, CA (310) 412-8100, www.empowerrf.com.

RS No. 322



Hybrid Capacitors Catalog

This catalog features the company's Hybrid® Capacitors that have been specified in numerous systems throughout the F-35 Joint Strike Fighter. Hermetically sealed, tantalum hybrid capacitors have more than 4× the energy density of other military-style capacitors. These capacitors are found in laser targeting, communications modules, controls, cockpit displays, phased-array radars, fire control systems and elsewhere on many advanced commercial and military aircraft.

Evans Capacitor Co.,
East Providence, RI (401) 435-3555, www.evanscap.com.

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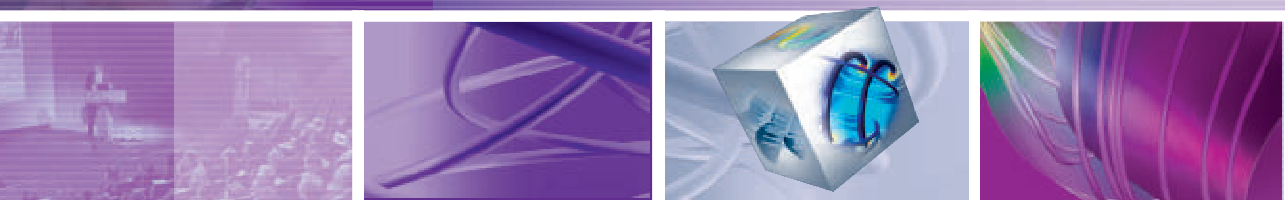

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New Literature

VENDORVIEW

The June 2009 Off-the-Shelf newsletter showcases 27 new product releases and includes several feature articles describing the new HMC-T2100 Signal Generator, Fractional-N PLL Synthesizer ICs and industry leading single and dual channel Power Detector ICs. The June 2009 Product Selection Guide summarizes over 750 items including 34 new products, while an expanded Frequency Generation section features Fractional-N and Integer-N PLL ICs operating to Ku Band.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343, www.hittite.com.

RS No. 313

Easy WiMAX Signal Creation and Analysis

Keithley's CD, "Advanced Measurement Techniques for OFDM- and MIMO-based Radio Systems: Demystifying WLAN and WiMAX Testing," includes a comprehensive set of RF measurement notes, an RF glossary and useful tables, as well as capsule descriptions of selected products designed for RF and DC testing. Request your free copy at www.keithley.com/at/557.

Keithley Instruments Inc.,
Cleveland, OH (800) 588-9238, www.keithley.com.

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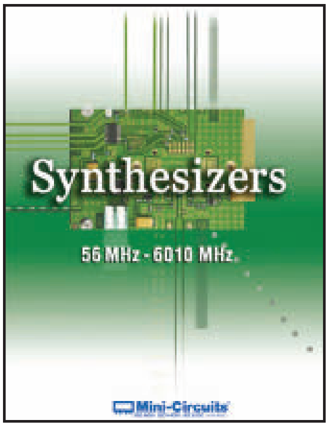

Synthesizer Catalog

VENDORVIEW

Let the Mini-Circuits design team create a custom frequency synthesizer tailored to your requirements. The Mini-Circuits' team will review your requirements and, following technical discussions between your engineers and Mini-Circuits designers, will work closely with you to create final specifications that meet or exceed your requirements. To ensure high yields, they will factor in component tolerances and even variations in manufacturing processes. You will have full access to performance data from sample units, and can even evaluate sample units in your system to ensure that final production units fulfill your performance requirements.

Mini-Circuits,
Brooklyn, NY (718) 934-4500, www.minicircuits.com.

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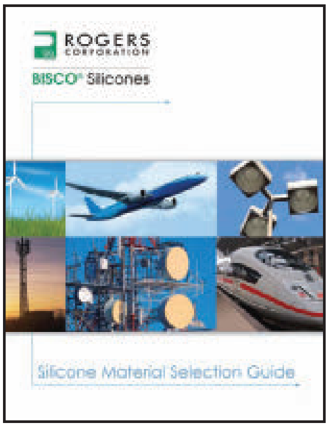


Selection Guide

VENDORVIEW

This 16-page Material Selection Guide highlights Rogers' BISCO® Silicone materials, which are offered in cellular, solid and specialty grades. These materials are used in a wide range of markets, from transportation and communications to electronics and high intensity lighting. The new BISCO Selection Guide includes product samples and tips for materials selection based on market applications.

Rogers Corp.,
Rogers, CT (800) 935-2940, www.rogerscorp.com.

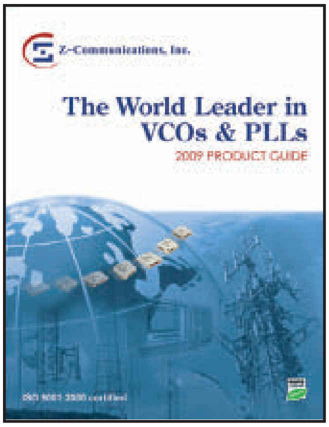
RS No. 318

Wireless Products Catalog

Times Microwave Systems announced the availability of the new 2009/2010 14th edition of the LMR® Wireless Products Catalog. The new catalog includes the entire range of LMR® cables including LMR-DB, LMR-FR, LMR-Ultraflex, LMR-LLPL and LMR-75 as well as TCOM® (low PIM cable), FBT® low loss, high power cables and T-RAD™ leaky feeder cables. Also included in this latest edition are a new LMR Installer Training Program, the new Intra-Flex™ in-the-box interconnect cable, updates on the LMR Bundled Cable and SilverLine product lines as well as new connectors, tools and installation accessories.

Times Microwave Systems,
Wallingford, CT (203) 949-8400, www.timesmicrowave.com.

RS No. 319



Product Guide

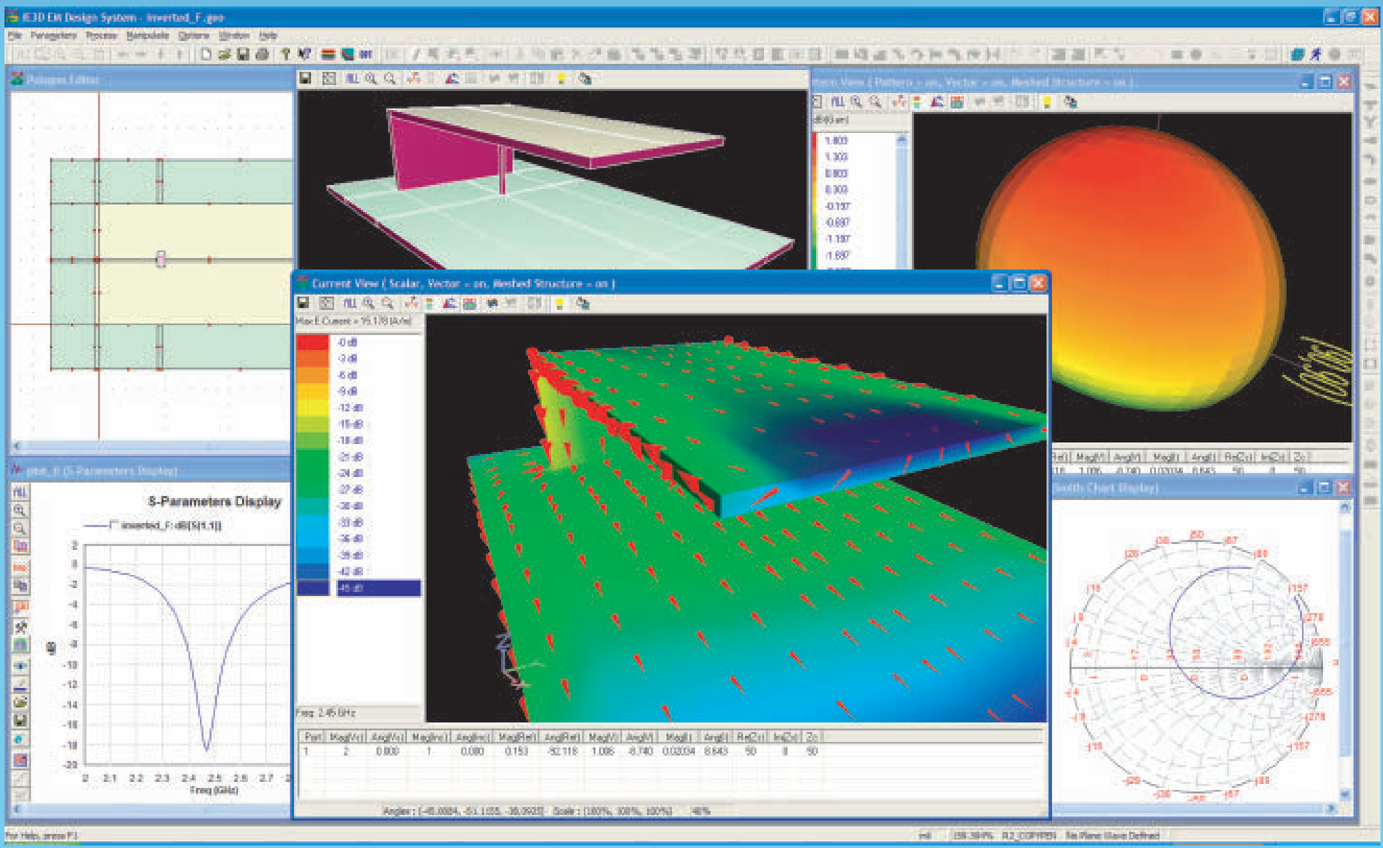
Z-Communications Inc. announced the release of the company's 2009 Product Guide. This short form catalog includes a wide variety of surface-mount voltage-controlled oscillator (VCO) and phase-locked loop (PLL) synthesizer modules ranging from 40 MHz to 10 GHz. A complete listing of all available parts and specifications can be found on the company's website. Users can also download an electronic version of the product guide online at www.zcomm.com or contact the company at sales@zcomm.com for a hard copy version.

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

RS No. 321

High-Performance EM Simulation and Optimization and Electronic Design Automation

IE3D Full-Wave EM Design System V14



IE3D V14 gets a new look with integrated layout editing, real-time EM tuning and optimization, s-parameters, current distribution, near field and radiation pattern visualization and post-processing.

Features:

- Accurate simulation from 1 Hz to 10 THz.
- Efficient full-wave EM design for microwave circuits, MMIC, RFIC, LTCC circuits, antennas, RFID, IC and PCB interconnects and signal integrity.
- Excellent for both planar and true 3D structures with precise thickness model.
- Automatic full-3D EM model creation from industrial standard layouts for streamlined and batch full-wave EM simulations.
- Integrated into Cadence Virtuoso, Cadence Allegro and AWR Microwave Office.
- Equation and Boolean based parameterized geometry modeling.
- Real-time full-wave EM tuning and optimization for both planar and 3D structures.
- Multi-CPU support and network distributed EM simulation and optimization.

ZELAND SOFTWARE, INC.

Fremont, California, USA, Tel: 510-623-7162 Fax: 510-623-7135, info@zeland.com, www.zeland.com

Visit http://mwj.hotims.com/23287-108 or use RS# 108 at www.mwjournal.com/info

Front-to-back Solution
VENDORVIEW

Agilent Technologies Inc. recently announced Advanced Design System (ADS) 2009 Update 1, a complete, front-to-back solution for monolithic microwave integrated circuit (MMIC) and RF module design. The release integrates 3-D electromagnetic (EM) analysis, wireless standards-based design verification libraries, X-parameter simulation, and statistical design and yield optimization. Advanced Design System 2009 Update 1 enables designers to stay within the design and simulation platform of choice for their entire design cycle and eliminates the need for separate, time-consuming point tools.
Agilent Technologies Inc., Santa Clara, CA (800) 829-4444, www.agilent.com.

RS No. 216

Simulation Solutions
VENDORVIEW

As wireless communication and electronic devices proliferate and become smaller and more functional, the need for robust simulation solutions increases. Ansoft™ software helps engineers design, simulate and validate the behavior of complex high performance RF, microwave and millimeter-wave devices in next-generation wireless communication and defense systems. Using Ansoft technology, customers can achieve a dramatic reduction in development time and cost, while at the same time realize increased reliability and optimization. Ansoft recently introduced planned enhancements to its 3-D full-wave electromagnetic field simulation software HFSS™, including domain decomposition, a high performance computing (HPC) option. The technology, which adds depth and breadth to the ANSYS multiphysics suite, enables engineers to solve problems such as electromagnetic-induced heating in high power microwave structures and antenna performance while under mechanical deformation through links with the ANSYS® Workbench™ platform.
Ansoft, Pittsburgh, PA (412) 261-3200, www.ansoft.com.

RS No. 217

Microwave Office Software
VENDORVIEW

AWR announced that users of AWR's Microwave Office design software now have access to XML library data for a broad array of microwave amplifiers from TriQuint Semiconductor Inc.'s San Jose design center (formerly WJ Communications). The devices include packaged gain-blocks, field effect transistors (FET) and heterojunction bipolar transistor (HBT) amplifiers. The library provides measurement-based models and footprints used for printed circuit board (PCB) and module layouts. It is available to users of AWR's Microwave Office software through the XML library link accessible from the software. While the majority of the library is targeted for small-signal simulation, there are a variety of nonlinear models available for the AP60x Series high-voltage HBT amplifiers.
AWR®, El Segundo, CA (310) 726-3000, www.awrcorp.com.

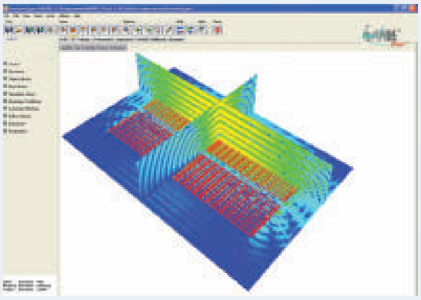
RS No. 218

Asymptotic Solver
VENDORVIEW

Engineers working on antenna placement, radar cross section simulation or other electrically large problems will benefit from CST's newest addition to the CST MICROWAVE STUDIO® (CST MWS) solver family. The new CST MWS asymptotic solver targets a range of simulation model sizes beyond the reach of even the successful integral equation solver, i.e. much larger than 100 wavelengths. The asymptotic solver is tightly integrated in the CST design environment and shares the same well-known usability features as the other CST MWS solver modules.
CST of America® Inc., Framingham, MA (508) 665-4400, www.cst.com.

RS No. 246

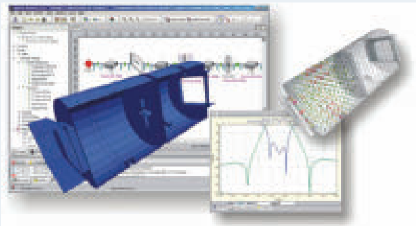
EMPIRE XCcel™ 5.3



The 3D EM solver EMPIRE XCcel 5.3 covers nearly all today's design challenges for RF designers, like antennas, passive circuits, packages, waveguides or EMC/EMI problems. Due to the unique structure and processor adapted code generation, a simulation performance up to 1600 million FDTD cells per second can be achieved on a conventional PC with full access to the built-in memory. Thus very complex structures can be modeled very fast and highly accurate (e.g. 23 lambda × 16 lambda × 4.5 lambda array antenna simulation at 24 GHz needs only 12 GB memory).
IMST GmbH, Kamp-Lintfort, Germany +49 2842 981 0, www.imst.com.

RS No. 219

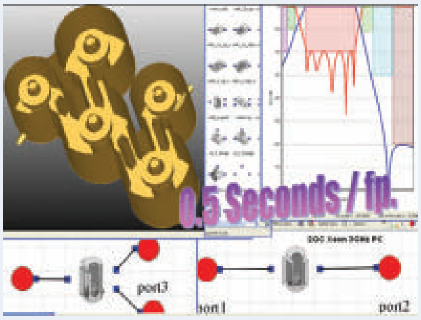
Design Tool



µWave Wizard, a design tool using the mode-matching technique, which is particularly suitable for simulation and optimization of passive microwave systems and components, including antennas. The aim of the latest introduction, version 7.0, is the execution of µWave Wizard on a 64 bit operating system and in parallel with the 3D finite element method (3D-FEM) solver for 3D-FEM based elements, as well for using 3D-FEM on a complete circuit. With this version the 3D-FEM solver supports multicore and multiprocessor computers on 32 bit and 64 bit Windows operating systems.
Mician GmbH, Bremen, Germany +49 (421) 168 993 51, www.mician.com.

RS No. 220

EM CAD and Optimization Tool



The latest version of its hybrid MM/FE/MoM/FD WASP-NET® tool now includes elements for aperture and wire-cross-coupled combline and dielectric resonator filters. Utilizing a novel ultra-adaptive sweep technique, which is particularly appropriate for fast optimization, such components can be calculated within fractions of a second. A new flexible, user defined input system for body-of-revolution (BOR) antenna structures, where all desired parameters can be individually parameterized by the user enables convenient design and optimization of complex antenna systems, including shaped subreflectors, shaped reflectors, lenses and radomes. Also, there are new user-friendly extended synthesis wizards for all kinds of filters, slot arrays and corrugated horn antennas.
Microwave Innovation Group (MiG) GmbH & Co. KG, Bremen, Germany +49 421 223 7966 0, www.mig-germany.com.

RS No. 247

3D Planar EM Simulator

Sonnet Software Inc. introduces Sonnet Lite Release 12, a free 3D Planar EM simulator, as a tool for learning and experimenting in high frequency RF transmission lines, circuits, packages and antennas. Sonnet Lite provides a full-wave EM analysis solution for 3D planar circuits and allows high frequency designers to solve problems that require up to 1 MB of RAM, without giving personal information. In return for registering and providing contact information, Sonnet will expand the memory resource limit to 16 MB of RAM.
Sonnet Software, North Syracuse, NY (315) 453-3096, www.sonnetsoftware.com.

RS No. 221

300 MHz-12 GHz

LTCC MIXERS

from $3.95 ea. (Qty.1000) IN STOCK

For Commercial, Military, and Industrial Use, Mini-Circuits proudly presents the MCA1 series of Low Temperature Co-fired Ceramic (LTCC) frequency mixers. Highly reliable, only 0.080" in height, and "tough as nails", these patented mixers have all circuitry hermetically imbedded inside the ceramic making them temperature stable and impervious to most environmental conditions. The process also gives you high performance repeatability and very low cost. There's a variety of broadband models and LO power levels to choose from, so you can use these mixers in a multitude of designs and applications. And MCA1 mixers are ideal for the COTS program! Just check all the specs on our web site. Then, choose the model that best fits your needs. Our team is ready to handle your requirements with quick off-the-shelf shipments, custom designs, and fast turn-around/high volume production.

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For RoHS compliant requirements,
ADD + SUFFIX TO BASE MODEL No. *Example: MCA1-85L+*

Model	LO Level (dBm)	Freq. Range (MHz)	Conv. Loss (dB)	LO-RF Isol. (dB)	Price $ ea. (Qty. 10)
MCA1-85L	4	2800-8500	6.0	35	9.45
MCA1-12GL	4	3800-12000	6.5	38	11.95
MCA1-24	7	300-2400	6.1	40	5.95
MCA1-42	7	1000-4200	6.1	35	6.95
MCA1-60	7	1600-6000	6.2	30	7.95
MCA1-85	7	2800-8500	5.6	38	8.95
MCA1-12G	7	3800-12000	6.2	38	10.95
MCA1-24LH	10	300-2400	6.5	40	6.45
MCA1-42LH	10	1000-4200	6.0	38	7.45
MCA1-60LH	10	1700-6000	6.3	30	8.45
MCA1-80LH	10	2800-8000	5.9	35	9.95
MCA1-24MH	13	300-2400	6.1	40	6.95
MCA1-42MH	13	1000-4200	6.2	35	7.95
MCA1-60MH	13	1600-6000	6.4	27	8.95
MCA1-80MH	13	2800-8000	5.7	27	10.95
MCA1-80H	17	2800-8000	6.3	34	11.95

Dimensions: (L) 0.30" x (W) 0.250" x (H) 0.080"
U.S. Patent # 7,027,795

40TH ANNIVERSARY 1969-2009
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IF/RF MICROWAVE COMPONENTS

385 Rev K

Visit http://mwj.hotims.com/23287-69 or use RS# 69 at www.mwjournal.com/info

Components

Programmable Attenuator

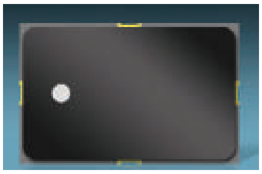
VENDORVIEW

This improved programmable 0.5 to 18 GHz attenuator incorporates a new driver circuit with faster switching and more accurate attenuation. Low insertion loss and stable operation over temperature extremes. Switching between all attenuation level is typically within 1 dB in 5 μs at 25°C. Sinewave scan modulation small and large signal bandwidth of 100 kHz and 50 kHz respectively. Temperature stability of ±2.5 dB over -10° to 85°C and ±3.5 dB over -40° to 95°C. Size: 2.00" × 1.81" × 0.5".

American Microwave Corp., Frederick, MD (301) 662-4700, www.americanmicrowavecorp.com.

RS No. 222

PIN Diode Switches



This family of surface-mount, silicon PIN diode SP2T switches offer power handling capability up to 100 W C.W. incident RF power. They are optimized to function in two frequency bands of interest: 20 to 700 MHz, and 400 to 4000 MHz, and are available in compact surface-mount packages measuring 8 × 5 × 2.5 mm. The MSW2000 series of surface-mount PIN diode SP2T switches is manufactured using Aeroflex/Metelics' proven hybrid manufacturing process incorporating high voltage PIN diodes and passive devices within a ceramic substrate. Both asymmetrical and symmetrical SP2T topologies are offered. The asymmetrical SP2T provides Tx/Ant insertion loss of 0.20 dB, with 20 dB return loss and 40 dB Tx/Rx isolation. Ant/Rx loss is similar at 0.3 and 20 dB return loss.

Aeroflex/Metelics, Londonderry, NH (603) 641-3800, www.aeroflex.com/metelics.

RS No. 223

Doppler Ranging Sensor Heads

Model SRU Series, ranging sensor heads are designed for long range distance detection where the sensitivity is essential. The SRU series ranging sensors are used for moving targets (where the Doppler shift is presented) distance detection. Four configurations are offered for special applications. The single channel versions are used for speed and distance sensing only while dual channel versions are offered for speed, distance and direction sensing. In addition, dual antenna versions are offered for high power to eliminate the limited TX/RX isolation problems due to the diplexer. The single antenna versions are constructed with a high performance horn antenna or lens corrected antenna, a linear to circular polarizer and T/R diplexer, a single side band up-converter or modulator, a balanced mixer or an I-Q mixer and an amplifier and a high performance Gunn Oscillator.

Ducommun Technologies Inc., Carson, CA (310) 847-2859, www.ducommun.com.

RS No. 224

Attenuator Design Kit

VENDORVIEW

EMC Technology introduces a new ultra broadband, wire bondable chip attenuator kit, K-BAND-DKIT. Designed with high frequency in mind, this kit offers a complete selection of wire bondable attenuators both fixed (KFA) and temperature variable (KTVA). The products included in the kit operate effectively in the 16 to 36 GHz frequency range. This is the perfect design kit for the high frequency customer and provides an ample amount of both fixed and temperature compensating attenuators to complete most designs. The K series attenuator product can handle up to 200 mW and is available in many dB values with an operating temperature range from -55° to +150°C.

EMC Technology, Stuart, FL (772) 286-9300, www.emct.com.

RS No. 225

High Power Terminations

Johanson Manufacturing Corp. has announced the production release of its new line of high-voltage terminations. The new line was developed in its NJ headquarters facility and is produced in volume at its Dominican Republic plant. Available in multiple package sizes with a range of termination values, the new family of terminations addresses critical circuit requirements, most notable in RF and power amplifier applications.

Johanson Manufacturing Corp., Boonton, NJ (973) 334-2676, www.johansonmfg.com.

RS No. 226

Elliptic Bandpass Filter

KR Electronics introduces part number 2897, a surface-mount 300 MHz group delay and amplitude equalized elliptic bandpass filter. The filter has a typical insertion loss of 3 dB and minimum 1 dB bandwidth of 48 MHz. The filter attains over 50 dB rejection by 225 and 380 MHz. Group delay variation is typically 5 nsec over the 48 MHz bandwidth. The filter is supplied in an surface-mount package measuring 2.0" × 0.5" × 0.3" and can also be supplied connectorized. The filter can be customized for other center frequencies and bandwidths.

KR Electronics Inc., Avenel, NJ (732) 636-1900, www.krfilters.com.

RS No. 227

Band Reject Filter

Lorch Model 18BRX-1350/X700-NM/N is a band reject filter

Visit http://mwj.hotims.com/23287-5

FIVE DAYS ■ FOUR CONFERENCES ■ ONE EXHIBITION

EuMW 2009

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Science, Progress and Quality of Radiofrequencies

EUROPEAN MICROWAVE WEEK

Rome

28 September - 2 October 2009

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EUROPEAN MICROWAVE WEEK 2009

PUTS CUTTING EDGE TECHNOLOGY ON A GLOBAL STAGE

28 September - 2 October 2009,
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Rome, Italy

FREE EXHIBITION VISITOR TICKET AND ADVANCE CONFERENCE REGISTRATION FORM

39TH EUROPEAN MICROWAVE CONFERENCE 2009

The 39th European Microwave Conference

EuWiT 2009

The 2nd European Wireless Technology Conference

EuRAD 2009

The 6th European Radar Conference

EuMIC 2009

The 4th European Microwave Integrated Circuits Conference

EuMW 2009

EUROPEAN MICROWAVE WEEK
Rome
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EUROPEAN MICROWAVE WEEK 2009

EuMW2009 PUTS CUTTING EDGE TECHNOLOGY ON A GLOBAL STAGE

The historical, cultural and stylish city of Rome will be the backdrop for the 12th European Microwave Week when it plays host to Europe's premier Microwave, RF, Wireless Technology and Radar event for the very first time. The vibrant Italian capital complements the focussed and challenging Week, which covers FIVE days, encompassing FOUR cutting edge conferences and ONE dynamic trade and technology exhibition featuring leading players from across the globe.

THE MUST GO SHOW

Concentrating on the needs of engineers the event showcases the latest trends and developments that are widening the field of application of microwaves. Pivotal to the week is the **European Microwave Exhibition**, which offers YOU the opportunity to see, first hand, the latest technological developments from global leaders in microwave technology, complemented by demonstrations and industrial workshops. **Registration to the Exhibition is FREE!**

- **International Companies** - meet the industry's biggest names and network on a global scale
- **Cutting-edge Technology** - exhibitors showcase the latest product innovations, offer hands-on demonstrations and provide the opportunity to talk technical with the experts
- **Technical Workshops** - get first hand technical advice and guidance from some of the industry's leading innovators
- **Four Conferences** - European Microwave Integrated Circuits Conference (EuMIC), European Microwave Conference (EuMC), European Wireless Technology Conference (EuWiT), European Radar Conference (EuRAD)

BE THERE

Exhibition Dates	Opening Times
Tuesday 29th September	09.30 - 17.30
Wednesday 30th September	09.30 - 17.30
Thursday 1st October	09.30 - 16.30

EUROPEAN MICROWAVE EXHIBITION REGISTRATION FORM

Please complete the following:

First Name: ______ Last Name: ______

Company/University: ______

Dept: ______

Address: ______

City: ______

Country: ______ Postal Code: ______

Tel: ______

E-mail: ______

☐ Yes, I would like to receive information by email from EuMA/Horizon House

☐ Yes, I would like to receive information by email from microwave/wireless industry companies

What is your job title? (please tick box)

Corporate Management ☐ Technical Management ☐ Technical Engineering ☐

Which market does your company serve? (please tick box)

Industrial / Commercial ☐ Government / Military ☐ Academia ☐

Attending the Exhibition is **FREE!** You can Pre-register on-line at **www.eumweek.com** by clicking on 'Registration'.
Alternatively, complete this form and fax to +44 (0) 20 7596 8749. Registration deadlines: for advance fax or mail, 1 September 2009; for advance website, 8 September 2009.
On-site registration is available at the event however fees are 30% higher.
Please note that ALL visitor badges to the exhibition can be collected on-site.
Badges will NOT be mailed to visitors prior to the event.

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EuMW 2009

EUROPEAN MICROWAVE WEEK
Rome
28 September - 2 October 2009
www.eumweek.com

EUROPEAN MICROWAVE WEEK 2009
CONFERENCE REGISTRATION

Don't miss Europe's premier microwave conference event. The 2009 week consists of four conferences and associated workshops:

- **The European Microwave Integrated Circuits Conference (EuMIC) - Monday & Tuesday**
- **The European Wireless Technology Conference (EuWiT) - Monday & Tuesday**
- **The European Microwave Conference (EuMC) - Tuesday, Wednesday, Thursday**
- **The European Radar Conference (EuRAD) - Wednesday, Thursday, Friday**

The four conferences specifically target ground breaking innovation in microwave research through a call for papers explicitly inviting the submission of presentations on the latest trends in the field, driven by industry roadmaps. The result is four superb conferences created from the very best papers, carefully selected from over 1,250 submissions from all over the world.

Special rates are available for EuMW delegates. For a detailed description of the conferences, workshops and short courses please visit www.eumweek.com. The full conference programme can be downloaded from there.

REGISTRATION

- ADVANCE REGISTRATION at reduced rates via the web at www.eumweek.com or by fax or mail - see form overleaf for details. Deadlines are 1st September 2009 (fax/mail) and 8th September 2009 (website).
- After these dates you must register ON-SITE at the conference at the higher rates listed below.

ON-SITE REGISTRATION FEES

Advance registration is up to 30% lower. See reverse for details.

Conferences	*Society Member (*any listed over)*		*Non-Member*	
(available options - choose one)	**Standard**	**Student/Snr**	**Standard**	**Student/Snr**
1 Conference				
EuMC	€520	€130	€680	€170
EuMIC	€410	€120	€540	€160
EuWiT	€410	€120	€540	€160
EuRAD	€290	€110	€380	€150
2 Conferences (10% discount for Standard)				
EuMC and EuMIC	€840	€250	€1,090	€330
EuMC and EuWiT	€840	€250	€1,090	€330
EuMC and EuRAD	€730	€240	€950	€320
EuMIC and EuWiT	€740	€240	€960	€320
EuMIC and EuRAD	€630	€230	€820	€310
EuWiT and EuRAD	€630	€230	€820	€310
3 Conferences (20% discount for Standard)				
EuMC & EuMIC & EuWiT	€1,080	€370	€1,400	€490
EuMC & EuMIC & EuRAD	€980	€360	€1,270	€480
EuMC & EuWiT & EuRAD	€980	€360	€1,270	€480
EuMIC & EuWiT & EuRAD	€890	€350	€1,160	€470
4 Conferences (30% discount for Standard)				
EuMC & EuMIC & EuWiT & EuRAD	€1,150	€480	€1,490	€640

Workshop and Short Course Prices	*Society Member (*any listed over)*		*Non-Member*	
	Standard	**Student/Snr**	**Standard**	**Student/Snr**
1/2 Day WITH conference registration	€80	€60	€110	€80
1/2 Day WITHOUT conference registration	€110	€80	€150	€110
Full Day WITH conference registration	€120	€90	€160	€110
Full Day WITHOUT conference registration	€160	€120	€210	€150

Advance Conference Registration
European Microwave Week 2009
28 September – 2 October 2009, Rome, Italy

Three ways to register:
On-line: www.eumwregistration.com
FAX: +44 207 596 8749
Mail: details below

For Office Use only:
Badge ______
Transaction ______
Order ______

Each delegate must submit a separate registration form. A copy may be used.
Registration deadlines: for advance fax or mail, 1 September 2009; for advance website, 8 September 2009. Fees 30% higher for on-site registration.
To register, tick ❑ the appropriate boxes and enter corresponding fees and totals on the lines provided.

Name |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| First |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| Last / Surname **(include business card if possible)**

Affiliation |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| Company/University |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| Department/Mail Stop

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❑ Yes,I would like to receive information by e-mail from Eu*MA*. ❑ Yes,I would like to receive information by e-mail from microwave/wireless industry companies.

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STUDENTS/SENIORS (Full-time students less than 30 years of age and Seniors 65 or older at 2 October 2009)

Date of Birth |_|_|_|_|_|_|_| **Student's University** |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

Student's Supervising Professor Email |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

If you want to benefit from reduced rates, subscribe for Eu*MA* membership NOW by ticking one of these boxes: ❑ Professional: €20/year ❑ Student: €10/year

The conference CD-ROM will be available FREE to all conference attendees.

CONFERENCES

	*Society Member (*any of above)*		*Non-Member*	
(available options - choose one)	**Standard**	**Student/Sr.**	**Standard**	**Student/Sr.**
1 Conference				
EuMC	❑ €400	❑ €100	❑ €520	❑ €130
EuMIC	❑ €310	❑ €90	❑ €410	❑ €120
EuWiT	❑ €310	❑ €90	❑ €410	❑ €120
EuRAD	❑ €220	❑ €80	❑ €290	❑ €110
2 Conferences (10% discount for standard)				
EuMC & EuMIC	❑ €640	❑ €190	❑ €840	❑ €250
EuMC & EuWiT	❑ €640	❑ €190	❑ €840	❑ €250
EuMC & EuRAD	❑ €560	❑ €180	❑ €730	❑ €240
EuMIC & EuWiT	❑ €560	❑ €180	❑ €730	❑ €240
EuMIC & EuRAD	❑ €480	❑ €170	❑ €630	❑ €230
EuWiT & EuRAD	❑ €480	❑ €170	❑ €630	❑ €230
3 Conferences (20% discount for standard)				
EuMC & EuMIC & EuWiT	❑ €820	❑ €280	❑ €1,070	❑ €370
EuMC & EuMIC & EuRAD	❑ €750	❑ €270	❑ €970	❑ €360
EuMC & EuWiT & EuRAD	❑ €750	❑ €270	❑ €970	❑ €360
EuMIC & EuWiT & EuRAD	❑ €680	❑ €260	❑ €880	❑ €350
4 Conferences (30% discount for standard)				
EuMC & EuMIC & EuWiT & EuRAD	❑ €870	❑ €360	❑ €1,150	❑ €480

Lunch Trays

Lunch trays are not included in your conference package and hence can be purchased at a rate of €10 per day. An advance reservation for the lunch trays is strongly advisable, since in the area of Fiera di Roma alternative choices are rather limited and, for logistical planning, last-minute on-site lunch reservation may no longer be possible.

Which days would you like to order lunch for? ❑ Monday ❑ Tuesday ❑ Wednesday ❑ Thursday ❑ Friday

	*Society Member **		*Non-Member*	
Workshops and Short Course Prices	**Standard**	**Student/Sr.**	**Standard**	**Student/Sr.**
1/2 Day WITH conference registration	€80	€60	€110	€80
1/2 Day WITHOUT conference registration	€110	€80	€150	€110
Full Day WITH conference registration	€120	€90	€160	€110
Full Day WITHOUT conference registration	€160	€120	€210	€150

DVD Archive EuMC

	EuMA members	***Non EuMA Members***
DVD Archive EuMC 1969-2003 Qty. _____ @	❑ €10	❑ €40
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PROCEEDINGS ON CD-ROM

All papers published for presentation at each conference will be on a CD-ROM given out with the delegate bags to those attending conferences. For additional CD-ROMs order here: Qty:____ @ €50

Conference dinners, side events and social events

For information on and registration, please visit the conference website: http://www.eumweek.com.
Early registration is highly recommended for these events as it will be required for logistical planning.

WORKSHOPS and SHORT COURSES

(Prices below left. Visit www.eumweek.com for titles and further details)

❑ WFMO1 (EuMC/EuWiT)	1 day €____
❑ WFMO2 (EuMC/EuWiT)	1 day €____
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❑ WHMO7 (EuMC)	1/2 day €____
❑ WHWE8 (EuMIC/EuMC)	1/2 day €____
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❑ WFWE10 (EuMC/EuMIC)	1 day €____
❑ WHWE11 (EuMC)	1/2 day €____
❑ WFTH12 (EuMC)	1 day €____
❑ WFTH13 (EuMC/EuRAD)	1 day €____
❑ SFTH1 (EuMIC)	1 day €____
❑ SFTH2 (EuMIC/EuMC)	1 day €____
❑ WFFR14 (EuRAD/EuMC)	1 day €____
❑ WHFR15 (EuRAD)	1/2 day €____
❑ SHFR3 (EuRAD)	1/2 day €____

Workshop & SC Total €_____
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- In excess of 250 exhibitors •

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EuMA European Microwave Association

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EuMIC 2009
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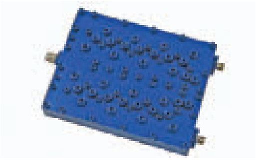
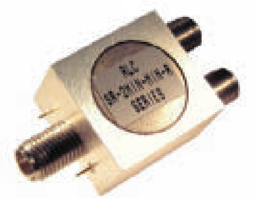
with specifications of 70 dB from 1200 to 1570 MHz. Insertion loss is 1.2 dB from 20 to 1000 MHz and 1.5 dB from 1800 to 2500 MHz. The VSWR is 1.5:1 over this range also. Power handling is 100 W and package size is 2.5" × 1" × 1" with an operating temperature of -40° to +65°C.
Lorch Microwave, Salisbury, MD (410) 860-5100, www.lorch.com.
RS No. 228

E-GSM Diplexer
VENDORVIEW



Reactel part number 2DP-EGSM-900 is a diplexer for the E-GSM Band. This unit features passbands of 880 to 915 and 925 to 960 MHz with an in-band insertion loss of less than 1.2 dB. With 40 dB of isolation and minimum handling capability of 20 W, this unit is a great fit for your application. For additional information, please contact the factory by calling (301) 519-3660, e-mailing reactel@reactel.com or visiting www.reactel.com.
Reactel Inc., Gaithersburg, MD (301) 519-3660, www.reactel.com.
RS No. 229

Micro Miniature SMA Switch

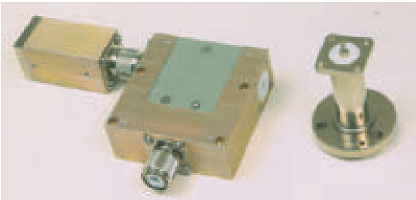


RLC Electronics' micro miniature SMA switch is a single-pole two position type. The switch incorporates SMA connectors to allow high density packaging and excellent electrical performance through 26.5 GHz. The switch is available in failsafe and latching configurations with a choice of three different frequency ranges and three different coil voltages.
RLC Electronics Inc., Mount Kisco, NY (914) 241-1334, www.rlcelectronics.com.
RS No. 230

Type N Panel Receptacles
VENDORVIEW

San-tron announced the release of a UG-58 A/U Type N panel receptacle that features single piece body construction. The seamless UG-58s are manufactured using a custom machine designed and built by San-tron for fully automated assembly. This automation and construction method saves time and money during the manufacturing process, allowing for lower prices that make the receptacles a cost efficient choice for the consumer. The one piece construction of the UG-58s also dramatically increases the reliability of the panel receptacle by eliminating interference. The result is consistently smooth signal transfer. The UG-58 A/U panel receptacles have a frequency range of DC to 11 GHz and a nominal impedance of 50 ohms.
San-tron Inc., Ipswich, MA (978) 356-1585, www.santron.com.
RS No. 231

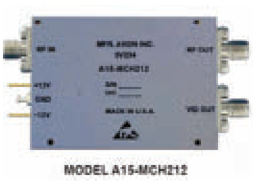
Interchangeable Connector Circulators



Utilizing the "QC" Interface, a wide range of connector types and loads can be chosen without ordering a custom circulator. Typical high power choices include N, HN, SC and EIA rigid line connectors. The circulator is operable over a 10 percent minimum bandwidth between 500 and 1600 MHz at power levels up to 50 kW peak and 1 kW average. Typical specs for the CT-1800-S Series are 20 dB minimum isolation, 0.3 dB loss and 1.25 VSWR over 0 to 65°C.
UTE Microwave Inc., Asbury Park, NJ (732) 922-1009, www.utemicrowave.com.
RS No. 232

Amplifiers

18 to 40 GHz SDLVA



Akon Inc. has available for immediate delivery an 18 to 40 GHz SDLVA with limited RF output (model A15-MCH212). This model is available with a -63 to +2 dBm video log range, ±1.5 dB video log linearity, and 11 nanosecond rise time, 40 nanosecond recovery time, and 15 nanosecond delay time.
Akon Inc., San Jose, CA (408) 432-8039, www.akoninc.com.
RS No. 233

Hybrid Power Amplifier Modules
VENDORVIEW

AR's new line of wideband, hybrid power amplifier modules (HPM) cover the 6 to 18 GHz frequency range, and are the result of combining Microelectronic technology with the latest developments in thin film substrates. These hybrid modules require a single DC voltage source and are 50 ohm cascadable building blocks with output powers up to 37 dBm. AR offers the in-house capabilities to create custom HPM design solutions with frequencies from DC to 20 GHz. Bring AR your requirements and they will work with you to create a solution.
AR RF/Microwave Instrumentation, Souderton, PA (215) 723-8181, www.ar-worldwide.com.
RS No. 234

Linear Power Amplifier
VENDORVIEW

This QFN packaged GaAs MMIC linear power amplifier with 49 dBm OIP3 and 16.5 dB small-signal gain, identified as XP1039-QJ, covers 5.5

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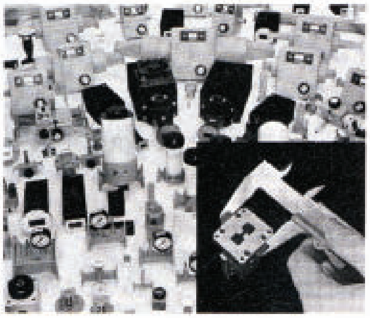

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RF Power Amplifier

A801M302-5353-R

■Frequency: 800M-3000MHz
■Power: 200W
and more.....

Model	Frequency	P@1dB (min)
A101K102-4141M/R	100k-1000MHz	+41dBm
A001M102-4141M/R	1M-1000MHz	+41dBm
A001M102-4343M/R	1M-1000MHz	+43dBm
A001M102-4747M/R	1M-1000MHz	+47dBm
A001M102-5050M/R	1M-1000MHz	+50dBm
A020M102-5353M/R	20M-1000MHz	+53dBm
A080M102-5757 R	80M-1000MHz	+57dBm
A080M102-6060 R	80M-1000MHz	+60dBm
A201M102-6363 R	200M-1000MHz	+63dBm
A501M272-3737M/R	500M-2700MHz	+37dBm
A501M272-4040M/R	500M-2700MHz	+40dBm
A501M272-4343M/R	500M-2700MHz	+43dBm
A501M272-4747M/R	500M-2700MHz	+47dBm
A501M272-5050 R	500M-2700MHz	+50dBm
A801M202-3737M/R	800M-2000MHz	+37dBm
A801M202-4040M/R	800M-2000MHz	+40dBm
A801M202-4343M/R	800M-2000MHz	+43dBm
A801M202-4747M/R	800M-2000MHz	+47dBm
A801M202-5050 R	800M-2000MHz	+50dBm
A801M202-5353 R	800M-2000MHz	+53dBm
A801M202-5757 R	800M-2000MHz	+57dBm
A801M202-6060 R	800M-2000MHz	+60dBm
A801M252-3737M/R	800M-2500MHz	+37dBm
A801M252-4040M/R	800M-2500MHz	+40dBm
A801M252-4343M/R	800M-2500MHz	+43dBm
A801M252-4747M/R	800M-2500MHz	+47dBm
A801M252-5050 R	800M-2500MHz	+50dBm
A801M252-5353 R	800M-2500MHz	+53dBm
A801M252-5757 R	800M-2500MHz	+57dBm
A801M252-6060 R	800M-2500MHz	+60dBm
A801M302-3737M/R	800M-3000MHz	+37dBm
A801M302-4040M/R	800M-3000MHz	+40dBm
A801M302-4343M/R	800M-3000MHz	+43dBm
A801M302-4747M/R	800M-3000MHz	+47dBm
A801M302-5050 R	800M-3000MHz	+50dBm
A801M302-5353 R	800M-3000MHz	+53dBm

* M-Module type, R-Rack type

R&K Company Limited

Tel : +81-545-31-2600 http://rk-microwave.com
Fax : +81-545-31-1600 E-mail: info@rkco.jp

Visit http://mwj.hotims.com/23287-85

RF Power Amplifier

A010K401-5353R

■Frequency: 10k-400MHz
■Power: 200W
and more.....

Model	Frequency	P@1dB (min)
A001K101-4444M/R	1k-100MHz	+44dBm
A010K251-4444M/R	10k-250MHz	+44dBm
A010K401-4444M/R	10k-400MHz	+44dBm
A001K101-4747M/R	1k-100MHz	+47dBm
A010K251-4747M/R	10k-250MHz	+47dBm
A010K401-4646M/R	10k-400MHz	+46dBm
A001K101-4949M/R	1k-100MHz	+49dBm
A010K251-4949M/R	10k-250MHz	+49dBm
A010K401-4848M/R	10k-400MHz	+48dBm
A001K101-5353M/R	1k-100MHz	+53dBm
A010K251-5353M/R	10k-250MHz	+53dBm
A010K401-5353M/R	10k-400MHz	+53dBm
A010K101-5757 R	10k-100MHz	+57dBm
A101K251-5757 R	100k-250MHz	+57dBm
A010K101-6060 R	10k-100MHz	+60dBm
A101K251-6060 R	100k-250MHz	+60dBm
A101K080-6363 R	100k- 80MHz	+63dBm
A101K251-6363 R	100k-250MHz	+63dBm
A101K080-6767 R	100k- 80MHz	+67dBm
A101K251-6767 R	100k-250MHz	+67dBm
A101K080-7070 R	100k- 80MHz	+70dBm
A101K251-7070 R	100k-250MHz	+70dBm

* M-Module type, R-Rack type

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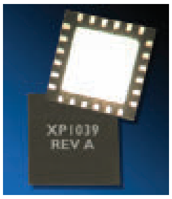

to 7.5 GHz and includes an on-chip temperature compensated power detector. The amplifier comes in an RoHS compliant, industry standard, fully molded 6×6 mm QFN package and includes on-chip ESD protection structures and DC bypass capacitors to ease implementation and volume assembly. The XP1039-QJ is well suited for highly linear communications applications such as point-to-point radio, LMDS, SATCOM and VSAT applications.

Mimix Broadband Inc., Houston, TX
(281) 988-4600, www.mimixbroadband.com.
RS No. 235

Instrumentation Desktop Amplifiers

VENDORVIEW

MITEQ's latest offering in its instrumentation amplifier series, Models NSP2000-NVG, NSP4000-NVG and NSP4000-NFG, are now available with a frequency range from 0.1 to 40 GHz. Fixed or digitally-controlled variable gain models are available. The variable gain models offer a digital control range of up to 15 dB with a step size of 1 dB. The amplifiers include a built-in CE approved power supply and cooling fans. Options include various frequency bandwidths, gain, noise figure and power outputs.

MITEQ Inc., Hauppauge, NY
(631) 436-7400, www.miteq.com.
RS No. 236

High Power Amplifier

VENDORVIEW

Mini-Circuits ZHL-16W-43+ offers high power (16 W) with rugged reliability over a broad frequency range from 1800 to 4000 MHz. Typical gain is 45 dB, IP3 +47 dBm, and DC current 4.3A max at +28 VDC. This model includes temperature sensing circuits for automatic shutdown and output load protection to operate into a short or an open making it ideal for use in laboratory or field applications.

Mini-Circuits, Brooklyn, NY
(718) 934-4500, www.minicircuits.com.
RS No. 240

Antennas

Circularly Polarized Antenna

The model 470M1 is a compact highly efficient, circularly polarized antenna that provides

hemispherical omni-directional coverage. The Model 470M1 has a VSWR of 1.5:1 maximum, nominal gain of -1 dBiC at the horizon and operates at RF power of 200 W CW. This antenna also employs a unique approach to generate circular polarization from a single linearly polarized input. Model 470M1 operates in the C-band, but can be scaled for other frequency bands of operation; contact Cobham Sensor Systems (Baltimore) for additional parameters. The antenna is five inches in diameter with a height of seven inches and the unit can withstand internal pressure of 10 psi. Model 470M1 has a WR187 connector and the antenna is qualified for a high mechanical shock environment.

Cobham Sensor Systems, Baltimore, MD
(410) 542-1700, www.cobhamdes.com.
RS No. 237

Sources

Miniature Frequency Synthesizers

The SLX and LX Series miniature frequency synthesizers are custom-designed to utilize 3 or 3.3 V inputs to meet the stringent low power consumption requirements of short range and battery powered wireless systems. The SLX and LX units feature extremely low power consumption (900 MHz, +3 V at 15 mA, typical) and typical power outputs of -5 dBm (up to +7 dBm, optional). The units also feature low spurious, low harmonics and exceptionally low phase noise. Available with operating temperature ranges of -40° to +85°C, the units are designed as cost-effective, surface-mount packages and can be fixed-frequency or programmable in bands from 50 MHz to 6 GHz, with extremely low phase noise (<-110 dBc/Hz at 100 kHz offset, at 400 MHz).

EM Research Inc., Reno, NV
(775) 345-2411, www.emresearch.com.
RS No. 238

Miniature Frequency Synthesizer

The SLSM5 is a new family of frequency synthesizers that operates to 12.5 GHz and covers up to octave bandwidths. This synthesizer features excellent phase noise (-95 dBc/Hz at 10 kHz at X-band) and excellent spurious performance (-60 dBc minimum). With 1 kHz steps and frequency controlled via convenient RS485 interface this synthesizer is a system friendly component. The SLSM5 operates on an external 10 MHz input or an internal TCXO. Only a single +5 V supply is needed to power this miniature (2.5" × 2.5" × 0.6") unit.

Luff Research, Floral Park, NY
(516) 358-2880, www.luffresearch.com.
RS No. 239

i2S® INTELLIGENT INTERACTIVE SYNTHESIZERS

FEATURES: Over an octave bandwidth tuning, Small step size resolution, Outstanding spectral purity, High spurious rejection, Fast lock settling time

MTS2500-110250-10

Output Frequency	1100 - 2500 MHz	
Bandwidth	1400 MHz	
External Reference	10 MHz	
Step Size	Programmable to 1 Hz	
Bias Voltage	+5 / +3.3 V	
Output Power	+9 dBm (Min.)	
Spurious Suppression	60 dB (Typ.)	
Harmonic Suppression	15 dB (Typ.)	
Typical Phase Noise	Offset	dBc/Hz.
	1 kHz	-93
	10 kHz	-95
	100 kHz	-110
Settling Time	Within 1 kHz	<22 mSec
	Within 10 Hz	<36 mSec
Operating Temperature Range	-20 to +70 °C	

MTS2500-200400-10

Output Frequency	2000 - 4000 MHz	
Bandwidth	2000 MHz	
External Reference	10 MHz	
Step Size	Programmable to 1 Hz	
Bias Voltage	+5 / +3.3 V	
Output Power	+5.5 dBm (Min.)	
Spurious Suppression	60 dB (Typ.)	
Harmonic Suppression	10 dB (Typ.)	
Typical Phase Noise	Offset	dBc/Hz.
	1 kHz	-88
	10 kHz	-87
	100 kHz	-100
Settling Time	Within 1 kHz	<10 mSec
	Within 10 Hz	<20 mSec
Operating Temperature Range	-20 to +70 °C	

MTS2500-300600-10

Output Frequency	3000 - 6000 MHz	
Bandwidth	3000 MHz	
External Reference	10 MHz	
Step Size	Programmable to 1 Hz	
Bias Voltage	+5 / +3.3 V	
Output Power	+2 dBm (Min.)	
Spurious Suppression	60 dB (Typ.)	
Harmonic Suppression	20 dB (Typ.)	
Typical Phase Noise	Offset	dBc/Hz.
	1 kHz	-87
	10 kHz	-83
	100 kHz	-108
Settling Time	Within 1 kHz	<6 mSec
	Within 10 Hz	<12 mSec
Operating Temperature Range	-20 to +70 °C	

Patented Technology

Programming Interface:

-- 3.3V SPI (Standard)

-- RS232

Also available in connectorized package with the following options.

-- Internal reference (TCXO & OCXO)

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Available Frequencies Ranging Up To 8000 MHz

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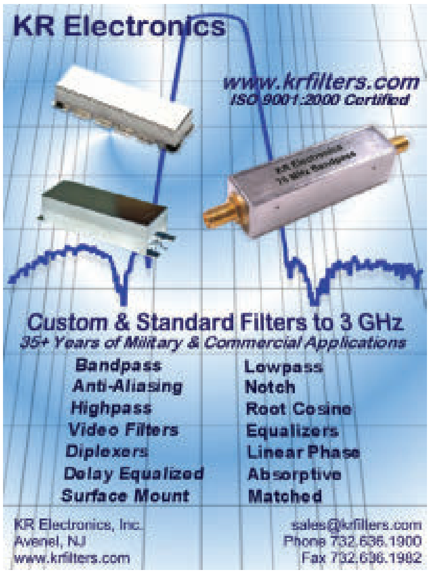
RS 2

New Modco MCR Series Ceramic Resonator VCO

These Voltage Controlled Oscillators offer exceptionally low Phase Noise in the industry Standard one half inch square package. Model MCR1270-1290MC with an Input Voltage of +5.0V, Tuning Voltage of 0.5V to 4.5V and a Frequency Range of 1270-1290MHz is rated -122dBc @ 10khz offset. Many other catalog models are available and custom designs can be supplied with no NRE

www.modcoinc.com

RS 75



RS 41

REVOLUTIONARY HERMETIC SMP CONNECTORS

These SMPs meet the requirements of MIL-STD-348, but utilize unique housing interface features, which significantly improves reliability and production assembly yields. Proprietary techniques are used to independently control plating thickness on pin and housing.

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RS 98

ULTRA LOW PHASE NOISE VCO

Modco MD Series VCOs offer very low Phase Noise in a half inch package. Models are low cost and available for a variety of Frequency Bands. No NRE for custom designs.

Model MD108MST

902–928 MHz
Vcc: 5 V
Vt: 0.5 to 4.5 V
Current: 16 ma
Power: +4 dBm
2nd Harmonics: –45 dBc
Pushing: 0.4 MHz/V
Pulling: 0.6 MHz with a 12 dB return loss
Phase Noise: –117 dBc @10 KHz

Modco, Inc.
Sparks, NV (775) 331-2442
www.modcoinc.com

RS 76

RS 96

RS 89

NEW PRODUCTS

High Resolution Synthesizers

VENDORVIEW

The MTS2500 series of high resolution synthesizers combine the latest in DDS and multi-loop synthesizer technologies with a high performance VCO to provide as low as 1 Hz step size, ultra low phase noise, wide bandwidth performance and low spurious, while permitting for increased loop bandwidth, faster settling time and higher stability under vibration. Several models are available covering wide frequency bands, the MTS2500-110250-10 (1.1 to 2.5 GHz), MTS2500-200400-10 (2 to 4 GHz) and MTS2500-300600-10 (3 to 6 GHz). Power consumption is less than 2.0 W. The low resolution offered by the MTS2500 series is ideal for applications in imaging equipment such as radar and magnetic resonance.

Synergy Microwave Corp., Paterson, NJ (973) 881-8800, www.synergymwave.com.
RS No. 241

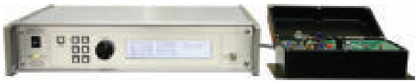
Voltage-controlled Oscillator

The model SMV4051A-LF is an RoHS compliant voltage-controlled oscillator (VCO) designed for C-band. The SMV4051A-LF operates from 4030 to 4070 MHz with a tuning voltage range of 0 to 5 VDC. This VCO features a typical phase noise of -83 dBc/Hz at 10 kHz offset and a typical tuning sensitivity of 55 MHz/V. The SMV4051A-LF is designed to deliver a typical output power of 2.25 dBm at 5 VDC supply while drawing 18 mA (typical) over the temperature range of -10° to 70°C. This VCO features typical 2nd harmonic suppression of -15 dBc and comes in Z-Comm's industry standard

SUB-L package measuring 0.3" × 0.3" × 0.08".
Z-Communications Inc., San Diego, CA (858) 621-2700, www.zcomm.com.
RS No. 242

Test Equipment

Reverse Recovery Tester



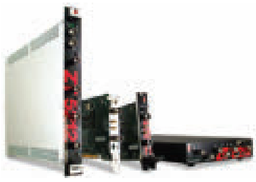
The AVR-CD1-B is a high performance, GPIB and RS232-equipped instrument intended for reverse recovery time testing of diodes and other semiconductor devices. The AVR-CD1-B applies a forward bias pulse of +0.1A to +10A to a device under test (DUT). At the end of that pulse, the current ramps downward at an adjustable rate of 100 to 200 A/us until the diode stops conducting. The current waveforms generated by this instrument are suitable for MIL-STD-750E Method 4031.4 Test Condition D tests. Standard and customized jigs for different device packages are available.
Avtech Electrosystems Ltd., Ogdensburg, NY (888) 670-8729, www.avtechpulse.com.
RS No. 243

20 GHz Signal Generator

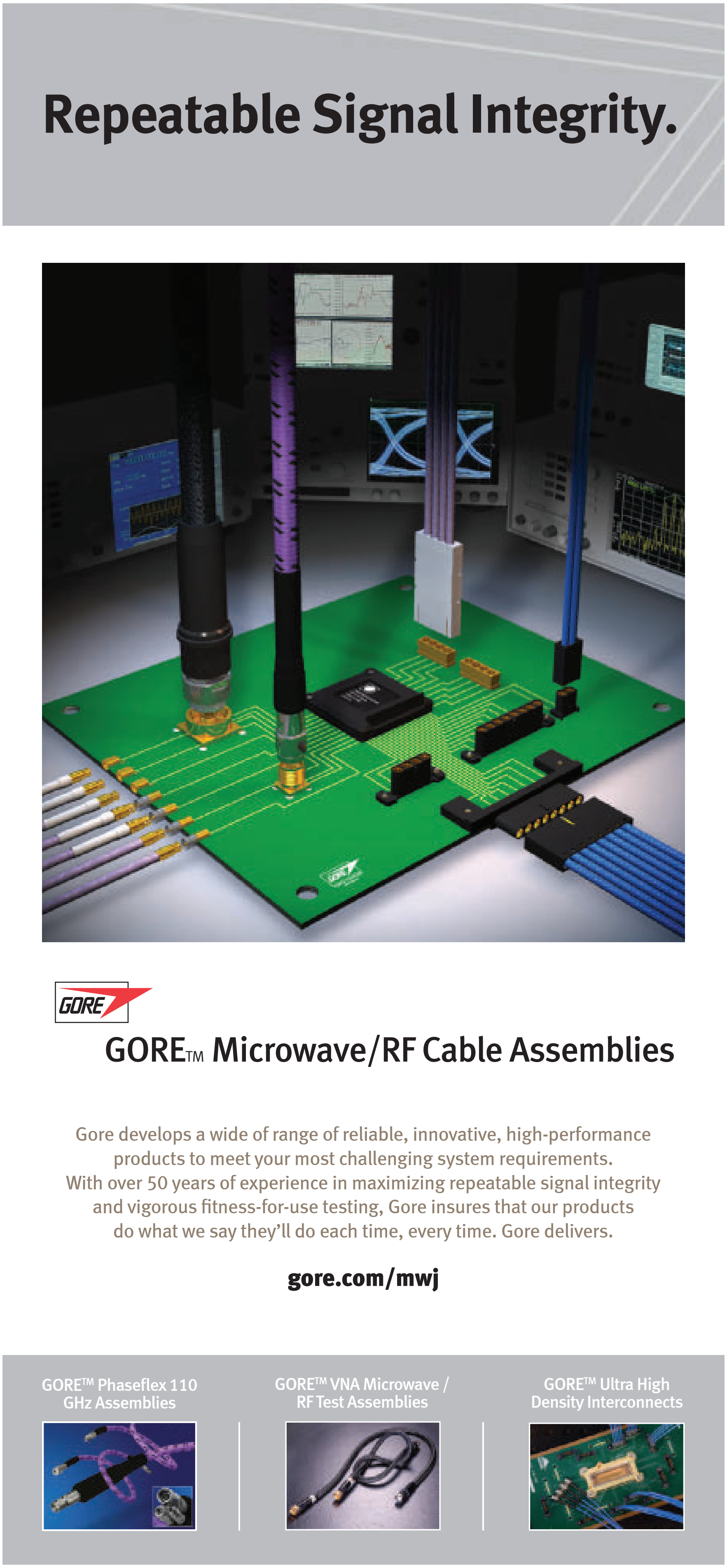
VENDORVIEW

The HMC-T2100 is a new, easy to implement 10 MHz to 20 GHz synthesized signal generator that provides high output power, low harmonic levels and broad frequency range for only $7,998.00. Ideal for use in automated test and measurement environments, research and development laboratories, the HMC-T2100 is a compact and lightweight frequency generator that delivers up to +27 dBm of CW output power in 0.1 dB steps over a 40 dB dynamic range. Harmonic rejection is better than -39 dBc at 1 GHz and spurious products are better than -65 dBc at 10 GHz.
Hittite Microwave Corp., Chelmsford, MA (978) 250-3343, www.hittite.com.
RS No. 244

Waveform Generators



ZTEC Instruments announces its new series of waveform generators, the ZT5210. Available in PCI, PXI, VXI and LXI, these multi-channel waveform generators feature a sampling rate of 200 MS/s, a bandwidth of 50 MHz, and 14-bit resolution. The arbitrary waveform functionality of these instruments is extremely flexible. Up to 32M samples per channel can be output using an 8M sample waveform library. Users can mix and match up to 8 sequences from the waveform library, each with 4096 segments/sequence. In addition to its arbitrary waveform generator features, the ZT5210 series offers a robust function generator library.
ZTEC Instruments Inc., Albuquerque, NM (505) 342-0132, www.ztecinstruments.com.
RS No. 245



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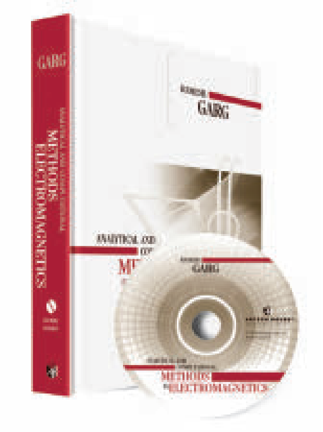

Analytical and Computational Methods in Electromagnetics

Ramesh Garg

This book allows one to achieve optimal microwave system performance by mastering the principles and methods underlying today's powerful computational tools and commercial software in electromagnetics. It offers clear and complete explanations of electromagnetics, providing the analytical background needed to understand such key approaches as MoM (Method of Moments), FDTD (Finite Difference Time Domain) and FEM (Finite Element Method), and Green's functions. This book includes all math necessary to master the material plus numerous solved problems that help ensure the understanding of key concepts throughout the book. It also includes time-saving Matlab® source code for the problems presented in the book that can be easily modified to help solve similar problems in the field.

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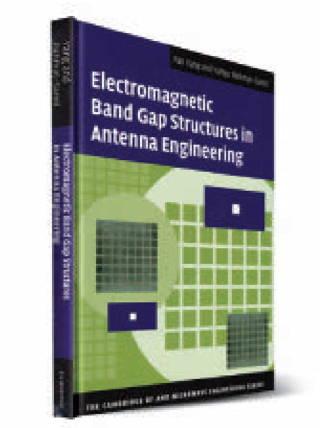

Electromagnetic Band Gap Structures in Antenna Engineering

Fan Yang and Yahya Rahmat-Samii

This comprehensive, applications-oriented survey of the state-of-the-art in Electromagnetic Band Gap (EBG) engineering explains the theory, analysis and design of EBG structures. It helps one understand EBG applications in antenna engineering through an abundance of novel antenna concepts, a wealth of practical examples and complete design details. It contains a customized FDTD method of EBG analysis, for which accurate and efficient electromagnetic software is supplied to provide a powerful computational engine for EBG designs. This book provides a dynamic resource for engineers, and researchers and graduate students working in antennas, electromagnetics and microwaves.

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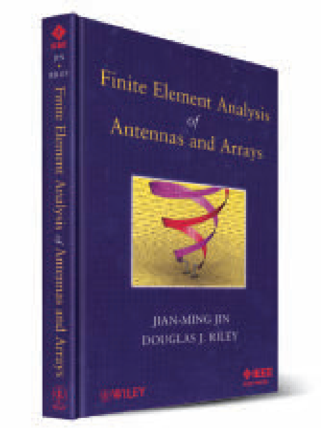

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Jian-Ming Jin and Douglas J. Riley

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RF/Microwave Engineering Job Market, June 2009

According to EngineerSalary.com, RF engineers held over 51,000 jobs in 2008, making this one of the smallest segments of the engineering community. They expect that this number will increase 8.2% by the end of 2010, and stay a fast growing segment until 2014.

Increasing number of contract-based employment is an interesting development, currently approaching about 9% of occupied RF engineers. Consulting opportunities for RF engineers are assumed to grow in conjunction with respective industry sectors.

Software defined radio skills were highlighted by EngineerSalary.com as "**incredible demand**" by both commercial and defense sector suppliers.

In general, defense and commercial companies are seeking experienced **hands-on** RF engineers and RF engineering managers. According to EngineerSalary.com, this stability is expected to last until 2015.

Current evidence indicates that the demand is mainly in the **security/defense** sector. Yet recruiters have reported signs of increasing demand in the wireless/telecommunications sector.

Is there a real shortage of RF engineers?

There is numerous contradicting evidence. One recent recruiter's e-mail says, "I have a great number of RF professionals looking for work and it amazes me that I am reading about an RF shortage," yet this very same e-mail says, "It is kind of a catch 22. I need the boards to help me find resumes but have to get placements to get money to afford the boards". This is a very common example these days. Apparently those RF engineers knocking on their door for work don't possess the skill sets required for the vacancies. **So the answer is YES. The shortage is real for those skill sets in demand right now!**

How is this explained?

RF/microwave engineering is expertise-sensitive. Electromagnetic-related engineering is not like IT, networking, programming and the like, where all industry sectors require similar skills. Microwave engineering encompasses a diverse range of expertise, each relevant in different industry sectors, while employers impose stringent requirements for hand-on experience in the specific field only.

The security sector is currently responsible for most of the demand for RF engineering skills. This places specific sets of expertise, which are in short supply while other brilliant RF engineers might be in the job market, not only defense. A handful of other sectors are active. Among these is the medical wireless (recognized among 2009 growth markets) and telecommunications (especially wireless networks), a market which is starting to show some positive signs of growing demand for design engineers.

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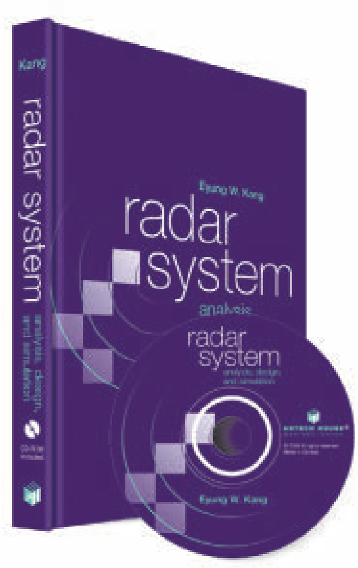

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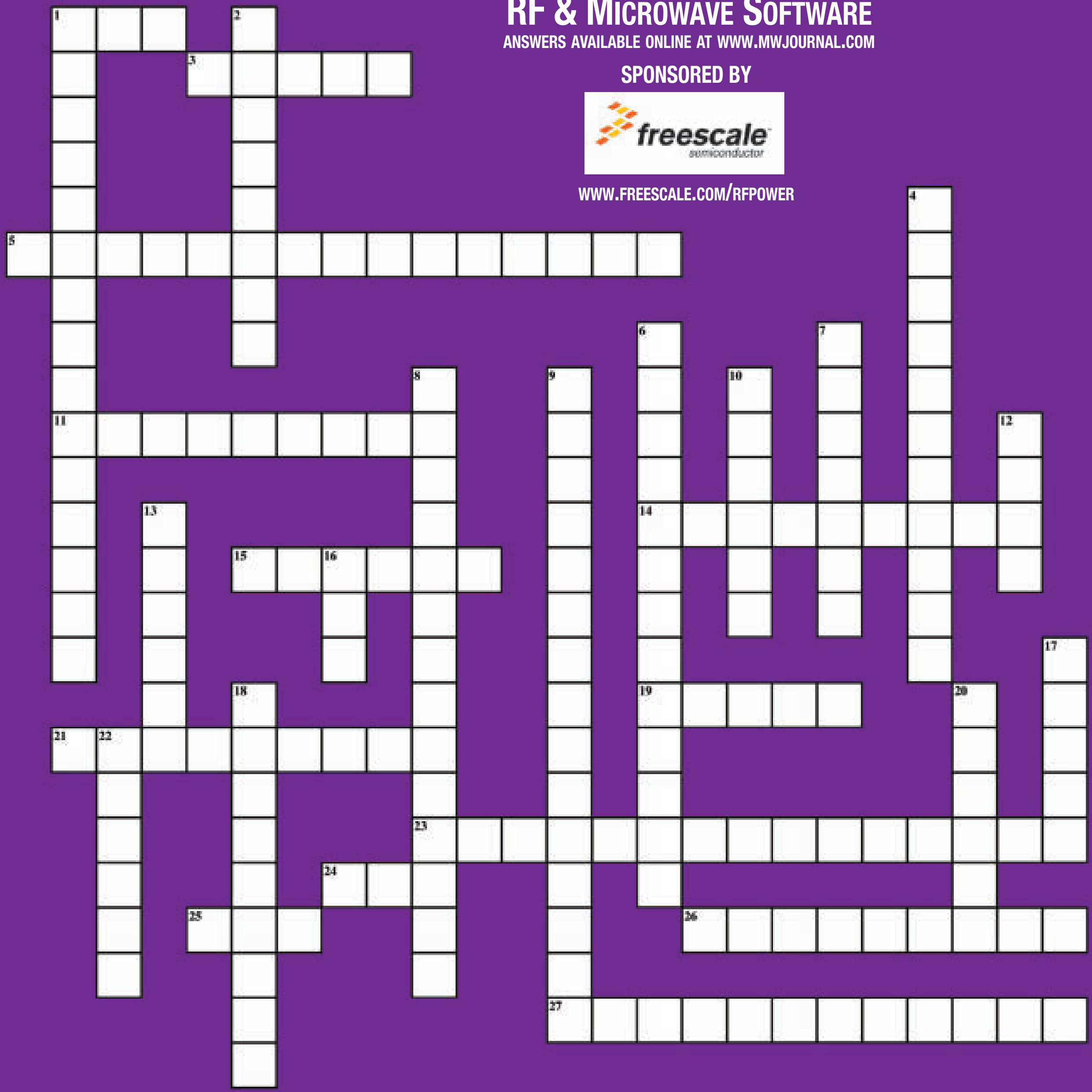

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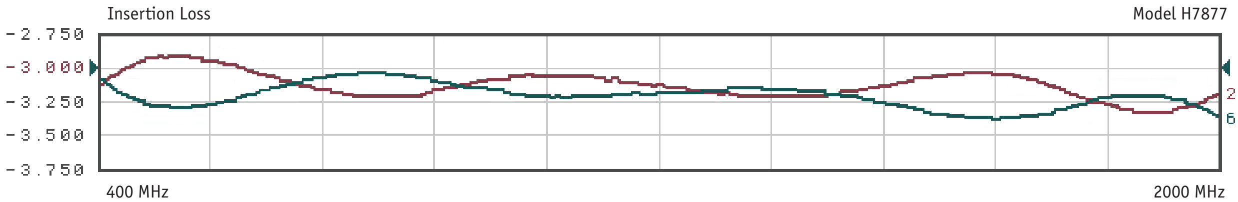

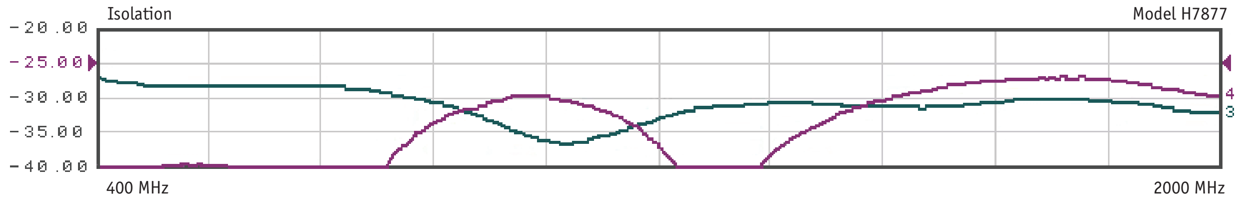

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H7450	100-500	200	1.0	1.35:1	20	6 X 5 X 2.25
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H3670	200-400	400	0.2	1.40:1	20	5 X 3 X 2.25
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