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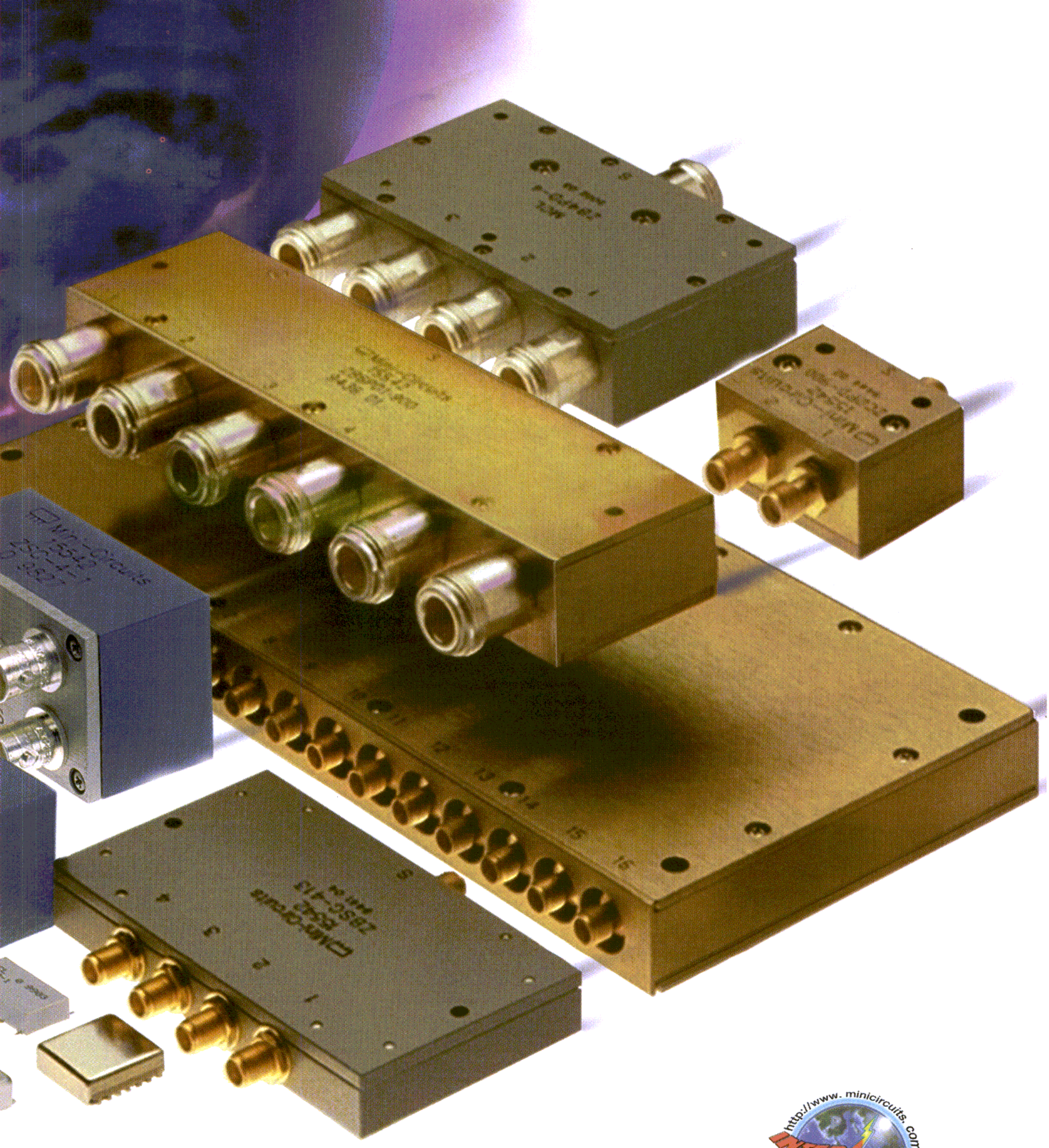

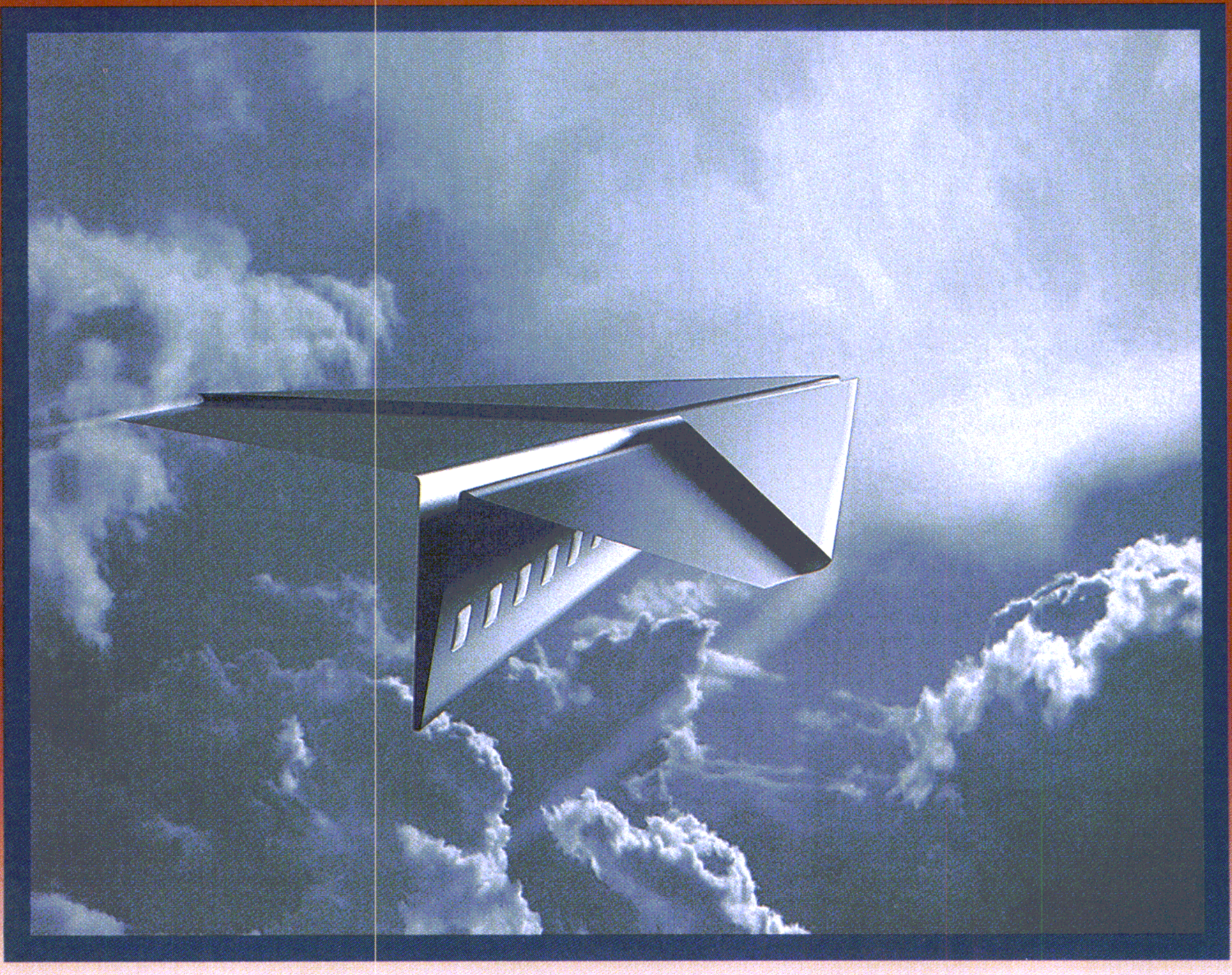

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NGA-386	0.1-5.0	4.0	35.0	20.8	14.5	25.8	144
NGA-486	0.1-6.0	5.0	80.0	14.8	18.3	39.5	118
NGA-586	0.1-6.0	5.0	80.0	19.9	18.9	39.6	121
NGA-686	0.1-6.0	5.9	80.0	11.8	19.5	37.5	121

Data at 1 GHz and is typical of device performance.

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Circle 36

Applied MICROWAVE & WIRELESS

August 2000
Vol. 12 No. 8

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Applied MICROWAVE & WIRELESS

PRODUCTS & TECHNOLOGIES

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Editorial

New Ideas for Wireless Infrastructure Need Strong Support

By Gary A. Breed
Publisher

Technology often develops faster than the marketplace can respond, requiring its developers to anticipate consumer desires. Consumers must be shown what services and capabilities can be achieved (and at what price) before they decide which ones will receive a popular mandate.

History has already provided this lesson. U.S. railroads, electrical utilities, telephone networks and even our interstate highways were not built to meet consumer demand; they were built to *create* it! These major infrastructure accomplishments were driven either by government mandate or by the foresight (okay, greed) of business monopolies. In the U.S. and much of the world, these forces are diminishing or no longer present.

The developers of modern wireless technology must think like the railroad barons of the 1800s! Powerful new ideas need strong support. The European approach to GSM is a good example. Government telecommunications agencies presented wireless companies with a mandate to develop a specific wireless infrastructure. The Internet is another example — the government developed the infrastructure with military dollars, and now commercial applications have blossomed.

There is an alternative to government or monopoly control. The proponents of LMDS wideband wireless services have demonstrated unprecedented cooperation in the development of transmission standards. Each LMDS operator is likely to offer a different package of consumer services, but they will all share the cost of developing a common infrastructure.

In the near future, we will see new concepts for wireless communications infrastructure. Ultra-wideband systems are being developed with conventional spread-spectrum and new pulse-based technologies. Iridium may have died, but other satellite systems will seek to provide global coverage, probably using methods other than channelized narrowband transmission. Adaptive systems that change their characteristics to fit the user's immediate need are already being designed.

Some of these new systems are radically different from existing "radio" technology. To get a chance for implementation, government and industry will be required to cooperate on spectrum usage, transmission formats and buildout schedules. New "railroads and highways" for wireless communications are being designed today in the laboratory; it will take a strong commitment to build them in tomorrow's world.

Practical filter construction

Editor:

I've been reading *Applied Microwave & Wireless* regularly, the filter articles in particular. As a senior citizen in the filter world, I am regularly reminded of what our friend Dr. George Szentermai told me. He said that it really does not do any harm when the same old techniques get republished every so often. There is always a new generation of engineers who either never learned, or already forgot, the simple way of doing things.

The case in point is the series of articles by Richard Kurzrok, the latest of which is "Build Filters Without PC Boards," in the June issue. Have there always been PC boards? If not, what did people do before PC boards? The answers to these questions are, "No, PC boards came into use in the 1950s," and, "They did point-to-point wiring on standoff insulators." I think these points belonged in the article.

Regarding technical content, it has been found, from the earliest days, that inductors cost more than capacitors, are larger and have characteristics that are more difficult to control. It is general practice to use the circuit with fewer inductors. The filter of Figure 1 has three inductors and two capacitors. Its dual, which would be used more often, has two inductors and three capacitors.

Next, the use of tunable capacitors in the 70 MHz bandpass filter can be condoned for a fast prototype, but it should have been pointed out that in production, air tuned coils are usually tuned by "tweaking" their length in the final assembly.

All I want to point out is that Mr. Kurzrok should be encouraged to include more information in his articles. Sometimes what is left out is as important as what is included.

Finally, a bit of proofreading. There are two tables labeled "Table 2" and readers should be cautioned to refer to the table that is on the same page as the text reference.

Bill Lurie
Lake Worth, FL

Antenna article corrections

Editor:

In the article "Efficiency Measurements of Antennas Using the Wheeler Cap" [June 2000 issue], there are a couple of mistakes. First the Wheeler cap radius shown in Figures 2 and 3 should be "$\lambda/2\pi$" not the "/2" that appeared in the article. Also, in the text on page 38, midway down the left column, the quantities "2 ohms" and "1/8 ohm" refer to power and should be in "watts."

William Domino and Darioush Agahi
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Calendar

CONFERENCES

AUGUST

August 21-25, 2000
2000 IEEE International Symposium on Electromagnetic Compatibility
Washington, DC
Information: William Duff
Tel: 703-914-8450; Fax: 703-914-8499
E-mail: w.duff@ieee.org
Internet: http://www.ieee.org

SEPTEMBER

September 6-8, 2000
ISSSTA 2000 — IEEE Sixth International Symposium on Spread Spectrum Techniques and Applications
Parsipanny, NJ
Information: Clare Naporano
Tel: 973-596-8474; Fax: 973-596-8473
E-mail: clare@megahertz.njit.edu

September 10-13, 2000
RAWCON2000 — 2000 IEEE Radio and Wireless Conference
Denver, CO
Information: Michael S. Heutmaker
Tel: 609-639-3116; Fax: 609-639-3197
E-mail: heutmaker@lucent.com
Internet: http://rawcon.org

September 10-13, 2000
SATCAM 2000
Cape Town, South Africa
Information: Susan Lock or Daleen Kleyn
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Fax: + 27 21 808 3951
E-mail: satcam@eng.sun.ac.za
Internet: http://satcam.ee.sun.ac.za

September 11-13, 2000
Second Annual SHARC International DSP Conference
Boston, MA
Information: SHARC 2000
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E-mail: sharc2000@herts.ac.uk
Internet: http://www.SHARC2000.com

September 11-14, 2000
Analog & Mixed-Signal Applications Conference
San Jose, CA
Information: Joan Watkins, CMP Media
Tel: 1-800-789-2223 or 415-278-5231
Internet: http://www.edtn.com/ams

September 12-15, 2000
MMET*2000 — Eighth International Conference on Mathematical Methods in Electromagnetic Theory
Kharkov, Ukraine
Information: MMET*2000
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Fax: + 380 572 441105
E-mail: veliev@dut.kharkov.ua

September 18-21, 2000
PIMRC 2000 — 11th IEEE International Symposium on Personal, Indoor and Mobile Radio Communication
London, England
Information: PIMRC
Tel: +44 20 7848 2898; Fax: +44 20 7848 2664
Internet: http://www.pimrc2000.com

September 23-28, 2000
WCNC 2000 — IEEE Wireless Communications and Networking Conference
Chicago, IL
Information: Debora Kingston
Tel: 212-705-8942; Fax: 212-705-8999
E-mail: d.kingston@comsoc.org

September 26-29, 2000
PCIA Global XChange
Chicago, IL
Information: PCIA
Tel: 1-800-759-0300; Fax: 708-344-4444
Internet: http://www.pciaglobalxchange.com

OCTOBER

October 1-4, 2000
ASSPCC 2000 — Symposium on Adaptive Systems for Signal Processing, Communications and Control
Lake Louise, Alberta, Canada
Information: Lola Brooks
Tel: 905-525-9140 x. 24291; Fax: 905-521-2922
E-mail: brooks@mcmaster.ca

October 2-6, 2000
European Microwave Week
Paris, France
Information: Nicole Jedrej
Tel: +44 171 861 6391; Fax: +44 171 861 6251
E-mail: nicola.jedrej@unmf.com
Internet: http://www.eumw.com

October 16-20, 2000
AMTA — Antenna Measurement Techniques Association Annual Meeting and Symposium
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Information: Irene Honeycutt
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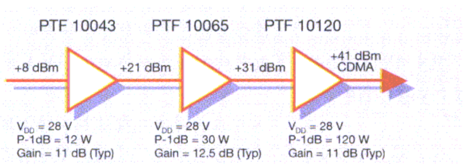

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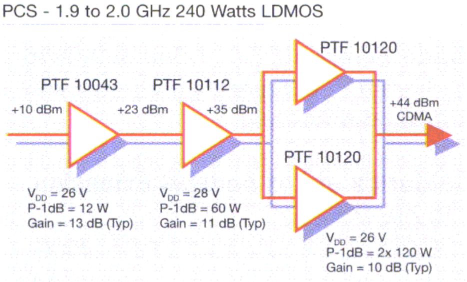

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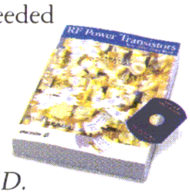

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RTP, NC . . . . .November 13-17, 2000

RF Test Equipment Operation (laboratory course)
Mountain View, CA . . . . . .August 21, 2000
Mountain View, CA . . . . . .October 31, 2000

RF Testing for the Wireless Age (laboratory course)
Mountain View, CA . . . . . .August 22-24, 2000
Mountain View, CA . . . . . .November 1-3, 2000

RF Power Amplifier Linearization Techniques
Mountain View, CA . . . . . .September 6-8, 2000

RF Wireless System Design Fundamentals
Dallas, TX . . . . .September 6-8, 2000

Wideband CDMA Communications
Dallas, TX . . . . .September 11-12, 2000
Mountain View, CA . . . . . .November 8-9, 2000

Behavioral Modeling
Mountain View, CA . . . . . .September 11-13, 2000

Applied RF Techniques I
Dallas, TX . . . . .September 11-15, 2000
Mountain View, CA . . . . . .October 16-20, 2000
San Diego, CA . . . . .November 6-10, 2000
RTP, NC . . . . .November 13-17, 2000

Short Range Wireless and Bluetooth
Mountain View, CA . . . . . .September 13-15, 2000
RTP, NC . . . . .November 13-15, 2000

Wireless Measurements: Theory and Practice
Mountain View, CA . . . . . .September 11-15, 2000

Frequency Synthesis Technology and Applications in Wireless Systems
Dallas, TX . . . . .September 13-15, 2000

RFIC Techniques for Wireless Applications
Mountain View, CA . . . . . .September 18-20, 2000

Introduction to Receivers, Signal and Noise
Mountain View, CA . . . . . .September 21-22, 2000

Signal Integrity, High-Speed and Power Distribution Design
Mountain View, CA . . . . . .September 25-26, 2000

RF Circuit Design Using EM Field Simulators
Mountain View, CA . . . . . .September 26-27, 2000

Bluetooth: An Introduction
Mountain View, CA . . . . . .October 2-3, 2001

DSP Made Simple for Engineers
Mountain View, CA . . . . . .October 4-6, 2000

RF and Wireless Made Simple
Mountain View, CA . . . . . .October 10-11, 2000
San Diego, CA . . . . .November 6-7, 2000
RTP, NC . . . . .November 14-15, 2000

RF and Wireless Made Simple II
Mountain View, CA . . . . . .October 12-13, 2000
San Diego, CA . . . . .November 8-9, 2000

Cellular and PCS Design: the Radio Interface
Mountain View, CA . . . . . .October 16-20, 2000

RF Transceiver Design
Mountain View, CA . . . . . .October 17-20, 2000

All About 3G (Third Generation Wireless)
Mountain View, CA . . . . . .October 23, 2000
RTP, NC . . . . .November 13, 2000

Frequency Synthesis and Phase-Locked Loop Design
Mountain View, CA . . . . . .November 6-7, 2000

Multitone Amplifier Design
RTP, NC . . . . .November 16-17, 2000

Information: Annie Wong, Tel: 415-949-3300; Fax: 415-949-4400; E-mail: info@bessercourse.com; Internet: www.bessercourse.com.

Georgia Institute of Technology

Digital Signal Processing 2000
Atlanta, GA . . . . .August 28-31, 2000

Near-Field Antenna Measurements and Microwave Holography
Boulder, CO . . . . .Aug. 28-Sept. 1, 2000

Basic Antenna Concepts
Atlanta, GA . . . . .September 26-28, 2000

Adaptive Array Radar Processing
Atlanta, GA . . . . .October 3-6, 2000

Principles of Modern Radar
Atlanta, GA . . . . .Oct. 30-Nov. 3, 2000

Information and Control Techniques for Intelligent Autonomous Vehicles
Atlanta, GA . . . . .October 25-27, 2000

Information: Georgia Tech Distance Learning, Continuing Education and Outreach, Tel: 404-894-2547; Fax: 404-894-7398; E-mail: conted@gatech.edu; Internet: www.conted.gatech.edu.

University of Wisconsin at Madison

Electrical Grounding of Communications Systems
Madison, WI . . . . .August 15-17, 2000

Preparing for 3G Wireless Technology: New W-CDMA Standards and Systems
Madison, WI . . . . .September 20-21, 2000

Preparing for 3G Wireless Technology: New Wideband TDMA Standards and Systems
Madison, WI . . . . .September 22, 2000

Information: Katie Peterson, Tel: 1-800-462-0876; Fax: 608-263-3160; E-mail: custserv@epd.engr.wisc.edu; Internet: http://epd.engr.wis.edu.

University of California at Los Angeles Extension

CDMA Mobile Radio Design
Los Angeles, CA . . . . .August 21-24, 2000

Digital Signal Processing: Theory, Algorithms and Implementation
Los Angeles, CA . . . . .September 11-15, 2000

Embedded and Real-Time Systems
Los Angeles, CA . . . . .September 19-21, 2000

Information: UCLA Extension, Short Course Program Office, Tel: 310-825-3344; Fax: 310-206-2815.

Henry Ott Consultants

Electromagnetic Compatibility Engineering
Palo Alto, CA . . . . .September 20-22, 2000
Information: Henry Ott Consultants, Tel: 973-992-1793; Fax: 973-533-1442.

University of California at Berkeley Extension

Design of Analog Integrated Circuits for Mixed-Signal Integrated Systems
San Francisco, CA . . . . . .October 5-7, 2000
Phase-Locked Loop (PLL) Systems
San Francisco, CA . . . . . .October 19-21, 2000
Low-Power Circuits and Systems for Digital Wireless Communications
Redwood City, CA . . . . . . .October 30-31, 2000
Information: Continuing Education in Engineering, Tel: 510-642-4111; Fax: 510-642-0374; E-mail: course@unex.berkeley.edu; Internet: www.unex.berkeley.edu/enroll.

University of Wisconsin at Milwaukee

Introduction to Electromagnetic Compatibility Design Practices
Northbrook, IL . . . . .October 12-13, 2000
Information: Loraine Samsel, Program Assistant, Tel: 1-800-222-3623; Fax: 1-800-399-4896; E-mail: samsel@uwm.edu; Internet: www.uwm.edu/dept/ccee.

Research Associates of Syracuse, Inc.

ELINT Interception and Analysis
Stockholm, Sweden . . . . .October 10-13, 2000
RF and Microwave Receiver Design
Stockholm, Sweden . . . . .October 24-27, 2000
Radar Fundamentals and FMCS Radar
Stockholm, Sweden . . . . .October 25-27, 2000
Information: Mary Chamberlain or Richard Wiley, Tel: 315-463-2266; E-mail: seminars@ras.com; Internet: www.ras.com.

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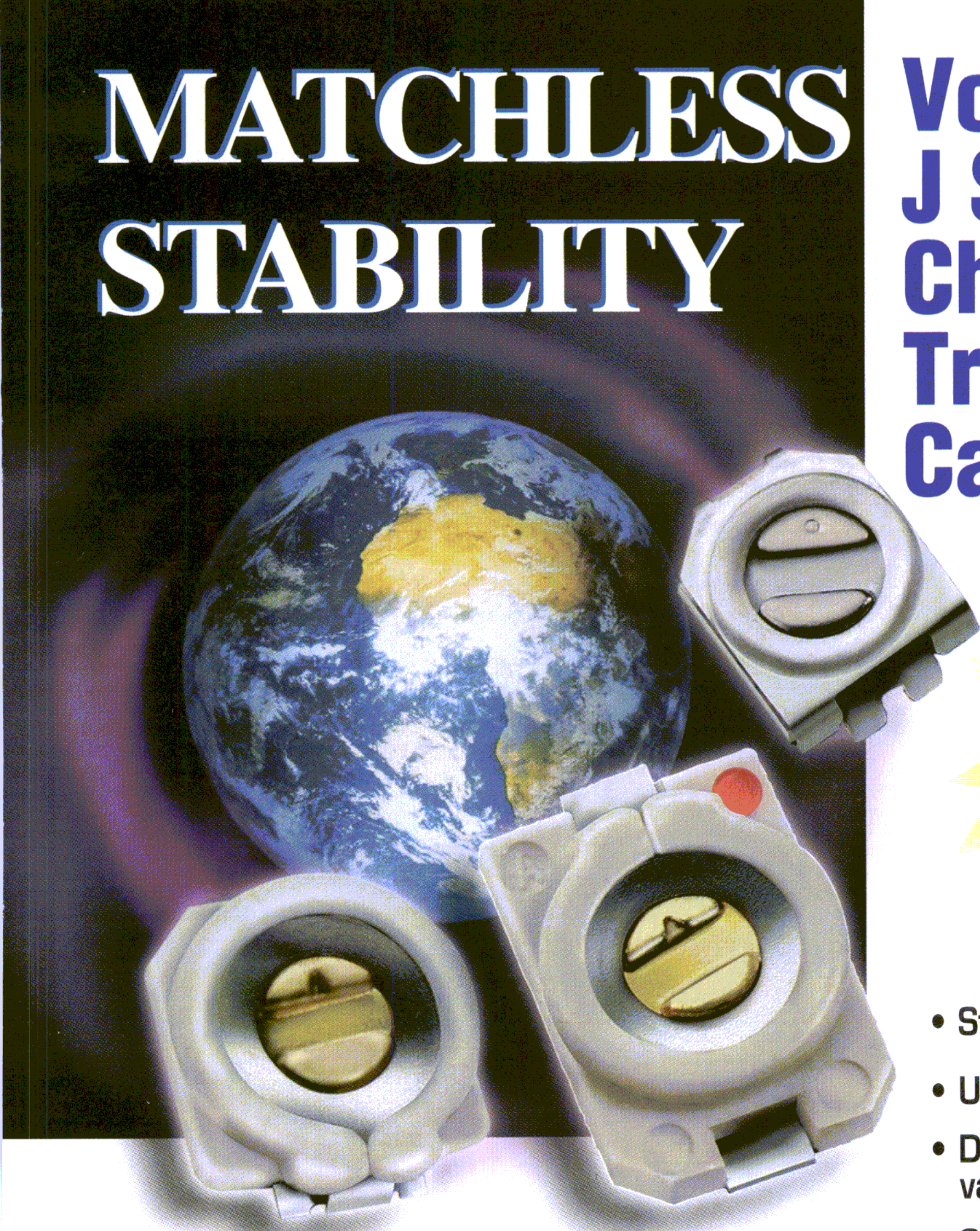

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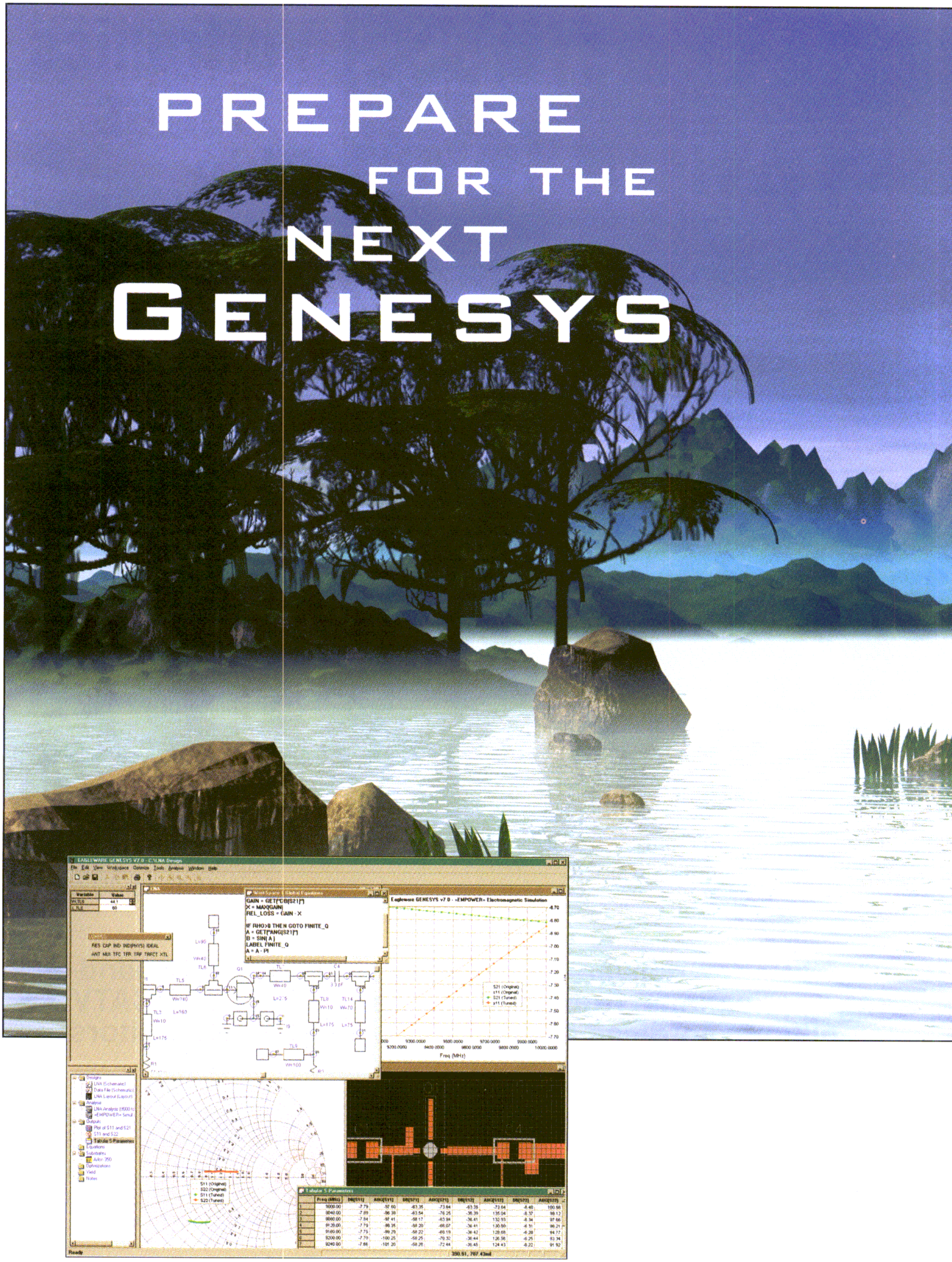
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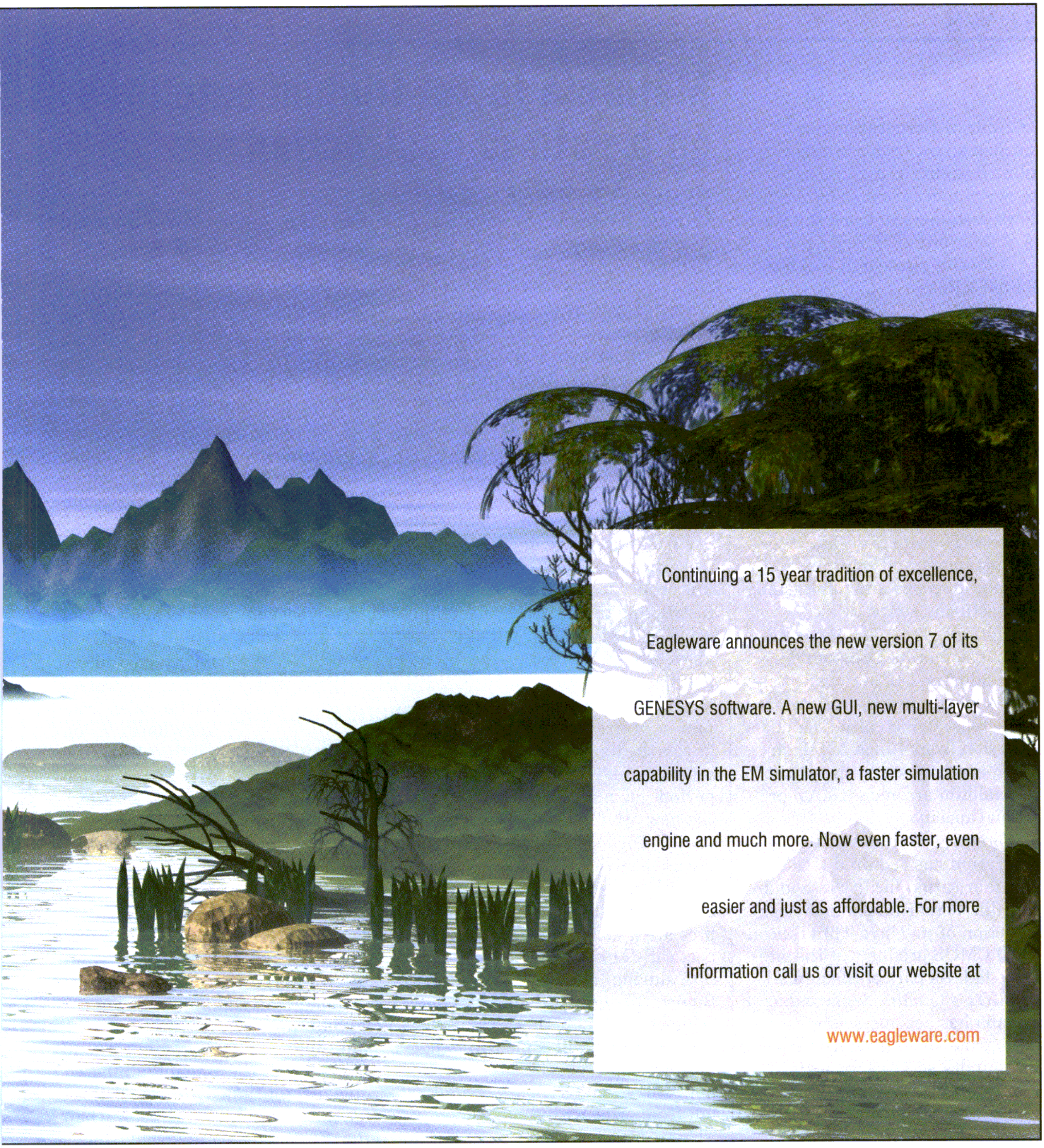
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BRIEFS

• Andrew Corporation has launched a new Order Status Online System through its web site, www.andrew.com. The service allows customers to track the status of their orders in real time.

• Adhesives Research Inc. has debuted a Research and Development Technology Center on its web site, www.adhesivesresearch.com. The new section provides information on the company's product development process.

• Manufacturing Technology Inc.'s www.totalpartsplus.com is an online resource that tracks more than 2 million electronic components from more than 1,100 manufacturers. The site is designed to help customers find solutions to parts obsolescence and diminishing manufacturing sources.

• Motorola Inc. has completed an expansion of its Compound Semiconductor-1 (CS-1) wafer fabrication facility in Phoenix, AZ. The increase, which also included a conversion from 4-inch to 6-inch wafers, has tripled the size of the site's gallium arsenide (GaAs) production capacity.

• Peregrine Semiconductor Corporation has acquired IDT's wafer fabrication facility in Sydney, Australia. Peregrine plans to begin production of its Ultra-Thin Silicon (USTi) CMOS products at the site by this fall. As part of the agreement, IDT's Quality Semiconductor Australia has become a subsidiary of Peregrine and will continue to offer foundry services for its 0.5-micron CMOS processes.

• TriQuint Semiconductor Inc. has opened a new Engineering Design Center in Lowell, MA, focusing on applications for the cellular phone handset market.

• EMCORE Corporation has announced plans to expand its site in Albequerque, NM. The expansion, scheduled to be complete by December 2000, will triple the cleanroom manufacturing capacity.

Motorola to set Iridium satellites on a path to destruction

By James P. Miller
Chicago Tribune
August 1, 2000
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CHICAGO, IL — Iridium LLC, jilted last week by a prospective buyer, threw in the towel on legal efforts to keep its multibillion-dollar system of satellites on life support.

The move effectively clears the way for Motorola Inc. to proceed with a "de-orbiting" procedure, in which all 86 of Iridium's communications satellites will re-enter the earth's atmosphere and burn up.

Perhaps as soon as next week, Motorola technicians will begin instructing the necklace of satellites orbiting 420 miles above the earth to fire their thrusters, altering course to a new orbit that grazes the top of the atmosphere. Over a period of months, the new orbit will slow the satellites until they eventually plunge towards earth.

The procedure apparently will not generate one big night of shooting stars.

With their lightweight solar panels outstretched, the Iridium satellites are a little smaller than a compact car. "Most of the satellite burns up" during re-entry, said Robert Beury, Iridium's deputy general counsel, although there "may be a few parts that will come through."

But people on the ground need not worry, added Beury. Satellites fall from orbit with some frequency. "There's always some risk, but in the history of the Space Age, no one's been hurt by an object plunging out of orbit. ... It's a big planet."

The procedure apparently will not generate one big night of shooting stars. Instead, the destruction will occur over time, the Iridium official suggested, because not all the satellites will be called in to die at once.

Left in their current orbit, Iridium's fleet of satellites could likely remain circling the earth for a century. But an eventual decommissioning was always envisioned for the satellites, said Iridium's Beury, because the space industry has started making an effort "to not leave floating junk" in orbit.

A Motorola spokesman said the Schaumburg telecom-equipment concern "will now finalize the implementation of a schedule to decommission the satellite constellation," but declined to provide any further details.

Iridium, with Motorola as its biggest backer, spent heavily on an ambitious plan to let customers place wireless phone calls from anywhere on earth. But the service, which began in late 1998 and lasted only 16 months, was never commercially viable. Consumers found it too expensive, and they were disappointed to discover that space-based wireless phones do not provide the high-quality sound transmission available through cheaper, conventional cell-phone service.

Iridium filed for Chapter 11 bankruptcy protection almost one year ago. But the Washington-based company continued to provide service until March of this year, when efforts to arrange a financial bailout fell through.

Payroll and other costs of monitoring the system are costing Motorola millions of dollars per month, and when Iridium service ended four months ago, the New York federal court overseeing the

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News

Companies form group for wireless DSL access

Six leading communications and semiconductor companies have announced the formation of the Wireless DSL Consortium, a coalition targeting the deployment of broadband wireless access solutions.

The consortium's founding members are ADC, Conexant Systems Inc., Gigabit Wireless, Intel Corporation, Nortel Networks and Vyyo. The group's goal is to provide the industry with standardized, timely, multivendor solutions for broadband wireless access.

The consortium is designed to provide a forum to define, develop and implement a set of open interfaces for broadband wireless access products operating in the multichannel multipoint distribution service (MMDS) and 3.5 GHz bands. Also provided will be rigorous testing and verification of standards-based products, as well as technical advice to carriers.

The consortium would also serve as a resource to the Federal Communications Commission and other regulatory bodies on spectrum management and interoperability.

More information on the consortium is available at its web site, www.wdslconsortium.com.

Intersil develops new manufacturing process

Intersil Corporation has announced the availability of UHF-2, a new manufacturing process, optimized for building highly integrated wireless communications chips.

The new process is capable of building ultra-high-frequency circuits. Intersil will use the process to make high-integration, high-performance, low power and low cost integrated circuits for wireless applications including wireless local area networking systems.

Intersil, based in Irvine, CA, develops silicon technology for wireless local area networks.

AmericanTCB certified for FCC wireless approvals

American Telecommunication Certification Body, a subsidiary of Rhein Tech Laboratories Inc. of Herndon, VA, has received certification from the Federal Communications Commission to approve certain types of radio frequency devices under Part 2 of the FCC Rules.

AmericanTCB is an independently-operating joint venture of Rhein Tech and Washington Laboratories Limited of Gaithersburg, MD.

Companies, organizations and institutions may submit information for our News section to: Shannon O'Connor, Managing Editor, Applied Microwave & Wireless, 4772 Stone Drive, Tucker, GA; 770-939-0157 (fax); amw@amwireless.com (e-mail).

News

RF Micro Devices, Atmel team up for reference designs

RF Micro Devices Inc. has announced a collaboration with Atmel Corporation for the development of reference designs based on the IEEE 802.11b 11 Mbps wireless LAN standard.

The designs use RF Micro Devices' 2.4 GHz chipsets and Atmel's family of Fast-VirtualNet™ ARM®-based Media Access Controllers. The designs include schematics, layout files and Bill of Materials.

RF Micro Devices, based in Greensboro, NC, provides proprietery radio frequency integrated circuits for wireless communications applications. Atmel, headquartered in San Jose, CA, manufactures advanced logic, mixed-signal, nonvolatile memory and RF semiconductors, as well as system-level integration semiconductor solutions.

Anadigics develops pilot assembly line

Anadigics has announced the development of a pilot manufacturing line for multi-chip assembly. Located at the company's 6-inch manufacturing facility, the module manufacturing line is operational for sample and pre-production quantities of highly integrated radio frequency modules.

The development of an in-house module assembly line allows Anadigics to greatly reduce design cycle times and shorten time to market. The assembly line is now developing InGaP HBT power amplifier modules for GSM, CDMA and TDMA standards, as well as advanced cable tuner modules for broadband digital cable systems.

Anadigics, based in Warren, NJ, manufactures radio frequency integrated circuits for broadband and wireless communications markets.

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continued from page 24

bankruptcy proceedings gave Motorola permission to shut down the network.

Motorola had planned to begin the shutdown June 30. A few weeks before that deadline, however, Iridium asked the court to protect the orbiting assets while Iridium continued a search for a buyer.

Castle Harlan Inc., a New York investment concern best known as an "asset stripper" and buyer of last resort, had tentatively agreed to acquire Iridium for $50 million. But on Friday, Castle Harlan decided it wasn't interested, even for that bargain-basement price.

At a hearing in New York Monday, Iridium dropped its effort to have the court block Motorola from liquidating the satellite system. Motorola agreed not to begin the shutdown until at least Aug. 9, to provide Iridium with a sliver of additional time to locate a buyer.

The pending destruction of its principal asset would eliminate any hope of a rebound for the long-troubled Iridium. "Some people are still trying to put together a deal," said Iridium attorney Beury. "We hope that happens." But for now, he said, "We don't have a buyer," and thus "don't have a justification for asking the satellites be continued in operation at someone else's expense."

The satellite-communications venture has been a financial disaster, having burned through nearly $5 billion from investors.

As a piece of engineering, however, the system is a technical triumph. Iridium constructed and put in space 66 satellites and 20 spares.

Combined with Iridium's earth-based facilities, the satellites allowed people to make wireless phone calls from far out at sea, or deep in a jungle. But it turned out that not enough people wanted to make calls from such places.

Motorola initially developed the idea, then invited other investors to help fund the hugely expensive project.

BUSINESS AND FINANCE

Intel to acquire Trillium Digital Systems

Intel Corporation has announced an agreement to acquire privately-held software company Trillium Digital Systems Inc. of Los Angeles, CA. The transaction is valued at approximately $300 million.

Under the agreement, Trillium will become a wholly owned subsidiary of Intel, part of the Network Processing Group. Its communications software will be integrated into Intel's Internet Exchange architecture.

Intel, based in Santa Clara, CA, manufactures chips and other products for computer, networking and communications.

Andrew, Lucent sign amplifier deal

Andrew Corporation and Lucent Technologies Inc. have signed a $23 million letter of agreement under which Andrew will develop and supply single-channel PCS-TDMA linear power amplifiers to Lucent.

Lucent will use the amplifiers in its TDMA PCS Minicell systems solutions., used in wireless networks to increase the efficienty of cellular systems.

Andrew, based in Orland Park, IL, supplies RF components and high power amplifiers for wireless, MMDS and LMDS markets.

Motorola wins network contracts

Motorola Inc. has received several contracts to install or expand wireless networks in Spain, China, Brazil, Japan, and Indonesia and Nigeria. The agreements are worth a combined total of more than $256 million.

• A contract with Telefonica Moviles Espana in Madrid, Spain, calls for nationwide deployment of TETRA infrastructure. The agreement is valued at $12.5 million.

• Under two contracts with China's Tianjin Mobile Communications Corporation and Liaoning Mobile Communications Corporation, Motorola will install a GSM 1800 system in Tianjin and expand a GSM 900 network in Lianong. The combined value of the contracts is $25 million.

• An agreement with Zhejiang Mobile Communications Corporation and China Eastern Communications Company Ltd. covers the deployment of a GSM 1800 network in Zhejiang Province. The contract is worth $53 million.

• A $21 million contract with Intercellular Nigeria Ltd. calls for the expansion of the company's existing CDMA fixed wireless local loop network.

• Two contracts in Brazil, worth a combined $48 million, are designed for the expansion of the cellular network in the state of Sao Paulo. Motorola will provide radio base transponders under one contract and internetworking units under the other.

• A $70 million agreement with Japanese cellular provider TU-KA Cellular Tokyo Inc. calls for the expansion of the existing personal digital cellular system in the Tokyo metropolitan area.

• A contract with Indonesia's Telkomsel covers the expansion of the company's nationwide GSM 900 cellular network. The agreement is worth $27 million.

Motorola, based in Schaumburg, IL, provides semiconductors, integrated communications solutions, embedded electronic systems and components.

P-Com signs access agreement with China PTIC

P-Com Inc. has announced a strategic alliance agreement with China PTIC Information Industry Corporation, a manufacturer of telecommunications infrastructure products. The three-year agreement is worth a total of $120 million.

The contract calls for P-Com to provide PTIC with technical training and support for use of the company's LMDS broadband wireless access services.

P-Com, based in Campbell, CA, manufactures point-to-multipoint, point-to-point and spread spectrum wireless access systems for telecommunications markets.

Texas Instruments acquires Dot Wireless

Texas Instruments Inc. has announced an agreement to acquire Dot Wireless Inc., a third generation CDMA wireless technology company based in San Diego, CA. The transaction is valued at $475 million.

Under the agreement, Dot Wireless will become part of TI's wireless group. TI will aslo establish a wireless technology center in San Diego.

Texas Instruments, based in Dallas, TX, provides digital signal processing and analog technologies, as well as materials, controls and educational and productivity solutions.

PMC-Sierra acquires Datum Telegraphic

PMC-Sierra Inc. has purchased privately-held wireless semiconductor company Datum Telegraphic in a stock transaction. The financial value of the agreement was not disclosed.

PMC-Sierra, located in Burnaby, British Columbia, Canada, is a supplier of broadband communication semiconductors.

Ansoft launches Altra Broadband

Ansoft Corporation has formed a new company, Altra Broadband Inc., focused on the development of intellectual property and products for broadband wireless and optical communications. Altra will develop components and subsystems based on the new Spin Polarized Wave Division technology.

Ansoft, based in Pittsburgh, PA, develops EDA software for wireless communications.

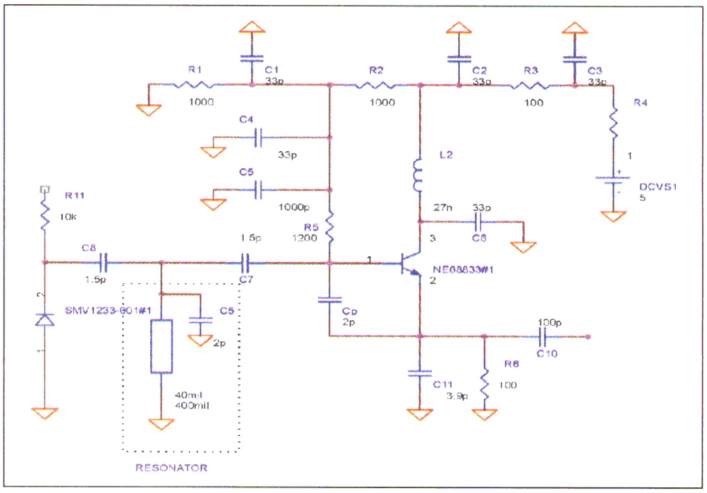
An Ultra Low Cost, Low Phase Noise VCO

A easy-to-manufacture capacitively-loaded microstrip resonating element is the key to this economical design

By Allen Bettner
Wireless Link Corp.

The ability to achieve good phase noise performance is paramount in most wireless design. Performance specifications that require adjacent channel rejection as well as transmitter signal purity are dependent on the phase noise of the receiver local oscillator and/or transmit local oscillator.

Oscillators capable of achieving these goals are becoming more available, but cost is still a factor when integrating off-the-shelf VCOs into any design. This article describes a method of achieving low phase noise at extremely low cost. The heart of the design is a resonating structure that can be employed directly on low cost printed circuit material and easily tuned to the desired frequency in a high volume production environment.



▲ **Figure 1. The resonating structure used in the oscillator keeps cost down while achieving low phase noise performance essential to wireless design.**

Both linear and nonlinear analysis of this oscillator has been accomplished using Xpedion's new simulator, Golden Gate. Using Golden Gate as a design tool, the theory of this design can be understood and the resulting performance ultimately verified with laboratory measurements.

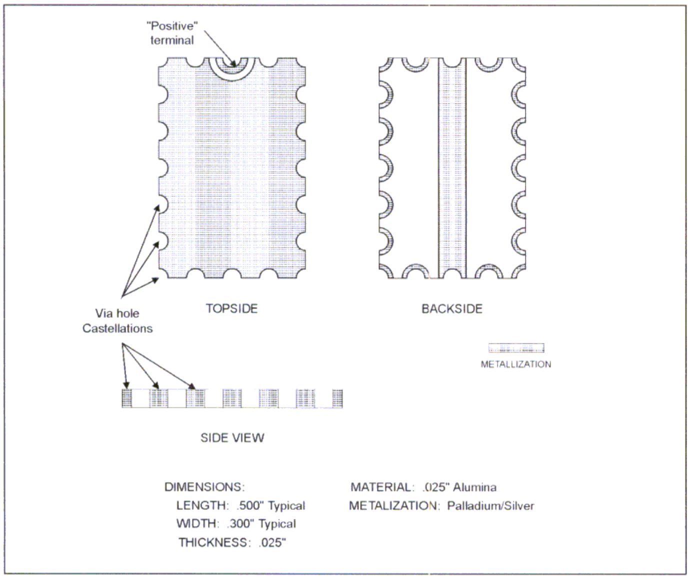
Basis for design

The basis for this design came from conventional VCO designs employing coaxial dielectric resonators, which offer advantages in terms of size, high unloaded Q and precise resonant frequency. However, these resonators are expensive compared to the other passive and active components in a VCO, making overall cost high. In addition, process variations from one VCO lot to another usually require some form of trimming of the resonator to achieve the proper center frequency. This process (grinding or laser trimming) can affect the resonator Q, lowering both phase noise and frequency stability.

Although this VCO uses essentially the same active circuit topology as a conventional VCO, it offers a significant cost advantage. In place of the coaxial resonator, an alternative resonating structure is used. This structure is quite simple, but when embedded properly can provide good performance in phase noise, tunability and frequency stability.

Basic oscillator topology

The basic circuit topology for this oscillator is shown in Figure 1. This configuration employs a grounded collector of the active device (NE68833), creating a negative resistance port



▲ **Figure 2. Illustration of the geometry of the resonator of the low-cost oscillator.**

at the base of Q1. The resonator (dotted area) sees this negative resistance and oscillations occur near its resonant frequency.

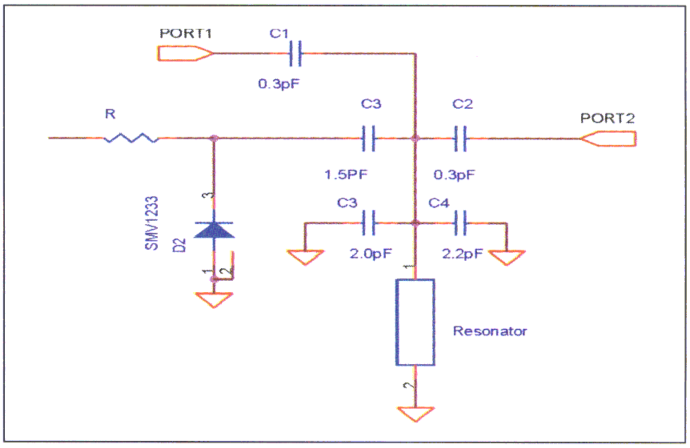
Resonating structure detail

The low cost resonating structure comprises three constituents:

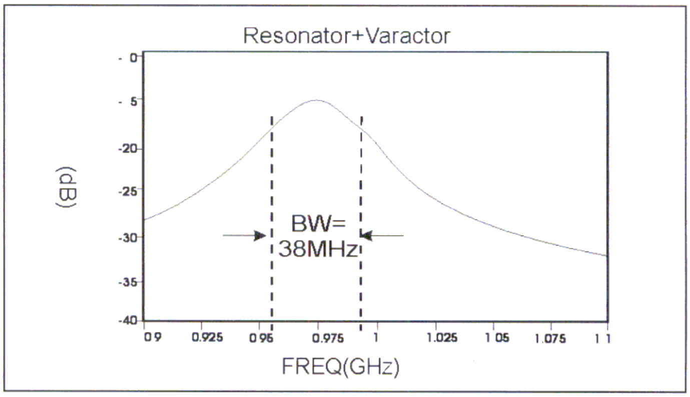
1. A short, low impedance transmission line (microstrip) on the PCB
2. A low cost thick film SMT alumina tuning structure covering the microstrip
3. A high-Q loading capacitor in shunt with the transmission line.

As noted by Rhea [4], the use of a short transmission line and high Q loading capacitor can produce a Q of several hundred, even on low cost FR-4. The unloaded Q of this structure was found to be around 60, the measurements for which will be described.

Figure 2 illustrates the geometry of the resonating structure. The transmission is a conventional microstrip line, in this case approximately 500 mils long and 60 mils wide. This line is fabricated on standard FR-4, in this case 62 mils in thickness. A unique part of the resonating structure is the alumina tuning structure, fabricated on low cost thick film alumina. The structure is designed so that it can be soldered directly on the transmission line to become a tunable element. The entire top of the alumina structure is grounded using a series of via holes along three of the four sides of the tuning slab. Two high Q loading capacitors are mounted directly adjacent to the "hot" end of the transmission line. In this case, a 2.0 pF and 2.2 pF capacitor were used.



▲ **Figure 3a. Loaded *Q* measurement setup of resonator and varactor.**



▲ **Figure 3b. Frequency response of the resonator and varactor using the test circuit shown in Figure 3a.**

The unloaded Q of the resonating structure was calculated using the relationship

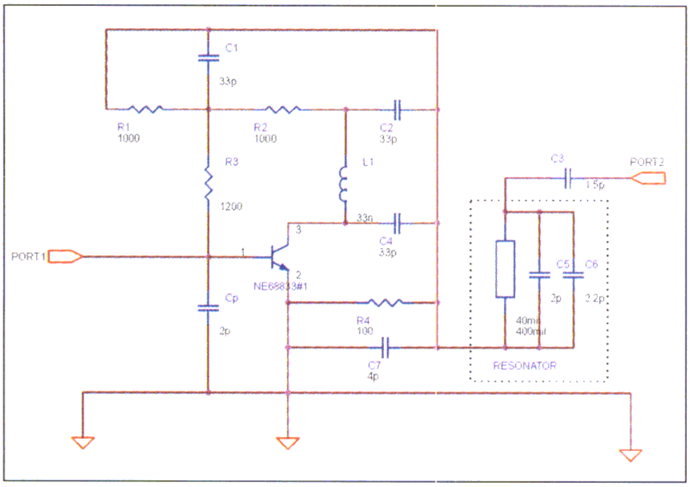
$$IL = -20\log\left(\frac{Q_u - Q_l}{Q_u}\right) \tag{1}$$

which is also from Rhea [4], as well as the fundamental relationship [3]

$$B = \frac{f_0}{Q} \tag{2}$$

The S-parameters of the resonator and the loading capacitors were first measured. The unloaded Q was then found by simulating the following test circuit containing the measured S-parameters of the resonator. By keeping C1 and C2 small, the loading effects of the 50 ohm test ports will be negligible. The unloaded Q will be

$$Q_u = \frac{Q_l}{1 - 10^{\frac{S_{21}}{20}}} \tag{3}$$



▲ **Figure 4. Analysis of circuit for gain and phase to determine potential for oscillation.**

For the resonator alone, the center frequency was found to be 1103 MHz, the 3 dB bandwidth approximately 33 MHz, and the insertion loss 10 dB, resulting in an unloaded Q of 50.27.

With the addition of the tuning varactor (Alpha SMV1233-001) and series coupling cap (1.5 pF) some additional losses are introduced. At 0 volts bias, the center frequency dropped to 975 MHz and the insertion loss of the test network increased to 15 dB. This resulted in an unloaded Q value of approximately 31.2 for the resonator-varactor combination. Figures 3a and 3b show the S_{21} response of the resonator and varactor.

Open loop oscillator analysis

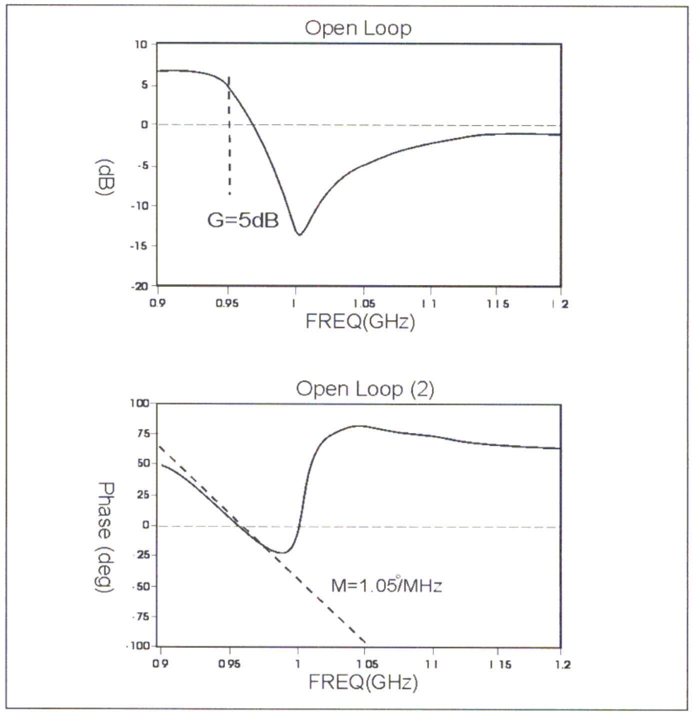
As well known from oscillator theory, two conditions are required to make a feedback system oscillate: the open loop gain must be greater than unity; and total phase shift must be 360 degrees.

Although not obvious, this circuit can be analyzed using this approach by the method of Harada [2]. This can be done by reconfiguring the original circuit to have a virtual ground at the emitter of Q_1, then breaking the connection at the base of Q_1 (the feedback path) to obtain a two port circuit for gain and phase analysis. The resulting circuit is shown in Figure 4. Using the linear S-parameter analysis, we can examine the oscillator's open loop transfer characteristic as a two port.

Figure 5 shows the results of this analysis (gain and phase). The phase crossover (frequency of oscillation) is approximately 960 MHz; at this same point, the open loop gain is approximately 4 dB, indicating potential for oscillation. The loaded Q of this circuit can be found by the relationship

$$Q_l = (\pi f_0/360)\times(d\phi/df) \qquad (4)$$

This can be estimated by taking the slope of the phase



▲ **Figure 5. Results of the analysis of the circuit in Figure 4.**

near the zero crossover, which is approximately 1.05 degrees per MHz at this point. Using Equation 4, the resulting loaded Q for the oscillator is approximately 9.94. It is important to note that the loaded Q for the oscillator is significantly lower than the unloaded Q for the resonator alone (due to losses in the active device). The loaded Q has an important bearing on phase noise, as will be discussed in the next section.

Making the loading capacitor larger will improve the loaded Q for this network, but reduce tunability. For this case, a 2.0 pF and 2.2 pF capacitor in parallel with the resonator was found to give good phase noise plus reasonable tuning bandwidth.

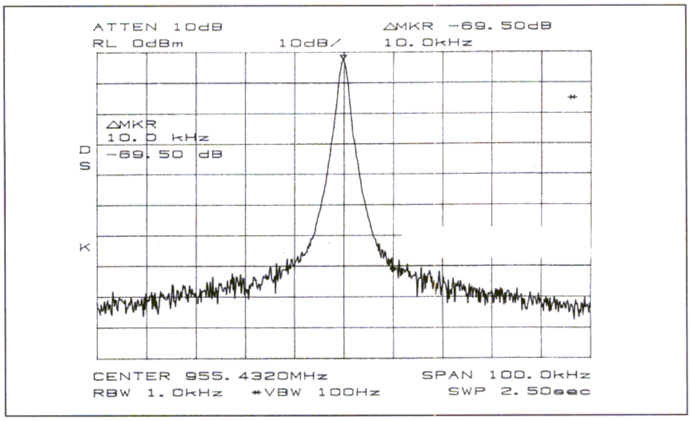
Phase noise prediction

Leeson's equation [6] describes the effect of loaded Q and other parameters on phase noise

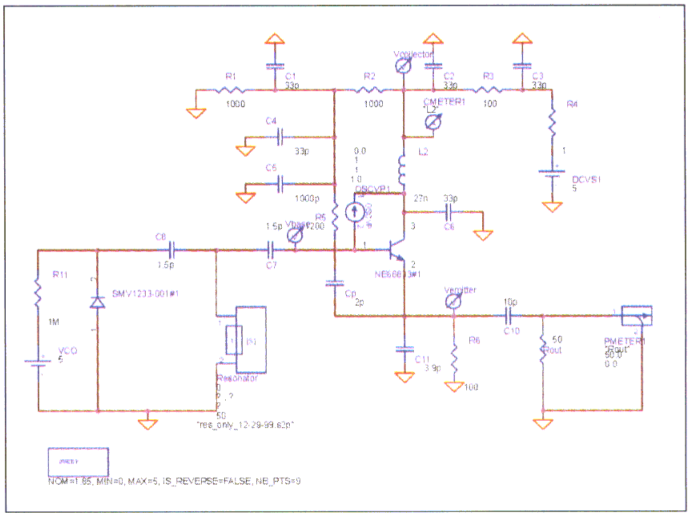
$$L(f_m) = 10\log\left[\frac{1}{2}\left[\left(\frac{f_0}{2Q_l f_m}\right)^2 + 1\right]\left(\frac{f_c}{f_m}+1\right)\left(\frac{FkT}{P_s}\right)\right] \qquad (5)$$

$L(f_m)$ is a measure of the phase noise in dBm/Hz from the carrier. We see that $L(f)$ is proportional to $1/Q_l^2$. Other factors enter the equation, including

1. f_0 — the frequency of oscillation
2. f_c — the flicker noise corner
3. F — the numeric noise figure
4. P_s — the carrier power
5. kT — Boltzmann's constant × temperature (Kelvin)



▲ **Figure 6. The design yields the expected oscillator phase noise response.**



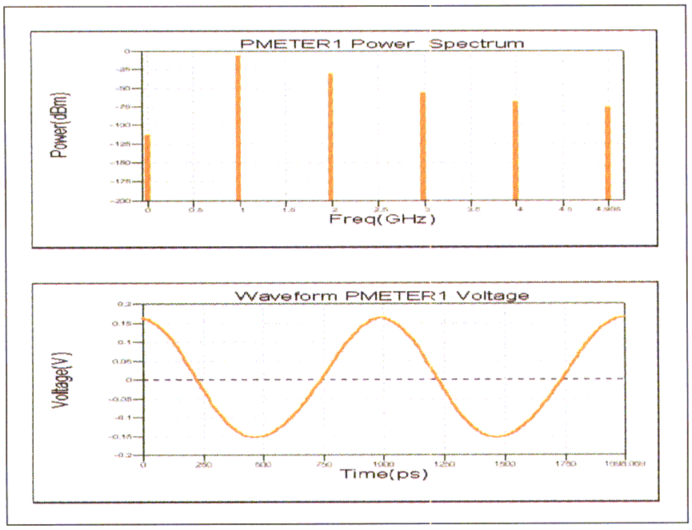
▲ **Figure 7. Xpedion circuit model used for active device and varactor analysis.**

Actual parameters used were

1. f_0 = 950 MHz
2. f_m = 10 kHz
3. Q_l = 9.94 (from above)
4. f_c (flicker noise corner) = 5.8 kHz (from datasheet)
5. F (noise figure) = 1.7 dB (from Xpedion analysis)
6. kT (Boltsmann's constant × temp) = 4.2×10^{-21}
7. P_s (available power) = 1 mW (estimated)

Flicker noise for the NE68833 was estimated using data from a similar device, the NE68819 [1], which has a flicker corner of approximately 5.8 kHz. The noise figure can be simulated using the open loop S-parameter analysis with noise parameters for the device. Using Xpedion's linear noise analysis, this gave a result of 1.75 dB at 950 MHz. P_s was estimated at 1 mW using measured data taken on the actual oscillator.

Inserting these values into Leeson's equation yields a resulting phase noise of –97.7 dBc/Hz at a 10 kHz offset.



▲ **Figure 8. Spectrum and voltage waveforms of oscillator response to linear noise analysis.**

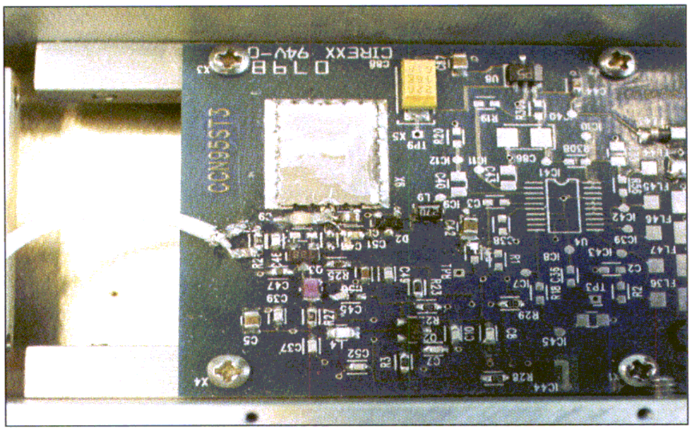
A graph of the actual oscillator response (Figure 6) indicates a phase noise of –98 dBc/Hz at 10 kHz offset, a very good correlation with the predicted result.

Nonlinear analysis

The active device (NE68833) was modeled using Xpedion's Gummel-Poon device. Input parameters for this model were obtained from manufacturer's device data. The varactor was modeled using Xpedion's SMV1233 (Alpha) varactor model operating at a reverse bias of 0 to 5 volts. The complete Xpedion circuit model is shown in Figure 7.

The spectrum and voltage waveform of the analyzed response is shown in Figure 8. Xpedion predicts an output power of –0.8 dBm, which is within 2 dB of the measured laboratory result. Xpedion predicts the first and second harmonics at 25 dBc and 45 dBc respectively. Results from laboratory measurements were 38 dBc and 59 dBc respectively, somewhat better than the simulation predicts.

Varying the varactor voltage in Xpedion produced a



▲ **Figure 9. Photograph of the oscillator as constructed.**

frequency tuning range of 27 MHz. Laboratory results indicated a tuning range of approximately 30 MHz over the same voltage range. In the actual VCO, the center frequency was adjusted by removing thick film metal from the top of the resonating structure using a grinding tool.

Conclusion

A very low cost VCO has been developed using a low cost resonating structure. The use of a short transmission line loaded with a high Q capacitor and thick-film tuning slab produces low phase noise at minimal cost. Xpedion's linear/nonlinear simulator has been used to analyze this device and predict power, harmonics, tuning bandwidth and phase noise. Good correlation between predicted and measured results for frequency, power, phase noise and tuning bandwidth has been obtained. By applying the proper design techniques, this simple structure can replace an expensive coaxial resonator for a multitude of wireless applications. ■

Acknowledgments

The author wishes to acknowledge Itron, Inc. for their support in the development of this oscillator. A patent is pending for this low cost resonator structure. The author wishes to thank Dr. George Vendelin of Vendelin Engineering for his time and support in helping publish this work. The author also wishes to thank Dr. Ravender Goyal of Xpedion Design Systems for his support in providing the software and software models used in developing this oscillator design. The author also wishes to thank the staff at Wireless Link for their support in completing this work including use of their laboratory equipment and assistance in photographs.

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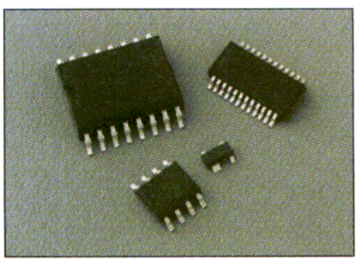

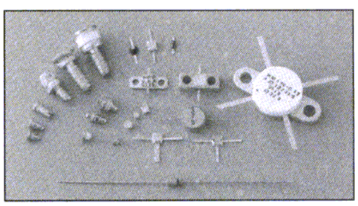

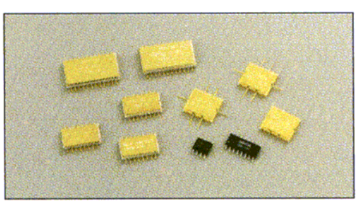

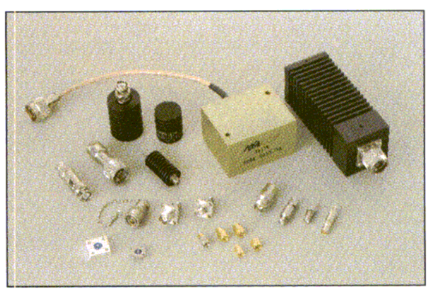

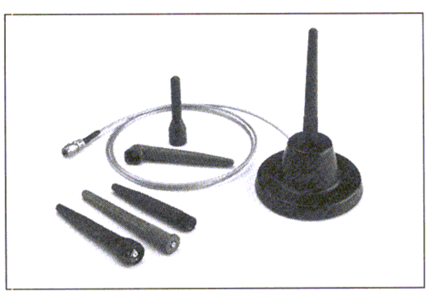

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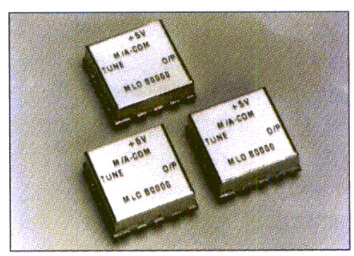

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ranges. The parts come standard with clear, flat cap, color-coded identifiers and TC bonded magnet wire on gold pads. Packaging is on tape and reel.

Frontier Electronics
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Surge arrester gas tubes

CITEL announces a new line of ceramic surge arrester gas tubes, designed to protect telecommunications and data communication equipment against electrical transients due to over-voltages, lightning-related surges, inductive switching or electrostatic discharge. Their high isolation resistance and low leakage current is well-suited for wireless and RF applications. Breakdown voltages are available from 75 kV to 1500 V, with high energy dissipation characteristics from 5 kA to 100 kA. Various sizes are available, provided on tape and reel for automatic assembly. A micro gas tube has also been introduced that is half the size of a regular tube. Two- and three-electrode devices are included in the new series. Pricing ranges from $0.30 to $0.90 each.

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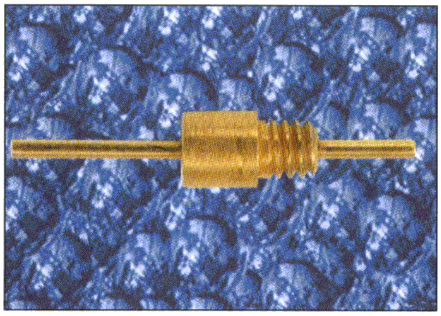
Circle #164

Coaxial EMI filters available in 2-56 bolt style

Sierra-KD Components introduces a series of 2-56 bolt style high-frequency coaxial EMI filters, offered in C-, L-, Pi- and T-sections.

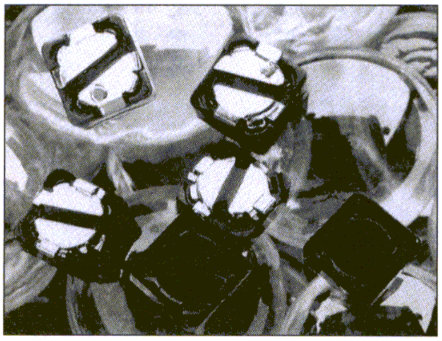


The filters offer EMI suppression from 10 MHz to 10 GHz. The four configurations allow the designer to obtain optimum suppression with various source and load impedances. They are offered with working voltages of 50, 100 and 200 VDC, with minimum capacitance of 10,000 pF to 1,000 pF respectively. In quantities of 1,000, the price is $3 to $5 each, depending on the model.

Sierra-KD Components
Circle #165

Shielded power inductors

Associated Components has introduced two new SHS series of surface mount power inductors. Both new series offer 100 percent ferrite shielding for high-density

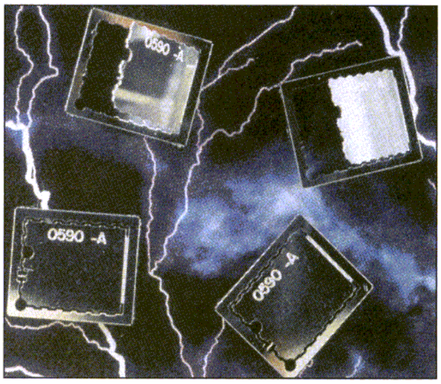


applications. The SHS-705 series includes inductance values from 10 to 1,000 μH with corresponding maximum DCR ranging from 0.05 to 6.0 ohms and maximum DC current from 1,840 to 180 mA. The low profile SHS-703 series has an inductance range of 10 to 1,000 μH with 0.08 to 9.44 ohm maximum DCR and 1,650 to 150 mA DC current.

Associated Components Technology
Circle #166

RF shielding has a removable cover

Photofabrication Engineering recently introduced a line of photochemically etched RF shielding cans with a patented, easy access removable cover. This design allows users to replace or repair internal components quickly and easily without damaging the surrounding shield.



An etched line on the surface is broken to minimize RF leakage. The tab connecting the lid to the RF shield can be easily snipped and resoldered to minimize downtime. The shields are available in brass and 10-10 steel with solder plating. Custom designs can accommodate a wide variety of customer needs.

Photofabrication Engineering, Inc.
Circle #167

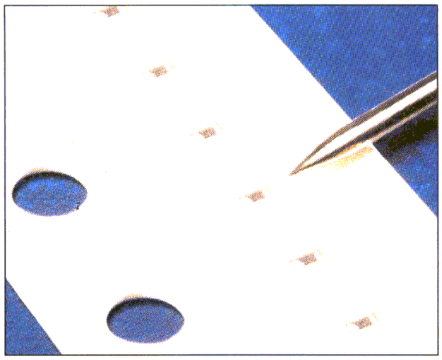
Inductors for CATV, wireless and other applications

Mercatus offers a line of inductors designed in Germany and manufactured in the Far East. Products include standard and custom SMD square coils, solenoid coils, RF transformers, chokes, filters and bobbin cores. SMD components are offered on tape and reel with up to 2,000 pieces per reel. The company also offers coiled wire springs, torsion springs and flat-coil springs.

Marcatus International Marketing
Circle #168

Resistors offered in tiny 0201 size

Kamaya announces a line of 1/20th watt resistors in a 0201 (0.6 × 0.3 mm) package. The resistors are designed for the high-density assembly required for portable devices and hybrid components. The RMC1/20 series has a maximum working voltage of 25 volts and are available in tolerances of F (±1%), G (±2%) or J (±5%). The resistors are packaged on an 8 mm press-pocket carrier with high dimensional accuracy for precise placement. In 100,000-piece production quantities, the resistors are priced at $30 per thousand.



Kamaya, Inc.
Circle #169

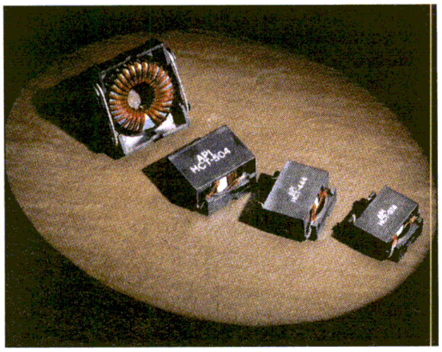
New series of EMI filters

Schaffner EMC has a new line of 26 single-phase chassis mounting RFI noise filters. The new FN series can be applied to a wide range of industrial and commercial systems requiring reduction of RFI emissions. The filters are agency-approved and have terminal blocks and studs configured for standard U.S. panels and mounting chassis. Within the FN series are models intended for general purpose use, plus models optimized for special applications requiring improved differential mode performance, extra filter sections for higher attenuation or low-leakage current. Two filters are available for medical applications. All models are manufactured with UL-rated materials. Pricing starts at $4.50 each.

Schaffner EMC, Inc.
Circle #170

High current inductors

API Delevan announces the Series HCT high current toroidal surface mount power inductors. Package sizes range from 15.6 mm square up to 24 mm square, with all sizes less than 10.2 mm in height. Inductance values range from 1.25 to 29 μH, depending on the size. Rated current is as high as 17.4 A.

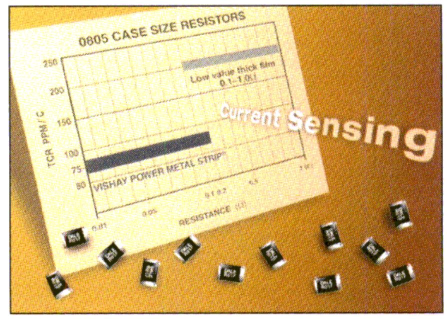


The self-leaded devices use a high temperature rated case that withstands all surface mount assembly processes. A powdered iron core ensures low losses and high saturation currents.

API Delevan
Circle #171

Current-sensing resistors

Vishay has expanded its WSL Power Metal Strip® resistor product line with an 0805 series. The new line provides current sensing in power management applications in wireless products and other



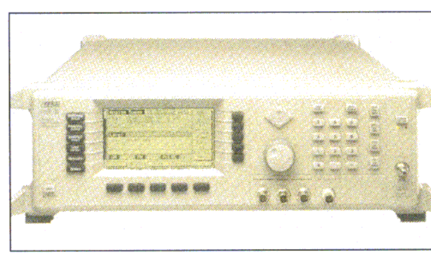
portable or small-size equipment. Resistance values can be as low as 10 milliohm and tolerance can be as tight as 1 percent. A low temperature coefficient of ±75 ppm/°C ensures consistent performance in varying environmental conditions.

Vishay Intertechnology, Inc.
Circle #172

TEST EQUIPMENT

Digital downconverter

Anritsu's family of "El Toro" synthesizers now features a digital downconverter (DDC) that offers ultra-low SSB phase noise performance in the 10 MHz to 2.2 GHz frequency range. The typical performance is –110 dBc/Hz at 10 kHz offset at 10 GHz and –134 dBc/Hz at

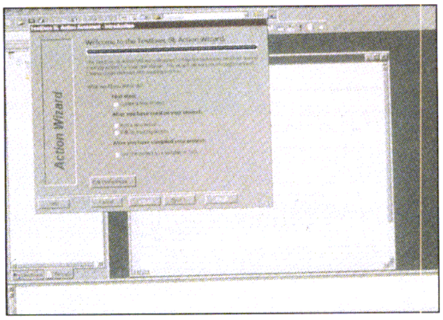


10 kHz offset at 500 MHz. The DDC achieves its performance by reducing carrier phase perturbations with each octave of frequency division and eliminating the non-harmonic signals generated by mixer-based downconverters. The 42 "El Toro" models cover 10 MHz to 65 GHz, with prices starting at $20,450.

Anritsu Company
Circle #173

Modular test software has reusable routines

Agilent Technologies has released Agilent TestExec 4.1, the first version of their test executive software available as a stand-alone product for controlling test system operation and automating test engineering tasks. TestExec SL's modular architecture includes mea-



surement libraries, along with test productivity features such as test sequencing, limit checking, data logging and export, plus ready-to-use operator interfaces. Users can develop, save and reuse their own routines. The test software operates on Windows® NT and 2000 and supports the programming languages of Visual Basic, C/C++, Agilent VEE Pro and National Instruments LabVIEW. Version 4.1 of the TestExec SL development kit is priced at $2,800. The run-time only version is $500.

Agilent Technologies Inc.
Circle #174

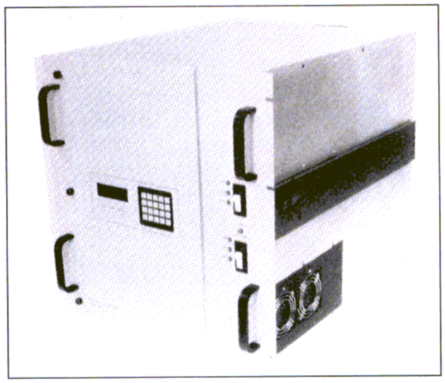
Modular digital test platform for Project 25

IFR Systems announces the 2975 digital radio test platform for Project 25 Phase I radios, repeaters and base stations. The system provides testing for C4FM, interoperability, voice testing and Type III encryption testing. Analog testing capabilities will soon be added. Testing is done with independent generate and receive functions from 1 MHz to 2.7 GHz. Project 25 is a joint effort of federal, state and local governments.

IFR Systems
Circle #175

200 MHz switching matrix

Matrix Systems offers a new 128 × 128 IF switching matrix covering the important IF bands of 70 ±20 MHz and 140 ±40 MHz. Features include a 3-stage architecture with auto routing, high isolation of 60 dB at 200 MHz, low crosstalk, solid



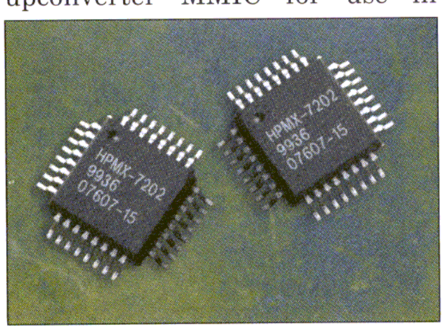
state switching, redundant switching and signal paths, and full operation and programmability via keypad or RS-232/IEEE-488 interface. The matrix enables testing of communications equipment or routing of IF signals among many signal sources, detectors or measuring devices in communications systems.

Matrix Systems Corporation
Circle #176

SEMICONDUCTORS

Upconverter MMIC for mobile phone handsets

Agilent Technologies, Inc. has announced the release of the HPMX-7202, a dual-band, tri-mode upconverter MMIC for use in

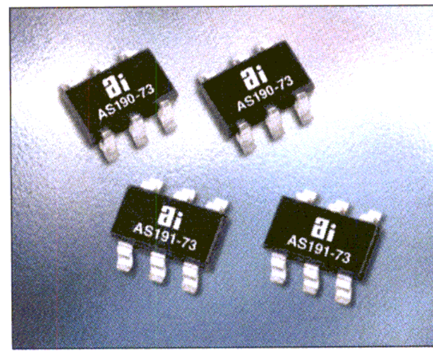


mobile phone handsets that operate with 800 MHz and 1900 MHz CDMA and conventional AMPS services. This MMIC provides ACPR of –58 dBc/30 kHz for PCS, and –55 dBc/30 kHz for CDMA cellular. The HPMX-7202 also helps reduce current consumption and extend battery life.

Agilent Technologies Inc.
Circle #177

High linearity SPDT switch

Alpha Industries introduces the AS191-73, a new PHEMT GaAs FET IC high linearity SPDT switch. This transmit/receive switch fea-



tures +2.5 to +5 V linear operation at input power levels greater than +35 dBm. The AS191-73 can be used in many analog and digital wireless communication systems. The switch is priced at $1.05 each in quantities of 50,000.

Alpha Industries
Circle #178

2.5 GHz LDMOS RF power transistor

Ericsson Microelectronics has

released the first in a line of 2.5 GHz LDMOS products for 3G and other wireless systems. The PTF102006 is a 25 W ($P_{1\ dB}$) 11 dB gain device with a drain-source breakdown voltage of 65 V and a load mismatch tolerance of 10 to 1. To ensure greater reliability and

NEW PRODUCTS NO. 73

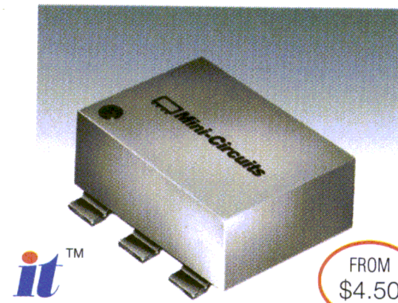
RF/IF MICROWAVE COMPONENTS

80 TO 2500MHz LEVEL 17 (LO) MIXERS HAVE HIGH IP3

Mini-Circuits has started shipment of their new SYM-25DHW frequency mixers for 80 to 2500MHz wireless designs. At center band, these versatile 200mW (max.) components typically display low 6.4dB conversion loss, high 37dB L-R, 36dB L-I isolation, and high 30dBm IP3. Applications include PCN, ISM, and cellular. A 5 year Ultra-Rel® guarantee is included.

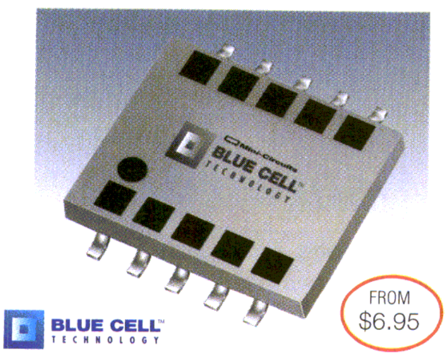
5W TYPE-N ATTENUATORS FOR DC TO 18GHz

Mini-Circuits BW-N10W5 precision fixed attenuators provide 10dB nominal attenuation with ±0.60dB accuracy (add 0.5dB typ above 12.4GHz) over the broad DC to 18GHz band. These low cost stainless steel units are built tough to handle 5W average with 125W peak power and exhibit high temperature stability, outstanding phase linearity, and excellent VSWR. Additional values between 1 and 40dB are also available, as well as 2 and 5W SMA designs. Available off-the-shelf.



.06 TO 300MHz TRANSFORMER PROVIDES 4:1 IMPEDANCE RATIO

Standing only 0.206 inches high, Mini-Circuits low profile ADT4-6T transformer provides 4:1 impedance ratio in the .06 to 300MHz band and is ideal for balanced amplifiers and impedance matching. When operated in the -20°C to +85°C temperature range, return loss is excellent at 24dB typical in 1dB bandwidth. Referenced to midband loss (0.3dB typ), maximum insertion loss is 1dB in the 0.15 to 200MHz range, 2dB .08 to 250MHz, and 3dB band wide. Patent pending.

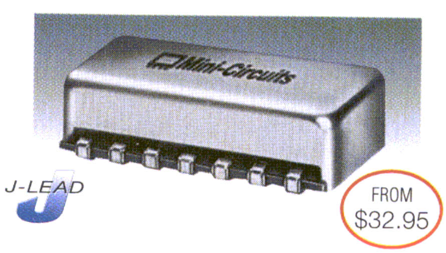


800 TO 900MHz 90° HYBRID SPLITS SIGNAL 2WAYS

A patented 2way-90° power splitter for cellular applications has been developed by Mini-Circuits. Outstanding characteristics of the QBA-12N typically include high 28dB isolation, low 0.25dB insertion loss (avg. of coupled outputs less 3dB), and high 50W power capability (as a splitter). These Blue Cell™ hybrids are housed in a low profile .050" ceramic package providing good heat dissipation and incorporate solder plated leads for excellent solderability. Available from stock.

180° VOLTAGE VARIABLE PHASE SHIFTER FOR 700 TO 1000MHz

The JSPHS-1000 from Mini-Circuits is a 180° (min.) voltage variable phase shifter used for cellular applications in the 700 to 1000MHz band. Important characteristics of this surface mount unit include 0 to 15V control voltage with typical control bandwidth ranging from DC to 50kHz and low 1.2dB (typ) insertion loss. VSWR is good at 1.2:1 typical. Solder plated J leads provide superior mechanical integrity over temperature.



5V VCO HAS 1060 TO 1121MHz LINEAR TUNING AND LOW NOISE

Mini-Circuits ROS-1121V voltage controlled oscillator performs in the 1060 to 1121MHz band from a 5V power supply (30mA max. current) targeting radio applications with low -111dBc/Hz SSB phase noise typical at 10kHz offset, 3dB modulation bandwidth typical at 10000kHz, and low 8-13MHz/V (typ) tuning sensitivity. Typical power output is 2.5dBm. Housed in a miniature 0.5"x0.5"x0.18" industry standard package and value priced.

Mini-Circuits®

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ISO 9001 CERTIFIED

F 326 Rev. Org.

longer lifetime, the PTF102006 is manufactured with all-gold metalization, ion implantation and surface passivation.

Ericsson Microelectronics
Circle #179

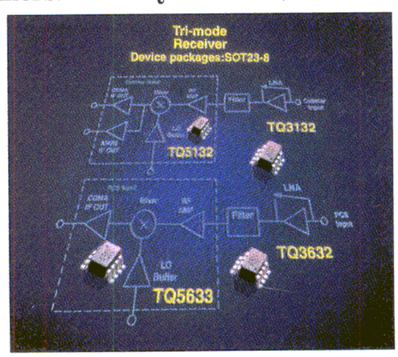
Bluetooth transceiver

RF Micro Devices announces the release of a series of Bluetooth transceiver chips and modules beginning with the RF2968, a transceiver for Bluetoooth applications. The RF2968 offers 1 Mbps data rates and requires minimal external passive components to complete the transceiver solution. With a receive sensitivity of –80 dBm and transmit power up to +4 dBm, the part is designed for Class 2 systems. High volume manufacturing and test capability allows RFMD to sell the RF2968 at low cost to the consumer.

RF Micro Devices, Inc.
Circle #180

Downconvert mixer-amplifiers RFICs for CDMA cell phone applications

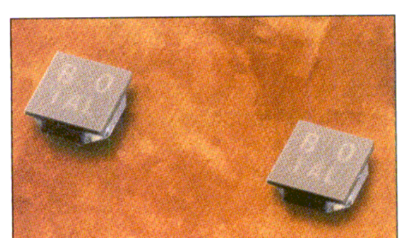
TriQuint Semiconductor offers a new pair of RFIC CDMA downconvert mixers. The TQ5132 RFA/Mixer is designed for Cellular band CDMA/AMPS receive applications, and the TQ5633 RFA/Mixer is designed for PCS band CDMA receive applications. Both are meant for use with multiple TriQuint LNA ICs, and when used together, provide tri-mode operation in the 800 MHz and 1900 MHz bands. When used at 110 MHz for both cellular and PCS bands, the IF filter can be eliminated, reducing production costs. The TQ132 CDMA/AMPS RF IC and the TQ5633 CDMA PCS RF IC are both priced at $1.09 each in 1,000 piece quantities.



TriQuint Semiconductor
Circle #181

Low-noise HEMT

As an addition to its low-noise HEMT family, Mitsubishi Electronics has developed the MGF4953A and MGF4954A, which both boost gain by 1.5 dB at frequencies through K band. The MGF4953A targets the first stage of low-noise amplifier applications with

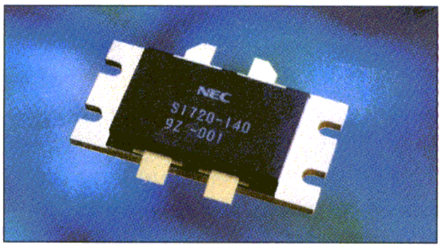


its 13.5 dB typical associated gain and .40 dB typical noise figure at 12 GHz. The MGF4954A targets the second and following stages, with the same 13.5 dB typical associated gain, but a slightly relaxed noise figure of 0.60 dB. The MGF4953A and MGF4954A low-noise HEMTs are now in volume production, with pricing at $2 each and $1.60 each, respectively, in quantitites of at least 5,000 units.

Mitsubishi Electronics America, Inc.
Circle #182

Twin transistor MESFET

California Eastern Laboratories has introduced the NES1720P-140, a partially matched, twin transistor

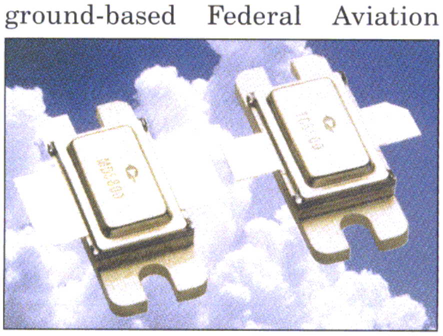


L-Band GaAs MESFET for applications in the output stage of power amplifiers. The transistor delivers 140 watts of output power as well as 200 MHz of instantaneous bandwidth, enabling it to serve 1.7, 1.8 and 1.9 GHz applications simultaneously. In quantities of 100, the price is $215 each.

California Eastern Laboratories
Circle #183

Bipolar transistors for next-generation avionics

GHz Technology has introduced two new bipolar transistors. The MDS 800 is in final prototype design for a next-generation, ground-based Federal Aviation

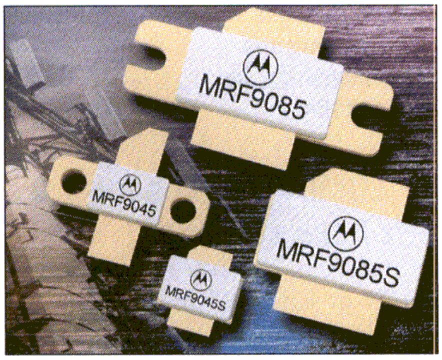


Administration route surveillance radar, slated for production early next year. Expected to enter production in 2002, the TCS 800 is in final prototype design for commercial transponder use in next-generation, long-range international collision avoidance systems. Both components are 800-watt, 50-volt high-power common base bipolar transistors, providing the highest power output in their respective commercial applications.

GHz Technology, Inc.
Circle #184

RF LDMOS devices for 1.0 GHz base stations

Motorola has introduced a new family of RF LDMOS devices optimized for 1.0 GHz base station



applications. The family's first member, MRF9085/MRF9085S, is a 90-watt, single-ended device characterized at frequencies in the 865 to 895 MHz band. It is intended for use in Class AB for 26 Volt base station equipment. The suggested resale price is $75 each per 10,000 quantity.

Motorola, Inc.
Circle #185

LITERATURE

RF connector catalog

Tru-Connector offers an updated catalog featuring a wide range of RF coaxial connectors, adapters and custom-designed cable assemblies.

The catalog highlights quick-disconnect connectors that correspond to LC, C, SC, BNC and TNC types. These types offer quick-change convenience for sputtering and wafer processing, as well as for wattmeters and other test and monitoring equipment temporarily placed in line. Also include is an overview of military connectors from UG-18/U through UG-1900/U.

Tru-Connector Corporation
Circle #186

Non-inductive resistors

A new brochure from Kanthal Globar describes the Series 500SP non-inductive bulk ceramic slab

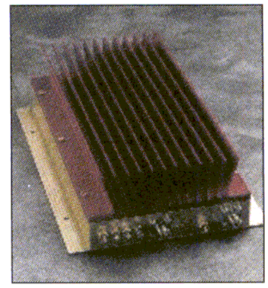
resistors. The catalog includes complete specifications and detailed drawings. Series 500SP models provide high power and energy dissipation in a compact size, offering 15 watts per inch of length and excellent pulse/overload capability. Resistance values range from 0.2 to 600 ohms in various terminations.

Kanthal Globar
Circle #187

AMPLIFIERS

Linear power amplifier for MMDS/WLL

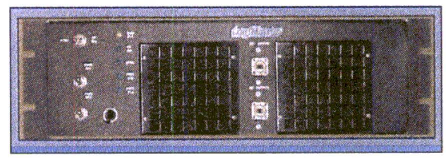
Stealth Microwave announces Model SM2527-42, a power amplifier providing 16 watts P_{1dB} and an output intercept point of +53 dBm, or +60 dBm with Model SM2527-41L. Both units operate from a +12 VDC supply and feature built-in isolators, voltage protection, thermal protection and logic on/off. Options include forward/reverse power detection and RF sampling.



Stealth Microwave
Circle #188

TWT amplifier

The LogiMetrics PA500/K/Ka is a CW traveling wave tube amplifier



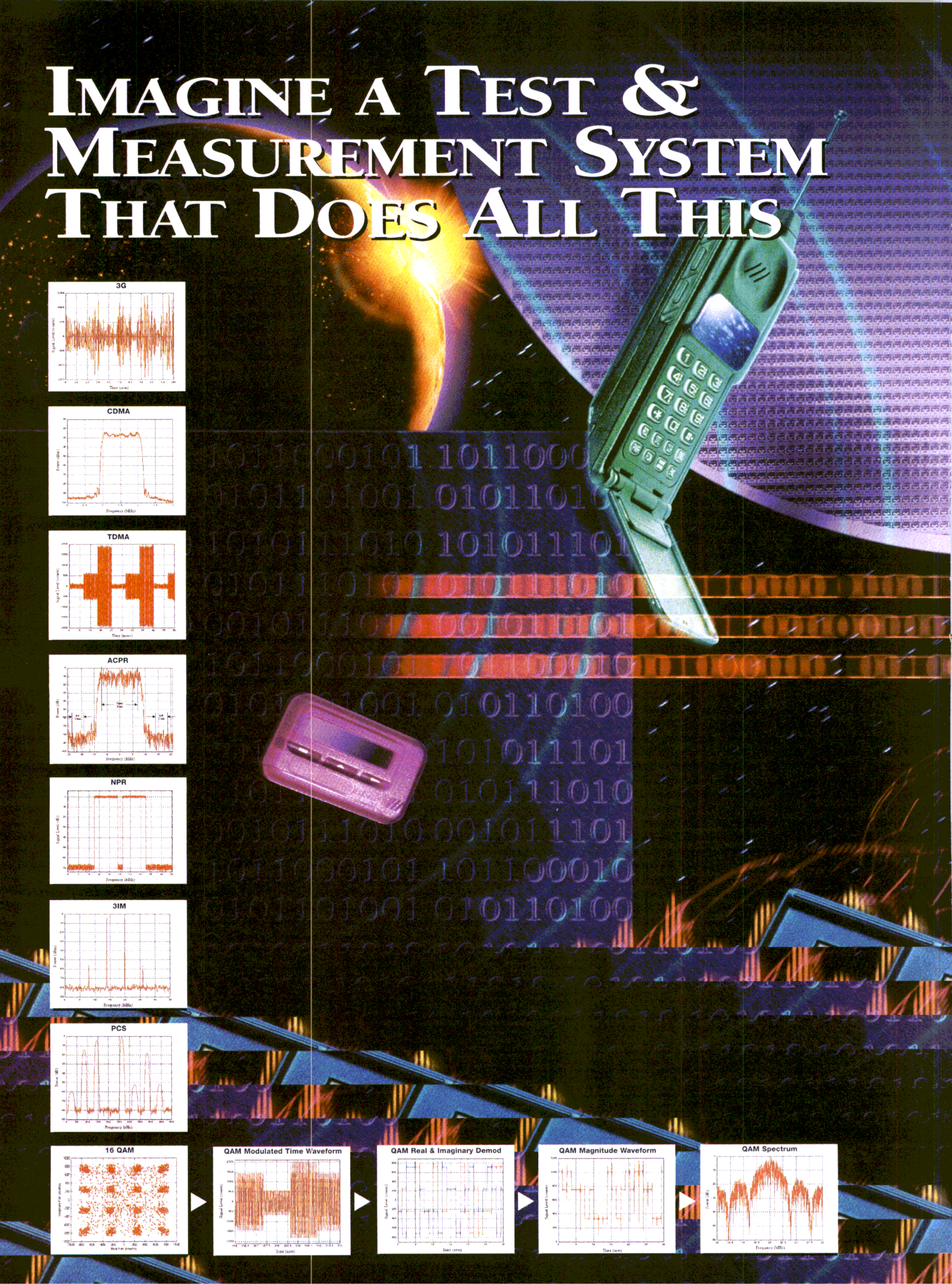
for K- and Ka-band operation. Three models provide 40 watts output in the 18.0 to 26.5 GHz and 26.5 to 40 GHz bands, or 120 watts from 27.5 to 30.0 GHz. All units provide 35 dB gain for various testing, communications and EW applications.

LogiMetrics
Circle #189

915 MHz magnetron delivers 60 kW

The Istok IMG-915-60KB magnetron is a fixed-tuned 915 MHz electromagnet-focused CW device providing 60 kW output in industrial applications. It is compatible with Western 30, 50 and 60 kW magnetrons and mounts in typical solenoids, waveguide transitions and launchers.

Istok Microwave
Circle #190



IMAGINE A TEST & MEASUREMENT SYSTEM THAT DOES ALL THIS
3G
CDMA
TDMA
ACPR
NPR
3IM
PCS
16 QAM
QAM Modulated Time Waveform
QAM Real & Imaginary Demod
QAM Magnitude Waveform
QAM Spectrum

Ceramic Bandpass Filters — Boon or Bane?

By Richard M. Kurzrok, P.E.
RMK Consultants

In recent years, the electronics industry has seen important technological advances superimposed upon an emerging commercial market place. The ceramic bandpass filter has become a reality and has found its niche in wireless communications equipment. This new version of coaxial bandpass filters has become feasible due to the miracle of new ceramic materials. They provide high dielectric constants, low loss tangents and markedly improved temperature stability. The ceramic bandpass filter has achieved dramatic unit cost reduction via a new and novel manufacturing process.

In this tutorial article, some of the basic capabilities and limitations of ceramic bandpass filters will be discussed.

Filter capabilities

Bandpass filter insertion loss, due to dissipation, can be computed readily [1]:

$$L = 4.343(Q_T/Q_{UL}) \times \text{sum of } g \text{ values from 1 to } n \quad (1)$$

where

L = filter insertion loss, due to dissipation, at the filter center frequency in dB.
Q_T = filter total Q
= filter center frequency/filter normalizing bandwidth
Q_{UL} = resonator overall unloaded Q
g values refer to normalized circuit elements from the low pass prototype
n = number of resonators or poles

The low pass prototype can be normalized to a ripple bandwidth, a 3 dB bandwidth, or some other selected bandwidth. The filter insertion loss is inversely proportional to the resonator unloaded Q.

The ceramic bandpass filter usually uses quarter-wave coaxial resonators in a combline configuration in which adjacent resonators have common short-circuit and open-circuit reference planes. Each resonator is fabricated by a metallization process in which copper conductors are deposited on a high dielectric constant ceramic. Conductor thickness should be greater than three skin depths. By using nominal 90-degree resonators, unloaded Q degradation due to resonator foreshortening is not encountered, as shown in Table 1.

Typical ceramic resonator dielectric constants of 20 to 90 have resulted in resonator physical lengths reduced by a factor of 4.473 to 9.487. Resonator cross sections use square outer conductors with rounded corners, along with round inner conductors. Typical outer conductor sizes range from 12 millimeters down to 2 millimeters. Resonator quality is quantified by overall unloaded Q [1].

$$Q_{UL} = 1/Q_C \text{ plus } 1/Q_D \quad (2)$$

where Q_C is the conductor unloaded Q and Q_D is the dielectric unloaded Q (the reciprocal of loss tangent).

Conductor unloaded Q is primarily a function of resonator size (cross section), metallic conductivity and metallic surface finish. For a conductor unloaded Q of 1,000 and a dielectric unloaded Q of 10,000 (loss tangent = 0.0001), the overall unloaded Q is reduced from 1,000 to 909.1 This illustrates the rather modest degradation of overall resonator unloaded Q due to the loss tangent of the ceramic resonator dielectric.

Two or more ceramic resonators are cascaded to form a direct coupled multi-resonator bandpass filter. Capacitive input, output and interstage couplings are used similar to a top-CLC lumped element bandpass filter. A simplified filter schematic is shown in Figure 1. Each individual resonator is affected by reactive loading from adjacent couplings and open-ended capacitive fringing. Resonator center frequencies are factory adjusted to a specified center frequency. This is achieved by trimming of metallization and solder modification of the short circuit reference planes.

The high dielectric constant ceramics reduce the res-

Resonator Length (degrees)	Unloaded Q Degradation
30	0.25
45	0.5
60	0.75
90	1.0

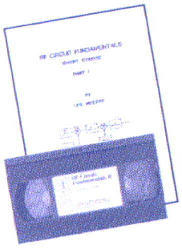
▲ **Table 1. Unloaded Q degradation for combline resonators of different lengths.**

THE POWER OF INFORMATION

Video Training Courses

RF Circuit Fundamentals
Instructor: Les Besser

An introduction to high-frequency analog design for new engineers, or for engineers from digital or low-frequency specialties. This class offers thorough coverage of all the basic concepts specific to RF engineering.



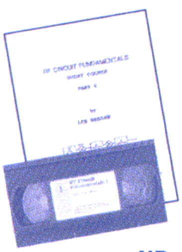
- RF Concepts
- Lumped-Element Component Methods
- Resonant Circuit and Filters
- Transmission Line Fundamentals
- The Smith Chart and its Applications
- Small-Signal Amplifier Design with S Parameters

Includes six one-hour tapes, class notes, and the book *RF Circuit Design* by Chris Bowick.

NP-16 . . . . $595.00

RF Circuit Fundamentals II
Instructor: Les Besser

Instruction continues from the above course, adding;



- Microstrip Transmission Lines
- Power Combiners and Dividers
- Broadband Match-ing Networks
- PIN Diode Circuits
- Broadband Amplifiers
- Large-Signal Amplifiers.

Includes six one-hour tapes, notes, and the book *Transmission Line Transformers* by Jerry Sevick.

NP-17 . . . . $595.00

Microwave Filters, Couplers and Matching Networks
Instructor: Robert Wenzel

Detailed instruction on distributed structures;

- FIlter Responses and Basic Calculations
- Realization of Practical Filters
- Filter Design
- Directional Couplers
- Distributed Element Matching Networks

Includes Six two-hour tapes and the complete class notes.

NP-15 . . . .$1195.00

Microwave Transmission Lines and Their Physical Realization
Instructor: Steven L. March

Six hours of transmission line education on striplines, microstrip, coupled lines, suspended substrates, coplanar waveguide,and more.

NP-18 . . . . $595.00

RF/Microwave Transistor Amplifier Design
Instructor: Les Besser

Amplifier design is covered completely, including CAD and Smith Chart methods, gain and stability analysis, low noise techniques and layout. Real-life examples are used throughout the course.

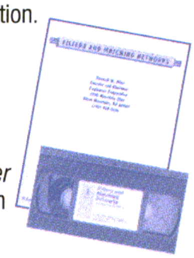
- Introduction to CAD
- Impedance Matching
- Lossless Transformations
- Applying Negative Feedback
- Classical amplifier techniques
- Review of Circuit Fundamentals
- Amplifier Design Methods and Comparisons

Includes six two-hour tapes and the book *Microwave Transistor Amplifiers* by G. Gonzales.

NP-14. . . . . $1195.00

Filter and Matching Networks
Instructor: Randall W. Rhea

Information on practical filters and matching networks that you will actually build, not just theory and equations with no application.



- Field-Coupled Microwave Filters
- CAE Techniques
- Real-World Effects
- Matching
- Direct-Coupled Microwave Filters
- Group Delay
- Bandpass Filter Symmetry

Includes the book *HF Filter Design and Computer Simulation* by Randall Rhea and nine one-hour tapes with complete notes.

NP-12. . . . . $895.00

Oscillator Design Principles
Instructor: Randall W. Rhea

No other course gives you as much insight into oscillator design. All common resonator types are discussed — LC, coaxial, microstrip, crystal, SAW; and many active devices — bipolar, FET, MMIC amplifier. Noise performance, oscillator starting, VCOs.

Includes the book *Oscillator Design and Computer Simulation* by Randall Rhea, plus the six-hour course with extensive notes.

NP-13. . . . . $595.00

Introduction to the Smith Chart
Instructor: Glenn Parker

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NP-19. . . . . $99.00

PAL Video format available upon request.

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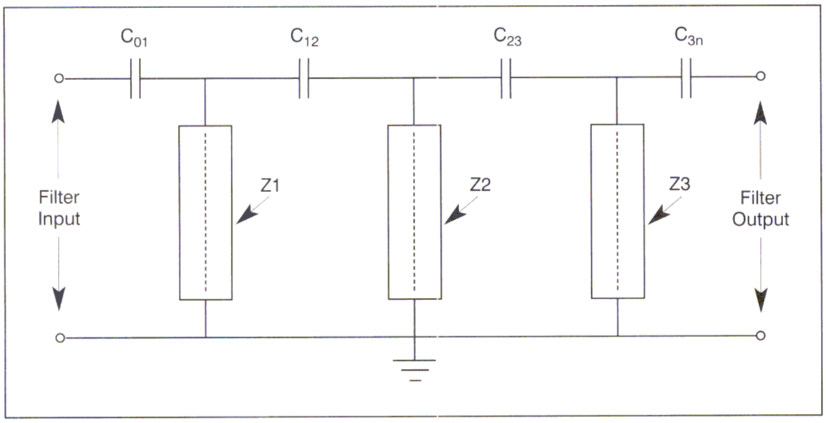

▲ **Figure 1. Simplified schematic for a three pole ceramic bandpass filter.**

onator operating impedances. Typical resonator impedance levels are 5 to 15 ohms. For a resonator (neglecting rounded corners), impedance is given by [2]:

$$Z_0 = \left[\frac{60}{\sqrt{\varepsilon_r}}\right] \ln\left(1.0787\frac{D}{d}\right), \quad \text{for } \frac{D}{d} > 0.9 \qquad (3)$$

where

Z_0 = characteristic impedance of the resonator in ohms
ε_r = ceramic dielectric constant
D = side of square outer conductor in inches
d = diameter of round inner conductor in inches

Ceramic bandpass filters have typical bandwidths of 1 to 5 percent. Center frequency tolerances are usually plus or minus 0.2 percent to plus or minus 1 percent. The temperature stable ceramic bandpass filters have thermal sensitivities less than 5 ppm/degree C. This is substantially better than air dielectric combline bandpass filters using milled block construction.

Ceramic bandpass filters achieve cost savings by avoiding coaxial input and output connectors. Input and output filter interfaces include flat pack surface mount, printed circuit board surface mount and through-hole pins for drop in printed circuit board mounting. Diligent solder techniques are needed when mounting ceramic bandpass filters on the next higher assembly. Proximity of ceramic bandpass filters to adjacent units must be examined to avoid spurious couplings to filter input/output and locations where resonator metallizations have been removed.

Dielectric Constant ε_r	TE_{11} Mode Cutoff Frequency (GHz)
1	15.02
20	3.359
37	2.469
90	1.583

▲ **Table 2. TE_{11} mode cutoff frequency for selected values of resonator dielectric constant.**

Filter limitations

Commercially available ceramic bandpass filter specifications usually do not include some specifications provided with other coaxial bandpass filters:

- A central usable passband
- Passband amplitude response
- Passband return loss (VSWR) response
- Location of filter spurious passbands
- Filter average and peak power handling

A ceramic bandpass filter with input and output VSWRs of 2.0 (return loss of 9.54 dB) has a reflection loss of 0.51 dB. Overall filter insertion loss includes both the reflection loss and the previously cited dissipation loss due to resonator finite overall unloaded Qs. If source and load VSWRs are also 2.0, a worst case multiplication of VSWRs could result in an overall VSWR of 8.0. This corresponds to an overall reflection loss of 4.03 dB, which is not necessarily trivial.

All coaxial bandpass filters have an upper frequency limit where unique dominant (TEM) mode operation no longer exists. The TE_{11} circumferential mode is the first higher mode for coaxial lines. Assuming ceramic resonator square outer conductor dimension D is replaced by a round outer conductor with diameter D, the higher mode cutoff frequency can be readily computed by [2]:

$$F = \left(\frac{7.51}{\sqrt{\varepsilon_r}}\right)\left(\frac{1}{D+d}\right) \qquad (4)$$

where $F = TE_{11}$ mode cutoff frequency in GHz.

Assuming D = 0.375 inch and d = 0.125 inch, then equation (4) becomes:

$$F = \left(\frac{15.02}{\sqrt{\varepsilon_r}}\right)$$

Letting ε_r = selected values, F is shown in Table 2.

For a ceramic bandpass filter operating at 5 GHz and a dielectric constant of 20, resonator cross section dimensions must be reduced to raise the TE_{11} mode cutoff frequency past the upper limit of the filter stopband. This size reduction is accompanied by a corresponding decrease in conductor unloaded Q and increase in filter insertion loss at the center frequency.

It should also be noted that nominal 90-degree (quarter-wave) ceramic resonators will have a first TEM spurious passband at three times the filter center frequen-

cy when the resonator electrical length is 270 degrees. Air dielectric foreshortened 45-degree combline resonators will have their first TEM spurious passband at six times the filter center frequency.

Capacitive couplings in ceramic bandpass filters are quite frequency sensitive and provide sharper selectivity below resonance than above resonance. Ceramic bandpass filters are not field tunable to a different center frequency. They are factory trimmed to a fixed center frequency and must be replaced by a different filter upon change of center frequency. Ceramic bandpass filters are not field repairable and are throw-away components when they fail. Air dielectric combline bandpass filters can be designed for field tunability and repairability. They also can provide larger percentage bandwidths than ceramic bandpass filters.

The future

Ultimate low cost bandpass filter design will certainly use active filters. This is compatible with integration at the overall system level. Of course, production volume must be sufficient to justify the nonrecurring costs. Implementation will probably start at lower UHF before moving up to microwave frequencies. Sometime in the future, ceramic bandpass filter replacement could begin. Until then, ceramic bandpass filters are here to stay.

Conclusions

Ceramic bandpass filters provide an adequate low cost solution to the needs of wireless communications and related equipment. This is enhanced by important advances in miniaturization and thermal stability. The limitations of ceramic bandpass filters must be carefully scrutinized before attempting to use them in applications with more stringent transmission requirements, such as high speed digital data and video. ■

References

1. G.L. Matthaei, L. Young and E.M.T. Jones, *Microwave Filters, Impedance Matching Networks, and Coupling Structures*, McGraw-Hill, 1964, pp. 154, 166.

2. R. Rhea, *HF Filter Design and Computer Simulation*, Noble Publishing, 1994, pp. 83, 94.

Author information

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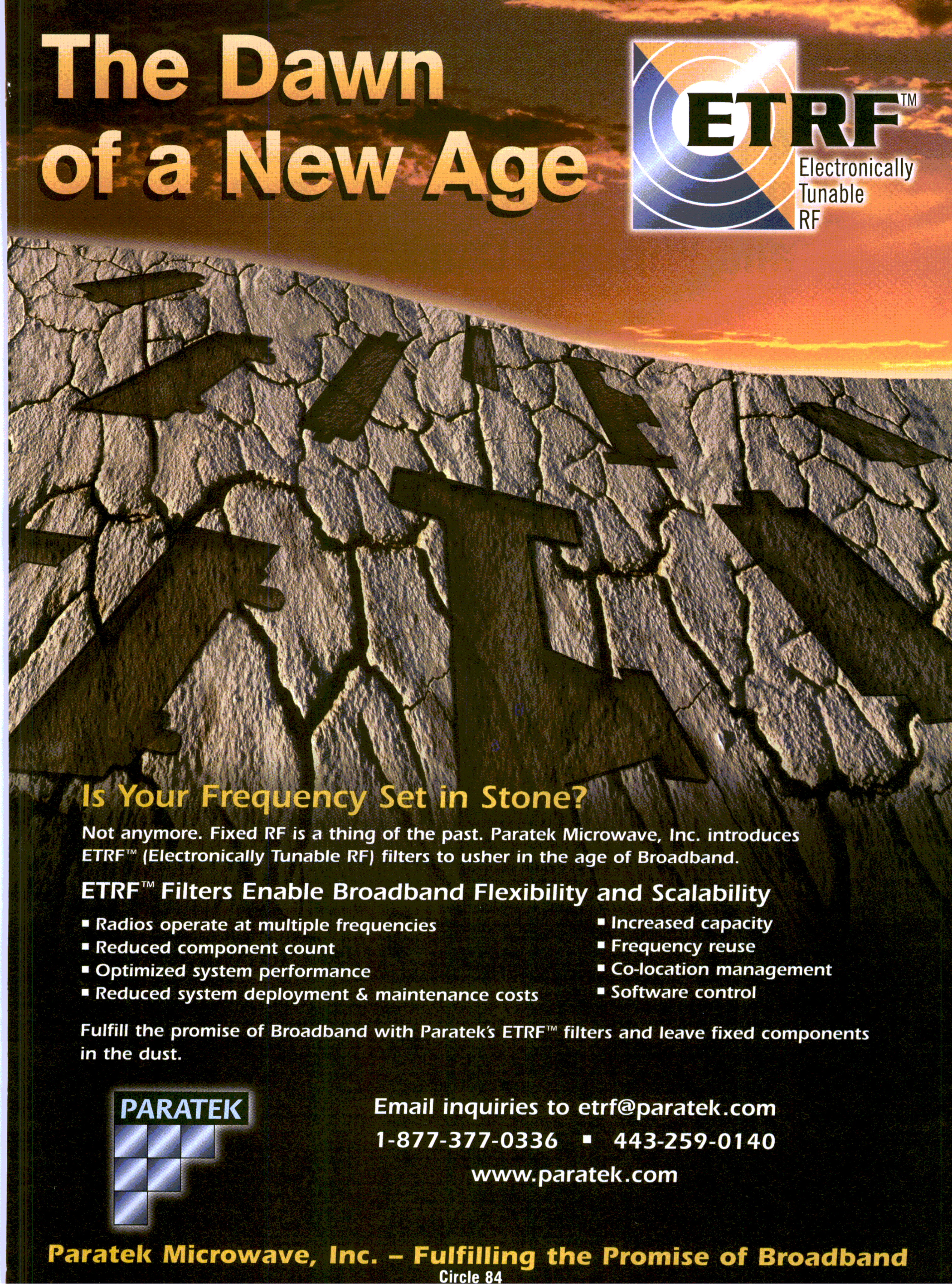
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Circle 84

A Preview of the Technical Program — 2000 IEEE Radio and Wireless Conference

The IEEE Radio and Wireless Conference (RAWCON) will hold its 2000 event at the Denver Marriott Southeast in Denver, CO, September 10–13, 2000. General Chairman Dr. Mike Heutmaker and Technical Program Chair Dr. Kari-Pekka Estola have organized an outstanding conference. RAWCON has become a major forum that brings together circuit and system design issues, with emphasis on development of new wireless technologies.

MONDAY, SEPTEMBER 11, 2000

1:00 PM

Opening Remarks

Keynote Address
Al Javed, Vice President and Chief Technology Officer, Access Networks Nortel Networks

1:50 PM
Session M1: Wireless Systems

Chair: Kari-Pekka Estola, Nokia Research Center

1Xtreme—1X Third Generation Radio Enhanced Modulation and Encoding (invited)
George Fry, Nokia

Design Efficiencies for Indoor Wireless (invited)
Theodore S. Rappaport, Virginia Polytechnic University

Design and Implementation of a Completely Reconfigurable Soft Radio
Srikathyayani Srikanteswara, Michael Hosemann, Jeffrey H. Reed, Peter M. Athanas, Virginia Polytechnic University

A Study of Wireless Access Networks Architecture Using Multi-Level Modulation Methods
Masahiro Nishi, Hitomi Teraoka, Teruaki Yoshida, Hiroshima City University

4:00 PM
Session M2: Signal Processing

Chair: Tim Brown, University of Colorado

Steerable Beam Antennas for Base Stations (invited)
Theodore Sizer, Lucent Technologies

Space-Time Open Architectures for Broadband Wireless Data Communications: Above the Log 2 (1+SNR) Bit/Sec/Hz Barrier
Max Martone, Watkins-Johnson Company

A Code Tracking Technique for DS-SS Using Adaptive Filtering
Michael Hosemann, Jeffrey H. Reed, Virginia Polytechnic University

Workshop: Ultra Wideband (UWB) Communications Technology
Sunday, September 10, 2000, 1:00–5:00 PM

Organizer:
Michael Heutmaker, Lucent Technologies

Speakers:
Rex Morey, Lawrence Livermore National Lab
Paul Withington, Time Domain Corporation
Additional speakers to be arranged.

Ultra Wideband (UWB) technology represents a radical departure from present-day architectures for communications systems, and may be on the verge of initial commercialization. UWB systems manipulate picosecond RF pulses to transmit and receive data. The speakers, from a government laboratory as well as some of the leading companies, will combine a technical tutorial with a snapshot of the state of this innovative technology.

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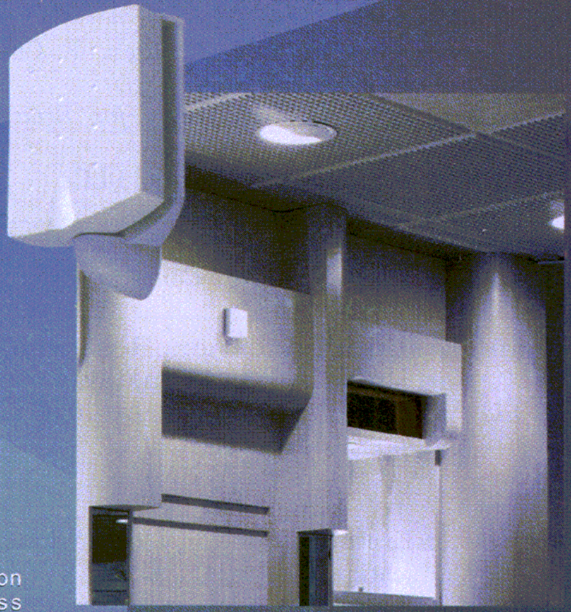

◄ Squint

Cushcraft Corporation leads the wireless communications industry in the design and development of access point antennas for micocell and picocell applications. Designed for concealment in today's environments, these antennas provide critical transmission links to transmit and receive voice and data communications between base stations or access points and remotes or portable phones and radios. Cushcraft's omnidirectional Squint antenna pattern shape is customized to provide maximum signal strength and RANGE from an overhead location. (See pattern.)

▲ DirectLink

Cushcraft's DirectLink antenna line is designed to promote effortless installation techniques with five simple mounting options to rapidly deploy networks in a cost-effective manner. This rugged indoor/outdoor, 7.5 dBi gain, directive antenna design combines superior electrical performance with contemporary styling for today's environments.

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Circle 19

5:30 PM

Session M3: Monday Poster Session

Chair: Mark Wickert, University of Colorado at Colorado Springs

System Architecture Posters

New Cellular Wireless System Concept for Very High Bit Rate Data Transmission With Smart Antennas at the Mobile and Base Station
Adrian Boukalov, Seppo J. Halme, Ren Aifeng, Helsinki University of Technology

Introducing FDM in MC-CDMA to Reduce Multiple Access Interference
Balasubramaniam Natarajan, Carl R. Nassar, Colorado State University

A New Broad Band Wireless Network for 5GHz License Exempt Applications
John Sydor, Communications Research Centre

New Transceiver Design Approaches for Digital Microwave Radios
Mina Danesh, N. Hassaine, A. Rich, F. Concilio, Harris Corporation

Mesh Networks: A New Architecture for Broadband Wireless Access Systems
Philip Whitehead, Radiant Networks PLC

System Performance Posters

IC-Friendly Line Codes for Direct-Conversion Receivers
Dongling Pan, John T. Stonick, Oregon State University

Performance of M-QAM with Nonlinear Transmit Amplifiers in Fading Channels
George Chrisikos, Moe Z. Win, AT&T Labs

Analysis of Wideband Measurement Data to Assess and Predict System Performance for IMT2000 Systems
Nikhil Adnani, R. J. C. Bultitude, Communications Research Centre

Antenna and Propagation Posters

FEM-Based Hybrid Methods for the Analysis of Antennas on Electrically Larg Structures
Dong-Ho Han, Anastasis C. Polycarpou, Constantine A. Balanis, Arizona State University

Planar Rectennas for 2.45 GHz Wireless Power Transfer
Jouko Heikkinen, Pekka Salonen, Markku Kivikoski, Tampere University of Technology

A Broadband 64-Element 2-D Quasi-Yagi Antenna Array
Kevin M. K. H. Leong, James Sor, William R. Deal, Yongxi Qian, Tatsuo Itoh, University of California, Los Angeles

A Fast Adaptive Algorithm for Direction of Arrival Estimation
Tanawat Mathurasai, Miloje Radenkovic, Delores Etter, University of Colorado, Boulder; Tamal Bose, University of Colorado, Denver

The poster session is followed by a banquet at 7:00 PM.

Panel Session: Education, Research, and the Wireless Industry

Monday, September 11, 2000, 8:30 PM–10:00 PM

Moderator:

Peter Staecker

Panelists:

Misty Baker, Executive Director, Global Wireless Education Consortium (GWEC)
Lawrence Dunleavy, Wireless and Microwave Program (WAMI), University of South Florida
David Falconer, Carleton University
Theodore S. Rappaport, Founding Director, Mobile and Portable Radio Research Group, Virginia Tech

In response to worldwide growth in wireless communications, relationships between universities and industry in RF/wireless technology are evolving. The panelists are leaders in finding ways for uni-versity researchers to identify needs of the commercial wireless industry and advance the state of the art; leveraging the advan-tages of industry sponsorship of leading-edge academic laboratory facilities; enabling university-industry collaboration to develop curriculum formats for wireless technology; contributing to emerging wireless standards; and more. The session will take place as the after-dinner program of the RAWCON2000 Banquet.

Workshop: Tutorial on Wireless Networking

Monday, September 11, 2000, 8:00 AM–12:00 PM

Organizers:

M. Heutmaker, Lucent Technologies
T. Brown, University of Colorado

Speakers:

Kumar Balachandran, Ericsson
Tim Brown, University of Colorado
Gerry Christensen, SignalSoft
Barry Dropping, Symmetricom

This workshop addresses one of the fundamental interdisciplinary aspects of wireless communications: how to configure communication networks to let a number of mobile users share a number of wireless channels. The presenters will cover the following topics:

- Cellular Architecture and Networking
- Network-Level Impact of the Wireless Channel
- Synchronization Issues in Wireless Networking
- Intelligent Mobile Networking and Applications
- Third Generation (3G) Wireless Networking
- Wireless Application Protocol (WAP)

RAWCON2000 Exhibition

RAWCON2000 includes an exhibition of wireless products and services on Monday (5:00–7:00 PM) and Tuesday (7:00 AM–7:00 PM). Booth and tabletop spaces may still be available. For information please check http://rawcon.org or contact the Exhibition Chair, Roger Marks of NIST (r.b.marks@ieee.org or +1-303-497-3037).

TUESDAY, SEPTEMBER 12, 2000

8:00 AM
Session T1: System Performance: Applications

Chair: Robert Achatz, Institute for Telecommunications Sciences

Busy Tone Access Control Using Low Power Non-License Radio for Wireless Infrared CATV System
Shinya Masumura, Yuichi Tanaka, Masao Nakagawa, Keio University

Orthogonal Frequency Division Multiplexing in Wireless Communication Systems with Multimode Fibre Feeds
Bryn J. Dixon, Roger D. Pollard, Stavros Iezekiel, The University of Leeds

Optimizing Frequency Reuse in Point-to-Multipoint Deployments
Dieter Scherer, Lucent Technologies

Development of Superresolution Spatio-Temporal Channel Sounder for Microwave Broadband Transmission
Kei Sakaguchi, Masachika Suda, Katsutoshi Fukuchi, Chisato Kenmochi, Jun-ichi Takada, Kiyomichi Araki, Tokyo Institute of Technology

Protocol Module of Wireless Data System Dedicated to Medical Care
Gen Fujita, Kenji Matsumura, Makoto Furuie, Isao Shirakawa, Hiroshi Inada, Osaka University

10:10 AM
Session T2: System Performance and Optimization

Chair: Peter Staecker

Invited Presentation (to be arranged)

Impact of Front-End Non-Idealities on Bit Error Rate Performances of WLAN-OFDM Transceivers
B. Come, R. Ness, S. Donnay, L. Van der Perre, P. Wambacq, M. Engels and I. Bolsens, IMEC-DESICS

System Performance Evaluation of Packet Data Transfer in UTRA-FDD Standard
Paolo Goria, Davide Sorbara, CSELT

Effect of Various Threshold Settings on Soft Handoff Algorithm Performance
Sung Jin Hong, I-Tai Lu, Polytechnic University

MMSE Frequency Combining for CI/DS-CDMA
Zhiqiang Wu, Carl R. Nassar, Colorado State University, Fort Collins

1:20 PM
Session T3: Propagation

Chair: Mark Reudink, Metawave Communications Corp.

A More Accurate Method to Define Exclusion Zones
Christof Olivier, Luc Martens, Ghent University

A Random-Phase-Assisted Ray-Tracing Model and Its Verification with a Spatio-Temporal Channel Measurement in a Suburban Micro-Cellular Environment
Houtao Zhu, Jiye Fu, Jun-ichi Takada, Kiyomichi Araki, Tokyo Institute of Technology; Hironari Masui, Masanori Ishii, Kozo Sakawa, Hiroyuki Shimizu, Takehiko Kobayashi, YRP Key Technology Research Laboratoris

Modeling and Analysis of Time Varying Radio Propagation Channel for LMDS
P. Soma, Y. W. M. Chia, L. C. Ong, National University of Singapore

Propagation Models at 5.8 GHz - Path Loss & Building Penetration
Thomas Schwengler, Mike Gilbert, U S WEST Advanced Technologies

3:10 PM
Session T4: Antennas

Chair: Jerry Grimm, Nokia

Kalman Filter Applied to GSC in Adaptive Antennas Array
Fabio A. L. Gomes, Adriao Duarte D. Neto, Aldayr D. de Araujo, Universidade Federal do Rio Grande do Norte

Analysis of Reflector Antennas Including Higher-Order Interactions
Dong-Ho Han, Anastasis C. Polycarpou, Constantine A.Balanis, Arizona State University

Implementation of a Real-Time, Frequency Selective,RF Channel Simulator Using a Hybrid DSP-FPGA Architecture
Jeff R. Papenfuss, Omnipoint Technologies Inc.; Mark A. Wickert, University of Colorado at Colorado Springs

Recent Results from Smart Antenna Experiments - Base Station and Handheld Terminals
W. L. Stutzman, J. H. Reed, C. B. Dietrich, B-K Kim D.G. Sweeney, Virginia Tech

5:30 PM
Session T5: Tuesday Poster Session

Chair: Bernard Geller, Sarnoff Corp.

Active Device Posters

Automatic Phase Alignment for High Bandwidth

Cartesian Feedback Power Amplifiers
Joel L. Dawson, Thomas H. Lee, Stanford University

Large-Signal Scattering Parameter Measurements for RF Power Transistors
John B. Call, William A. Davis, Motorola

RF Frequency Properties of a Reverse Biased Thick Switching PIN-Diode
Lioudmila Drozdovskaia, Villanova University

High Power Effects on Gallium Nitride-Based Microwave and RF Control Devices
Robert H. Caverly, Nikolai Drozdovski, Michael Quinn, Villanova University

Design of Tuning Bandwidth and Linearity for VCO by Mathematical Solution and Computer Method
Tseng-Chuan Wang, Industrial Technology Research Institute (ITRI)

A New Pinched-Off Cold-FET Method to Extract Parasitic Capacitances of MESFETs and HEMTs
Yeong-Lin Lai, Kuo-Hua Hsu, Feng Chia University, Taichung

0.24-um CMOS Technology for Bluetooth Power Application
Y.J.E. Chen, D. Heo, M. Hamai, J. Laskar, Georgia Institute of Technology; D. Bien, National Semiconductor Corporation

Panel Session: Accessing the Wireless Internet: Cellular, LAN, or Other?

Tuesday, September 12, 2000 7:00 PM–9:00 PM

Organizers:
Michael Heutmaker, Lucent Technologies
Modest Oprysko, IBM

Moderator:
Andrew Seybold, Senior Partner, Andrew Seybold Group LLC; Editor-in-Chief, Andrew Seybold's Outlook

Panelists:
Kumar Balachandran, Senior Consulting Engineer, Ericsson, Inc.
Phil Belanger, Vice President, Wireless Business Development, Wayport, Inc.; Chair, Wireless Ethernet Compatibility Alliance (WECA)
Bruce Rowland, Senior Manager, Internet Wireless Systems, Lucent Technologies
Durga Satapathy, Principal Member of Technical Staff, Sprint; Chair, IEEE 802.16's Wireless High-Speed Unlicensed Metropolitan Area Networks Study Group
(To be announced), IBM
(To be announced), NTT DoCoMo

Technology, business, and performance aspects of wireless access to the Internet are reshaping the landscape of the wireless industry. How many people will use their mobile phone to access the Internet, and for what purposes? Will third-generation cellular technology be economically feasible on a mass scale? Will ubiquitous and economical high-speed wireless LAN connections be a significant player for portable users? Will fixed wireless access significantly enhance the availability of broadband access? Will all of these modes complement each other or all exist independently? The panelists bring the perspectives of service providers, mobile phone developers, infrastructure developers, and computer companies to the discussion of what is happening now and what might happen next.

Passive Device Posters

Design and Characterization of CPW Feedthroughs in Multi-Layer Thin-Film MCM-D
Geert Carchon, B. Nauwelaers, KULeuven; O. DiMonaco, K. Vaesen, S. Brebels, W. DeRaedt, IMEC

A Method for Creating Multiple Attenuation Poles by a Microwave Filter Based on Tapped-Resonators
Kouji Wada, Osamu Hashimoto, Aoyama Gakuin University

Two Ring DRs Bandpass Filter Analysis Using the FDTD Method in an MIC Environment
Young-Sik Kim, Korea University

Antenna and Propagation Posters

Aperture-Coupled Stacked Microstrip Antenna With Dual Polarisation and Low Back-Radiation for X-Band SAR Applications
F. Klefenz, A. Dreher, German Aerospace Center (DLR)

Miniature Broadband Packaged Microstrip Antenna Using Wire-Bonding Technique
Wei Ping Dou, M. Y. W. Chia, Centre for Wireless Communications, Singapore Science Park II

Small Broadband Microstrip Patch Antenna for IMT-2000 Handsets
Wang Yajun, Lee Ching Kwang, Nanyang Technological University

WEDNESDAY, SEPTEMBER 13, 2000

8:00 AM
Session W1: Active Device Characterization and Modeling

Chair: Joseph Staudinger, Motorola SPS

Prediction of Output Carrier-to-Interference Ratios from Nonlinear Microwave Components Driven by Arbitrary Signals Using Intrinsic Kernel Functions
H. Ku, J. S. Kenney, Georgia Institute of Technology; A. Leke, Stanford University

Measurement Technique for Characterizing the Memory Effects in RF Power Amplifiers

Micro Lambda, Inc. a leader in the development of next-generation YIG devices now offers YIG-Based Frequency Synthesizers covering the 2-12 GHz frequency range. Designed specifically for Digital Radio ODU's and harsh commercial environments, these synthesizers offer excellent integrated phase noise characteristics over carrier offset frequencies from 10 kHz to 10 MHz.

Tunable bandwidths of either 2 GHz or 3 GHz are available as standard products. This results in fewer numbers of synthesized sources required for a variety of Digital Radio frequency plans. Millimeter-Wave frequencies can easily be obtained using frequency multipliers to obtain output frequencies between 24 GHz through 44 GHz.

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Low Power, Low Noise YIG-Based Synthesizers for Digital Radios

Features

- 2 - 12 GHz Frequency Coverage
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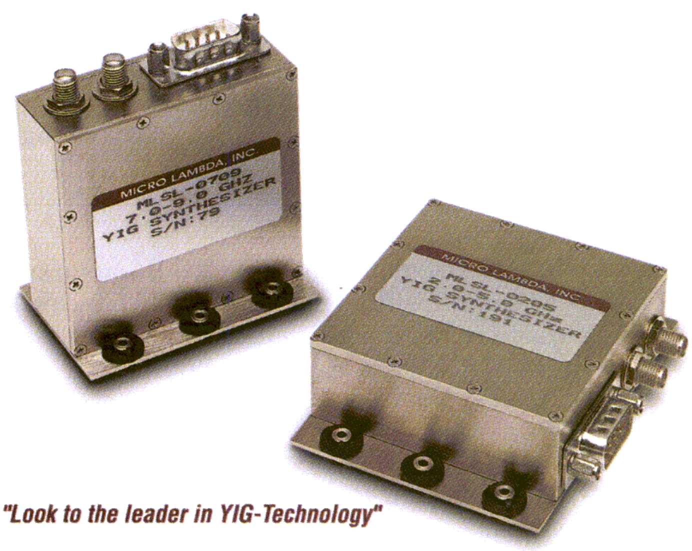
- 3-Line Serial Interface
- Low Prime Power
- 500 kHz Step Size
- Internal Memory (last frequency programmed - recall)

MLSL-Series Synthesizers

This series of synthesizers utilize an external 1 to 50 MHz crystal reference oscillator to generate tunable frequencies covering the 2 - 12 GHz range. Output power levels of +12 dBm to +15 dBm are offered depending on frequency, with a standard tuning step size of 500 kHz. Input tuning commands are via 3-Line Serial interface. The size of these compact units is 2.5" x 2.5" x 1.0" without mounting plate and consume less than 6 watts of prime power. The units have an internal memory capability which "recalls" the last frequency programmed when the prime power is removed and reapplied. Standard models include 2-4 GHz, 4-6 GHz, 5-7 GHz, 7-9 GHz and 9-11 GHz. Specialized frequency ranges are easily implemented utilizing the versatile synthesizer architecture.



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Circle 79

Joel Vuolevi, Timo Rahkonen, Jani Manninen, University of Oulu

Analysis of the Effects of Supply Noise Coupling on Phase Noise in Integrated LC CMOS Oscillators
Radu Fetche, Cristina Fetche, Washington State University; Terri Fiez, Kartikeya Mayaram, Oregon State University

An RF MOSFET SPICE Model with a New Substrate Network
Seonghearn Lee, Hankuk University of Foreign Studies; Cheon Soo Kim, Hyun Kyu Yu, Electronics and Telecommunictions Research Institute

9:50 AM
Session W2: Wireless Receiver Circuits

Chair: Masami Akaike, Science University of Tokyo

Optimization of Tunable Oscillators with AM to FM Conversion for Near-Carrier Phase Noise
Gleb V. Klimovitch, Watkins-Johnson Company

High Performance RF Front-End Circuits for CDMA Receivers Utilizing BiCMOS and Copper Technologies
Tom Schiltz, Carl Denig, Charles Dozier, Hua Fu, Henry Lau, Glenn Watanabe, Motorola Inc. SPS

Adaptive Dual-Loop Algorithm for Cancel-lation of Time-Varying Offsets in Direct Conversion Mixers
Christian Holenstein, John T. Stonick, Oregon State University

A 900 MHz CMOS Balanced Harmonic Mixer for Direct Conversion Receivers
Zhaofeng Zhang, Zhiheng Chen, Jack Lau, Hong Kong University of Science & Technology

Novel Indirect-Conversion Transceiver Architectures Using Phantom Oscillators
Leonard MacEachern, Tajinder Manku, University of Waterloo

1:00 PM
Session W3: RF Power Amplification

Chair: Lutfi Albasha, Filtronic

Measurement Technique for Improving the Linearity by Optimising the Source Impedance of RF Power Amplifiers
Joel Vuolevi, Timo Rahkonen, Jani Manninen, University of Oulu

ACPR Comparison of Low Pass and Band Pass Type Power Amplifier for 22 Mbps Wireless LAN Application
K. H. Koo, L. Larson, University of California, San Diego; M. S. Jung, J. S. Park, University of Inchon

Integrated Power Measurement Circuit for RF Power Amplifiers
Ossi Pollanen, Esko Jarvinen, Nokia Mobile Phones

A European ISM Band Power Amplifier Module
Ming-ta Hsieh, Jonghae Kim, Ramesh Harjani, University of Minnesota, Minneapolis

2:50 PM
Session W4: Passive Devices

Chair: Liz Logan, Intarsia Corp.

Improved Techniques for the Measurement and Modeling of Plastic Surface Mount Packages to 20 GHz
Darryl Jessie, Lawrence E. Larson, University of California, San Diego

Design of a Direct Ku-band Linear Subharmonically Pumped I/Q Vector Modulator in Multi-Layer Thin-Film MCM-D
Geert Carchon, D. Schreurs, B. Nauwelaers, KULeuven; W. De Raedt, IMEC

High-Q Integrated Spiral Inductors for High Performance Wireless Front-End Systems
P. Pieters, K. Vaesen, G. Carchon, S. Brebels, W. De Raedt, E. Beyne, R. P. Mertens, IMEC

Simplifying Passive Integration and Simulation
Steve Whelan, Intarsia Corporation

Low-Cost Realization of ISM Band Pass Filters Using Integrated Combline Structures
Mi-Hyun Son, Sung-Soo Lee, Yong-Jun Kim, Samsung Electronics Co.

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Monday, September 11	7:00 AM to 6:00 PM
Tuesday, September 12	7:00 AM to 6:00 PM
Wednesday, September 13	7:00 AM to 12:00 PM

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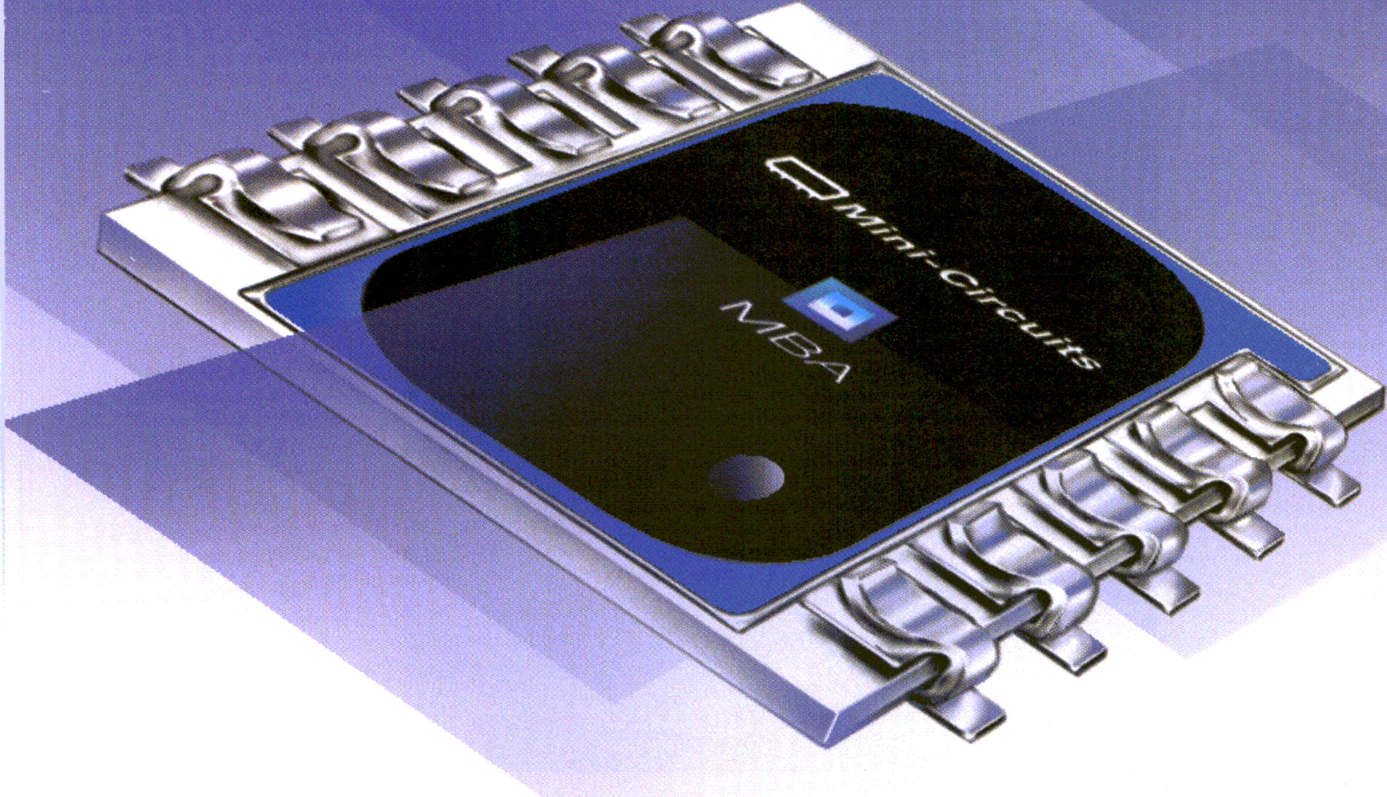

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MBA-26	+7	2.2-2.7	5.95	MBA-25MH	+13	2.0-3.0	7.95
MBA-591	+7	2.8-5.9	6.95	MBA-35MH	+13	3.0-4.0	7.95
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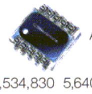

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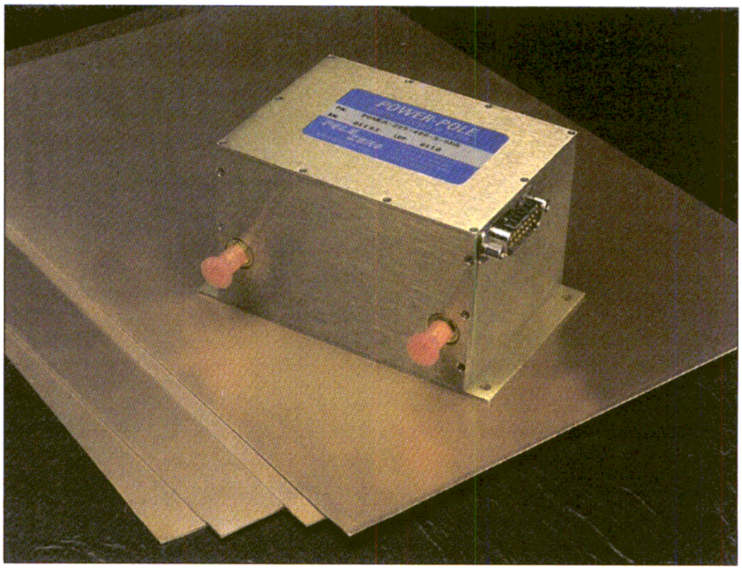
TALENT

DESIGNERS

Circuit Board Material Meets Performance Requirements for High Power Hopping Filters

Requiring a circuit material with good electrical properties and ease of fabrication, design engineers at Pole/Zero of West Chester, OH, selected Rogers' RO4003® laminate for the Power-Pole® digitally tuned hopping filter.

Named for its very high RF power handling capability (up to 20 watts in-band), the Power-Pole filters noise and spurious outputs from transmitters, exciters and synthesizers. Developed for both military and commercial use, its commercial applications include those in automated test equipment and university laboratories.



▲ **Figure 1. Pole/Zero selected RO4003 laminate for use in its Power-Pole hopping filter. This device filters noise and spurious outputs from transmitters, exciters and synthesizers.**

While evaluating circuit board laminates for this application, Pole/Zero was faced with a common problem — to find a moderately-priced material with acceptable RF electrical properties that can be fabricated in standard PC board manufacturing processes, according to Rick Hahn, Pole/Zero RF Engineer. The company evaluated several materials, including glass epoxy, PTFE glass and the RO 4003 laminate (a glass-reinforced hydrocarbon/ceramic composite).

Priced between FR4 board and PTFE laminates, "RO4003 material provided us with good RF performance for the cost," Hahn said. The material's electrical properties include a dielectric constant of 3.38 +0.05 and a dissipation factor of 0.0027 at 10 GHz. The least expensive alternative, glass epoxy, "did not have the dielectric control we needed for this RF application," Hahn said. Thus, the FR4 board was eliminated from further consideration.

The Power-Pole filter consists of a 2-layer lumped element circuit that includes vias. The laminate used for the filter circuit would have to withstand standard epoxy/glass manufacturing processes. This proved to be a hurdle for the PTFE laminate.

RO4003 mechanical properties

"We found that while the PTFE laminate had excellent RF performance, we experienced manufacturing problems with this material," Hahn said. "Yields were low because the laminate expanded during processing, causing the copper traces to peel away."

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Circle 35

On the other hand, the RO4003 material withstood the thermal and mechanical conditions of the circuit manufacturing process. This is due in part to the material's thermal coefficient of thermal expansion (CTE), which provides several key benefits to Pole/Zero, said Kevin Walker, Rogers Marketing Manager, Microwave Materials.

"The expansion coefficient of RO4003 laminate is similar to that of copper," Walker said. "This allows the material to exhibit excellent dimensional stability. In addition, its low Z-axis CTE provides the circuit with reliable plated through-hole quality." He added that the laminate's glass transition temperature, which exceeds 536° F/280° C, gives it mechanical stability over a wide range of circuit processing temperatures.

Walker said mechanical properties of RO4003 laminate, shown in Figure 1, include dimensional stability of <0.3 mm/m (after etch); coefficient of thermal expansion of 11 ppm/C (X direction), 14 (Y direction) and 46 (Z direction); and flexural strength of 276 MPa. Because it is a rigid laminate, the material can be processed with automated handling systems and scrubbing equipment.

In addition to its electrical and processing attributes, RO4003 material has good availability and delivery, Hahn notes. "Our manufacturing department says that they have been able to get this product when they need it," he said.

Pole/Zero filter products

RO4003 laminate is used in a variety of Pole/Zero filters, including those found in military subsystems, according to Bill Enigk, Pole/Zero Products Manager. These devices are an integral part of the communications platforms of E-3 AWACS planes, Naval command ships and Army command posts. Pole/Zero filters screen out interference created by the simultaneous operation of multiple antennae. The filters "hop" in sequence with transceivers, which operate over rapidly changing frequencies. The "hopping" action of the signal is a technique used to block outside parties from monitoring communications.

All Pole/Zero filters are high *Q*, narrowband RF filters whose center frequency is controlled digitally. They are tuned to the desired frequency by PIN diode switched capacitor arrays. The company offers both bandpass and notch filters.

From an RF standpoint, Pole/Zero's full product line behaves as any passive LC filter tuned by high *Q* variable capacitors, Enigk said. All Pole/Zero products offer outstanding RF characteristics including:

- A wide tuning range up to 3:1 over the 1.5 MHz to 1 GHz band;
- Precision tuning including 251 tuning positions per filter across each band, with each position providing 0.5 percent tuning accuracy over a temperature range from –40° C to +85° C (–40° F to +185° F); and
- A fast tune time (as fast as 10 microseconds) to any frequency after receipt of tune command.

Pole/Zero has worked closely with circuit board design house Alpha-C when laying out filter circuit patterns, Hahn said. Based in Dayton, OH, Alpha-C helps its clients achieve a "seamless transition of the circuit design from the schematic to the production floor," said Mike Floyd, Alpha-C General Manager.

Pole/Zero was established in the early 1990s during a period when military budgets were dramatically reduced. "We were in the unique position of being a low-cost supplier," Enigk said. Pole/Zero has expanded its markets to include commercial customers, and today it positions itself as the "Catalogue Shop for Tunable Filters."

"We call ourselves the Catalogue Solution, meaning you open our catalogue, pick a product, put it in your module, and presto, you're done," Enigk said. ■

For further information on RO4003 laminate, contact:

Rogers Microwave Materials Division
100 South Roosevelt Avenue
Chandler, AZ 85226
Tel: 480-961-1382
Fax: 480-961-4533
Internet: www.rogers-corp.com/mwu/info.htm

Or circle Reader Service #200

For information on Pole/Zero hopping filters, contact:

Pole Zero Corporation
5530 Union Centre Drive
West Chester, OH 45069
Tel: 513-870-9060
Fax: 513-870-9064
Internet: www.polezero.com

Or circle Reader Service #201

Distribution Plays an Ever-Larger Role in Wireless Manufacturing

By Gary A. Breed
Publisher

Not many years ago, the RF and microwave industry used distributors almost exclusively for the "generic" electronics parts that are used in all types of electronics. Capacitors, resistors, general-purpose transistors, logic ICs, operational amplifiers and other common components were obtained through distribution.

Components specific to the industry, however, were typically obtained either by a direct sales arrangement or by coordination through manufacturers' representatives. Only a few of the most widely used products for RF and microwave applications were successfully sold through distribution. For example, common connector types and vacuum tubes for the industrial and broadcast replacement market have been sold through distribution for many years. However, even manufacturers of these products relied heavily on direct or rep sales.

Wireless communications brings change

The industry's situation is much different today. Explosive growth in wireless communications has created new mass markets for RF and microwave technology, as well as an atmosphere of increased competition. Demand is high, which means continually increasing business for most distributors.

"Were seeing lots of new customers," said Chuck Swift of C.W. Swift & Associates.

In many cases, these new customers are unfamiliar names in the RF and microwave industry, since new companies are moving into the wireless business daily. Many are startups and spin-offs just getting started in the industry.

Some of the other new business, however, comes from one-time purchases from companies who cannot get delivery from a preferred supplier. A few are contract manufacturers.

Along with the change to a more commodity-oriented market, the wireless industry has adopted manufacturing methods that were pioneered by consumer electronics firms over the past ten years. Many of these methods require greater participation by distributors, taking on new roles in the control of inventory and delivery, and sometimes in the manufacturing process itself. Some of the services distributors are now providing to their customers include:

- maintaining local inventory;
- coordinating tightly-controlled delivery schedules;
- maintaining inventory in the customer's facility on consignment, to be sold when used;
- kitting parts in preparation for assembly;
- performing quality pre-screening;
- offering parametric testing and sorting; and
- arranging medium- to long-term pricing agreements.

Distributors are even providing system integration, prototype design and assembly and value-added services for either customer or principal, services seen as a significant growth area for some distributors. For example, Avnet Electronics provides custom packaging services and even manufactures the Avantek line of modular components. RF Vision, an RF/microwave distributor recently started by Wyle, included cable assembly capability as part of its initial development plan.

With the pool of available RF/microwave engineers at an all-time low, manufacturers are also turning to their suppliers to provide techni-

cal expertise. For their principals, a distributor may develop and provide evaluation boards and sample kits. For customers, prototype circuits, applications support and engineering design are among the services that may be requested.

The "problem" of high demand

Distributors are facing one major obstacle for growth — finding supplies to keep up with demand. Some parts, especially capacitors, are on allocation despite rapid expansion by capacitor manufacturers, and customers are trying every means possible to get the parts they need to meet manufacturing timetables.

For some components, "It's been a scramble for the past six to eight months to see who's got it," says Mike Caputo of Microwave Components.

Distributors are looking for new suppliers to meet this demand, but the consensus is that everyone is experiencing this problem. Although the market is strong and business is good, all distributors are as frustrated as their customers about supplies. They see unfilled orders as business that could be lost, not just delayed. Companies who cannot get what they need from their regular distributors will try other companies instead.

Where is new business coming from?

The wireless infrastructure market is strong. Current large-scale business includes delivering cable, connectors or completed assemblies for cellular, PCS and other wireless base station equipment. Additional business comes from passive components like couplers, filters, and isolators, although distribution is smaller than direct or rep sales for these products.

A developing large market is millimeter-wave components. Demand is growing for 2.9, 2.4 and 1.8 mm connectors used at mm-wave frequencies, along with passive components and semiconductors. LMDS, point-to-point and point-to-multipoint systems are in the early phases of rapid growth.

A developing large market is millimeter-wave components.

Future challenges

The principal advantages of purchasing through a distributor are a local presence and the ability to obtain parts from multiple sources in a single order. While

there are challenges to traditional distribution by new methods, including e-business, distributors are optimistic that the advantages noted above will not be seriously eroded by new, less personal avenues.

Service remains the first objective of distributors. They want to provide a conduit for sales that satisfies their principals, and they understand that customers' needs must be met in order to keep their business.

In the RF and microwave specialty, changes are dramatic compared to military and commercial business of the past. The customer base includes new players and the quantities, delivery schedules and value-added services required by customers have all changed. The good news is that the wireless industry is presently very strong, and distributors are sharing in that success. With few signs pointing to a slowdown, distributors should be prepared to continue their efforts to satisfy high demand for their services. ■

Distribution News

IFR Systems is now the exclusive reseller for Hameg Instruments of Frankfort, Germany. Hameg makes oscilloscopes, spectrum analyzers, and a line of bus-controlled instruments that includes multimeters, frequency counters, function generators, synthesizers, power supplies and frequency standards.

Digi-Key has added Coto Technology to its line of relay products. Coto is a maker of reed relays, including models for RF switching. Digi-Key will stock several of the company's product lines.

Richardson Electronics has signed a worldwide distribution agreement with ANADIGICS, a supplier of integrated circuits and modular components for wireless and broadband communications. Richardson is a specialized distributor of RF products, with 37 stocking locations worldwide.

Avnet Electronics has announced the signing of a global distribution agreement with Semflex. Semflex manufactures RF coaxial cable assemblies for test equipment and wireless infrastructure equipment.

Circle 87

Product Focus: Oscillator and Frequency Control Products

Here is a collection of recently-introduced products that represent the latest innovations in oscillator, synthesizer and resonator technology. Applications for these products include wireless, optical and wireline communications, as well as classic RF and microwave systems and instrumentation.

VCO for subscriber equipment

Vari-L has introduced the VCO19O-830X, which generates frequencies from 812 MHz to 849 MHz with control voltages from 0.5 to 4.5 volts. Typically, the unit requires 13 mA current from a +5 volt supply. Phase noise is typically –132 dBc/Hz at 100 kHz offset. Output power is +3.5 dBm. Second harmonic suppression is –15 dBc, and third harmonic suppression is typically –20 dBc. The unit is housed in a 9.0 × 7.0 × 2.0 mm surface mount, pick-and-place compatible package.

Vari-L
Circle #191

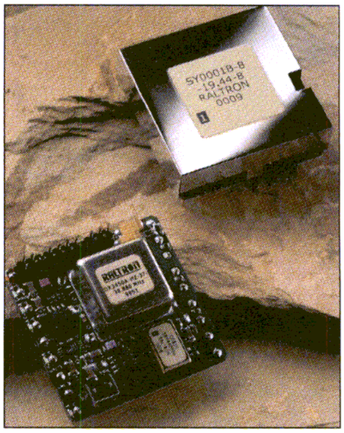
Miniature oscillator for high-performance communication systems

Temex Electronics has introduced the QEO SV 93, a pared-down, oven-controlled crystal oscillator with low phase noise, power and aging rate. This HCMOS oscillator is intended for use in UMTS and GSM base stations, broadband radio access (LMDS and BWA) and telecommunication switching platforms. Lifetime stability is ±4.6 ppm to meet ANSI Stratum-3 requirements. It is packaged in a 0.38 inch high, hermetically sealed DIP. Frequencies are available from 1 to 35 MHz, with 5 or 12 volt power supply. The QEO SV 93 has a warmup time measured at less than 60 seconds.

Temex Electronics
Circle #192

Synchronous clock module

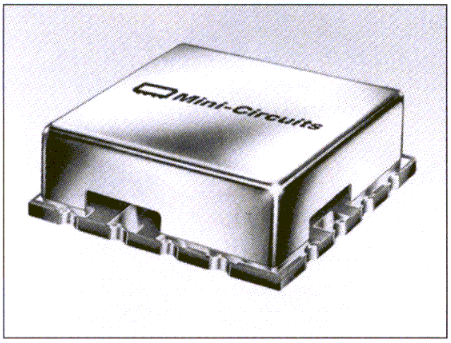
Raltron Electronics announces a new Stratum 3 synchronous clock module for telecommunication network synchronization and wireless communication systems. Model SY-0001 is a semi-custom subsystem offering a turnkey solution for faster design of telecommunication systems. The module includes its own Stratum-3 OCXO, two independent inputs of any reference frequency from 8 kHz to 77.76 MHz, plus a DSP-based phase-locked loop with a bandwidth of 0.1 Hz that avoids jitter in any incoming signal. DSP coefficients are stored in on-board flash RAM that can be field modified. A self-correcting temperature sensor maintains OCXO and PLL accuracy. Packaging can be hermetically-sealed, EMI shielded or an open board.



Raltron Electronics Corp.
Circle #193

VCO tunes 485–765 MHz

Mini-Circuits introduces a compact voltage controlled oscillator. Typically, the ROS-765 provides



near-octave tuning from 485 to 765 MHz, low –95 dBc/Hz SSB phase noise at 10 kHz offset and –27 dBc harmonic suppression. The VCO requires 12-volts at 22 mA maximum. The miniature 0.5 × 0.5 × 0.18 inch size conserves space for applications include digital cordless phones and test instruments, such as signal generators. In 5 to 49 unit quantity, the price is $15.95 each.

Mini-Circuits
Circle #194

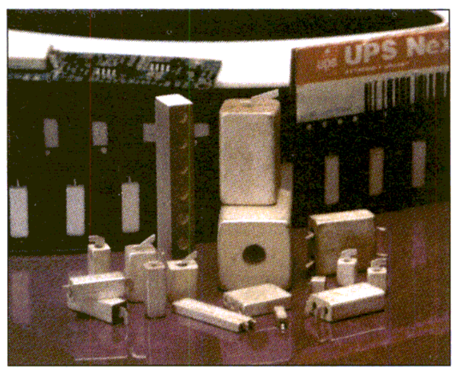
PLL synthesizer ICs

Analog Devices announces a new family of PLL synthesizers with excellent phase noise performance. The ICs can provide digitally-controlled frequencies up to 4 GHz for a wide range of products. The ADF411x family has two series of chips. One series is pin-compatible with the LMX23xx PLL products and can be used in existing designs. The other set of chips are intended for new designs that require additional features, such as software-programmable charge-pump current and anti-backlash pulse width. The family offers low phase-noise integer-N PLL performance exceeding 92 dBc/Hz at 900 MHz with 200 kHz channel spacing. TSSOP and chip-scale packaging are available. The PLL ICs are priced starting at $1.99 each for 10,000 units.

Analog Devices, Inc.
Circle #195

Ceramic resonators

PicoFarad/Val Jackson & Associates has announced low-cost, quick-delivery, high-volume resonators, inductors and custom elements. These products cover 200 to 8500 MHz and are available in sizes from 1.8 mm to more than 12 mm



square. They can be used in VCOs, CROs, filters, duplexers, splitters and other applications requiring high Q inductors and resonators. The products are manufactured in the U.S. Pricing starts at less than $1 each in production quantities, with common frequencies in stock.

PicoFarad/Val Jackson & Associates, Inc.
Circle #196

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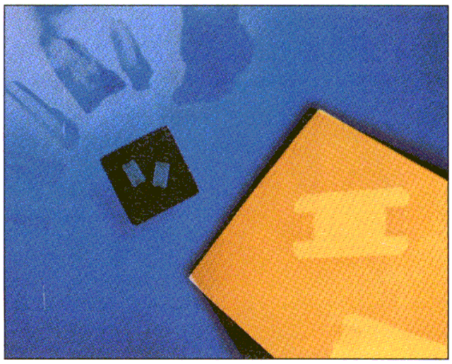
Circle 27

Low cost crystals

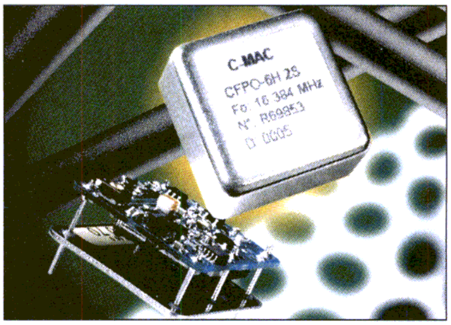


A new family of microprocessor crystals has been introduced by Vishay Intertechnology. The XT36C series have a low profile (1.6 mm) for portable computing and communication products. The crystals are available in frequencies from 10 to 64 MHz. Equivalent series resistance for the devices ranges from 60 to 120 ohms. Frequency stability is ±100 ppm at 25° C, with a frequency tolerance of ±50 ppm. Drive level is 100 μW maximum with maximum shunt capacitance of 7 pF. In 500-piece quantities, pricing ranges from \$1.20 to \$1.48.

Vishay Intertechnology, Inc.
Circle #197

Miniature OCXOs

C-MAC Frequency Products offers an inexpensive (from \$60 per piece) OCXO for use in cellular base stations and Stratum-3 SDH/

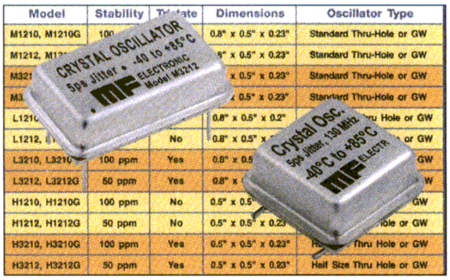


SONET switching. The CFPO-6 line offers stability to within ±0.02 ppm over the –20° to +70° C at frequencies from 4 to 40 MHz. Aging is within $\pm 3\times10^{-10}$ per day after 30 days of operation and phase noise is –140 dBc/Hz at 100 kHz. The OCXO is offered in six standard frequencies, with custom units also available.

C-MAC Frequency Products
Circle #198

Low jitter oscillator

MF Electronics provides 24 oscillators in the M1210-H3212G family, offering low jitter of 5 ps RMS at 1



kHz to 100 MHz. Applications include gigabit ethernet and other high-speed datacom applications. Pricing is as low as \$3.95 each in OEM quantity.

MF Electronics Corp.
Circle #199

Indoor and Cross-Polarized Antennas Provide Performance Options for Wireless Systems

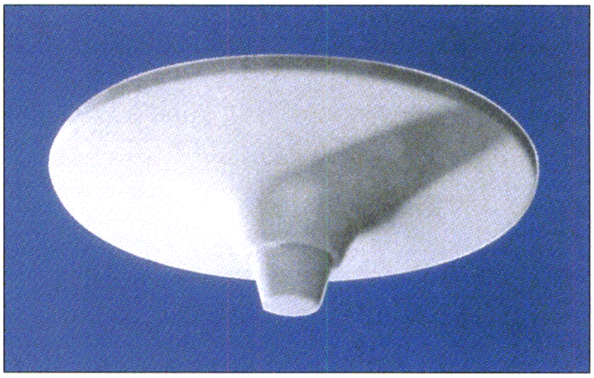
The Scala Division of Kathrein Inc. has introduced two new antennas for cellular and PCS systems. The antennas include performance features for specialized installations. The IDBO 890/1900 is an unobtrusive omnidirectional dual-band antenna for indoor installation, while the AP8-1850/09OD/XP is an 1800–1900 MHz ±45 degree cross-polarized cellular sector antenna.

The IDBO 890/1900 dual-band indoor antenna simplifies installation by accommodating both cellular and PCS bands in a single antenna. Microcells and picocells can be more easily implemented with less cabling and fewer antennas. The antenna is provided with a standard type N female connector.

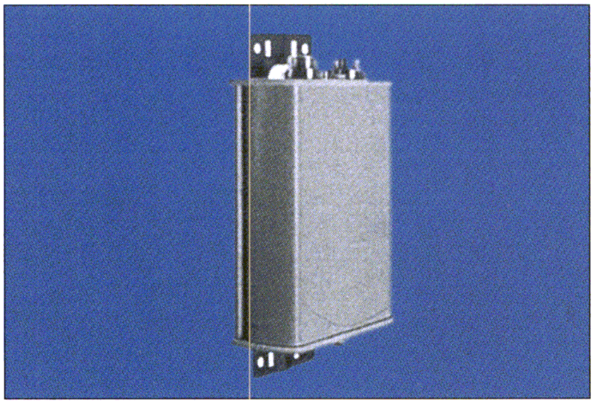
Because the antenna is designed for an indoor environment, attention was given to a low-profile and a pleasing appearance. The antenna also features easy installation.

The AP8-1850/09OD/XP allows system operators to take advantage of polarization diversity when it is desirable due to the local environment. Up to ±45 degree cross-polarization is provided. This model has a small profile for low visibility and is constructed from materials designed for a long operational lifetime.

Kathrein Inc. is worldwide supplier of broadcast and communication products. The Scala Division manufactures antennas and filters for many communications applications. ■



▲ **Kathrein Inc., Scala Division offers this unobtrusive dual-band cellular/PCS antenna for indoor installation.**



▲ **For systems requiring polarization-diversity, this antenna provides ±45 degree polarization in the 1800–1900 MHz band.**

For more information, contact:

Kathrein Inc., Scala Division
P.O. Box 4580
Medford, OR 97501
Tel: 541-779-6500
Fax: 541-779-3991
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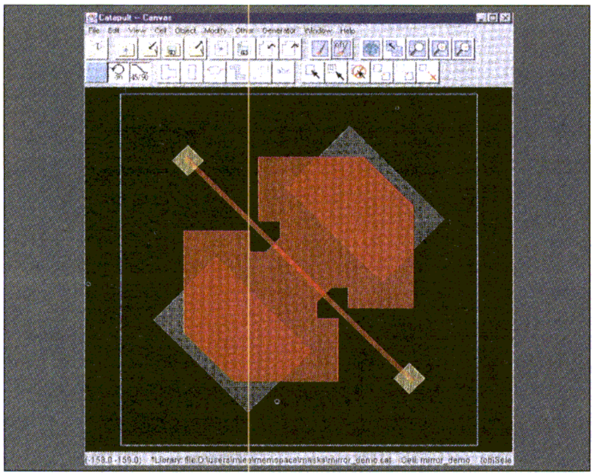
Or circle Reader Service #202

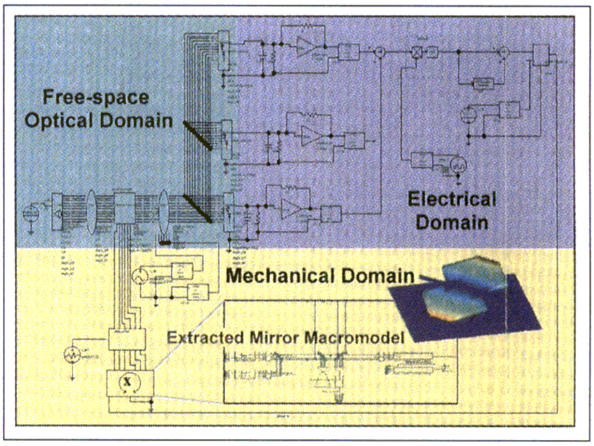
Micro-Electro-Mechanical Systems Get Improved Development Tools

Microcosm Technologies has extended their MEMCAD development software and Cadence library elements for products that include micro-electro-mechanical systems (MEMS) technology. MEMS can be used in the design of high Q resonators and varactors, inductors and filters for K-band and higher, and high performance switches.

The latest enhancements provide the capability to use standard IC and system design tools for top-down design of systems integrating MEMS and non-MEMS technologies. The first interface announced is with the familiar Cadence schematic-driven layout environment. Designers can create MEMS structure within the Cadence environment using Microcosm's library elements and foundry-specific process information. They can also import parameterized 6-degree-of-freedom (6DOF) models using MEMCAD software.



▲ MEMCAD allows 6-degree-of-freedom models that can be used with the Cadence design environment to develop MEMS-enabled products.



▲ Microcosm has added optical capability and extended modeling capability for RF/wireless MEMS applications.

The company has also announced support for optical-electrical applications to enable development of control systems, sensors and other systems. Extended support for RF/wireless applications is also included, offering improved support for development using the Catapult 2-D layout editor, then performing 6DOF simulation in MEMCAD. ■

For more information, contact:

Microcosm Technologies, Inc.
4001 Weston Pkwy., Suite 200
Cary, NC 27513
Tel: 919-854-7500
Fax: 919-854-7501
Internet: www.memcad.com

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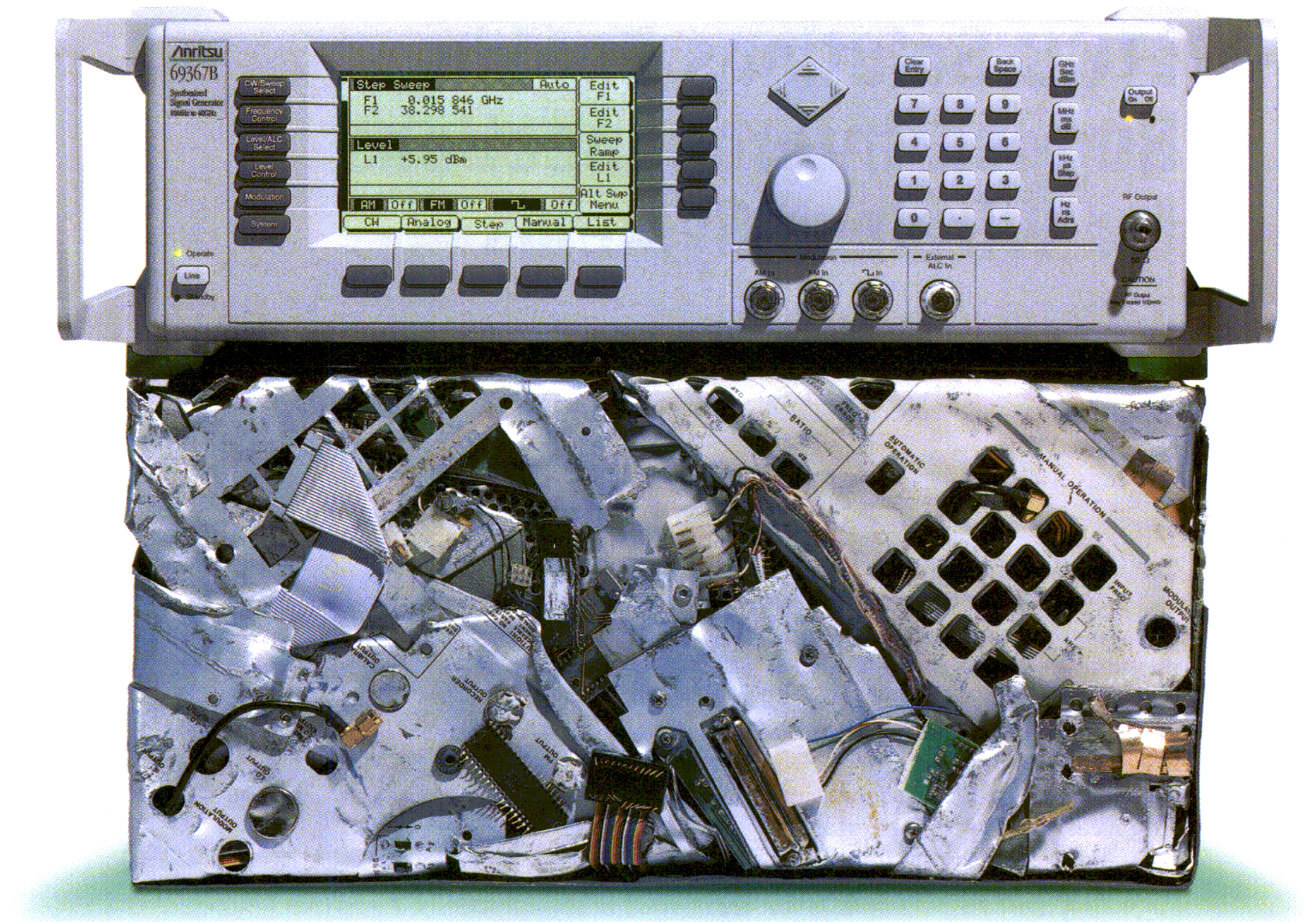

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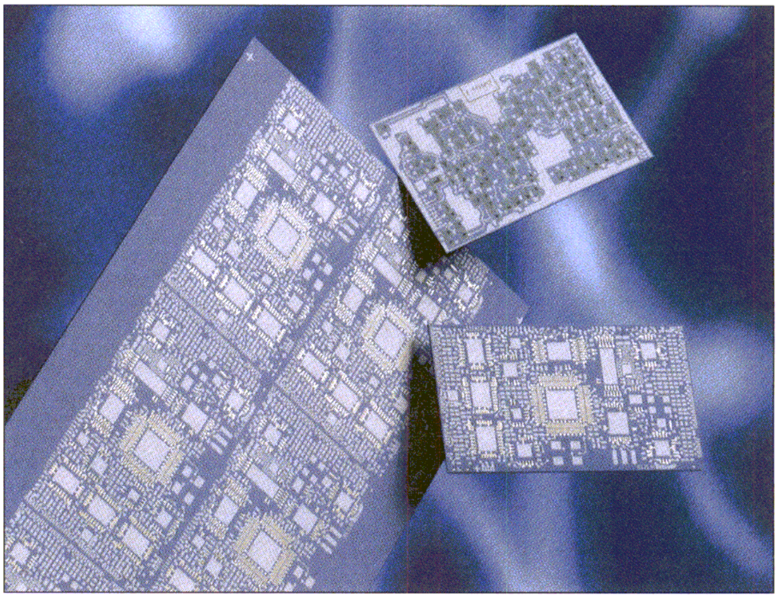
Circle 56

LTCC Solutions Enable Rugged Interconnections for Wireless Systems

Low-temperature cofired ceramic (LTCC) technology enables rugged interconnection systems with high dielectric performance and integrated passive components. C-MAC MicroTechnology offers LTCC solutions with full customization from ceramic mix formulation through track, via and component layout, to assembly of complete modules.



▲ **C-MAC MicroTechnology provides custom LTCC multilayer systems with integrated passive components for reliable wireless, telecommunication and automotive products.**

Using LTCC, up to 50 layers of ceramic tape are sandwiched together and fired to form a single multilayer rigid substrate. Each layer can have holes punched for vias and be printed to form tracks and simple passive components before firing. With the ability of both formulate and process the ceramic substrate, C-MAC can customize the physical and electrical properties including embedding ferrite inductors. The company can also integrate other technologies such as flipchip and wire bonded chip-on-board to provide complete functional solutions in the form of packaged and tested modules.

The properties of the ceramic substrate are well suited to wireless applications. Dielectric loss is much lower than conventional FR4 substrates, especially at frequencies above 1 GHz. This reduces power consumption and improves circuit performance. In addition, track widths and spacing are more precise, also improving high frequency performance.

In automotive applications, systems may be exposed to temperatures up to 200° C along with extreme shock and vibration. The mechanical properties of a ceramic substrate survive in this environment where other options may not. ■

For more information, contact:

C-MAC MicroTechnology
4222 Emperor Blvd., Suite 300
Durham, NC 27703-8466
Tel: 919-941-0430
Fax: 919-941-0530

Or circle Reader Service #204

System Software Links to DSP Development System, RF/Microwave Analysis

Version 4.5 of SystemView has been released by Elanix. The latest version of this system-level software for DSP and communications applications links with Texas Instruments' Code Composer Studio for C5x/C6x software development and test. A partnership with Xpedion Design Systems has produced a link between the two companies' system and RF/microwave design software.

A highlight of SystemView 4.5 is the Real Time DSP Architect (RTDA), which links with TI development tools. The RTDA has been enhanced to include support for the TI TMS320C54x family of DSPs. The TI TMS320C549 and 5410 evaluation boards are also supported, and those products are resold by Elanix as part of two development kits. The RTDA C code generator now supports OFDM modulation/demodulation used in Digital Video Broadcasting, 802.11 wireless LAN applications and MFSK models.

SystemView 4.5 includes new technology for interoperability with Xpedion's GoldenGate/Sim RF and microwave simulation software. The combined solution bridges the divide between system engineers and RF designers, allowing them to see the impact of design changes at any level of abstraction early in the design cycle. The software is targeted to designers developing products for 2G, 3G and Bluetooth communications standards.

Performance has been improved that enables version 4.5 simulations to run twice as fast as in version 4.0. Workgroup features have been enhanced to allow designers to link their files automatically over the LAN. Analysis tools are improved with a new A-B overlay mode in the Dynamic System Probe.

▲ **Elanix' latest version is previewed in a new catalog/demo CD that includes technical notes and application examples.**

Library enhancements include a new Walsh Generator, Encoder and Decoder, used in CDMA systems, plus updates to opamp models and LC elliptic filter design. SystemView configurations start at $3,995.

For more information, contact:

Elanix, Inc.
5655 Lindero Canyon Road
Westlake Village, CA 91362
Tel: 818-597-1414
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Internet: www.elanix.com

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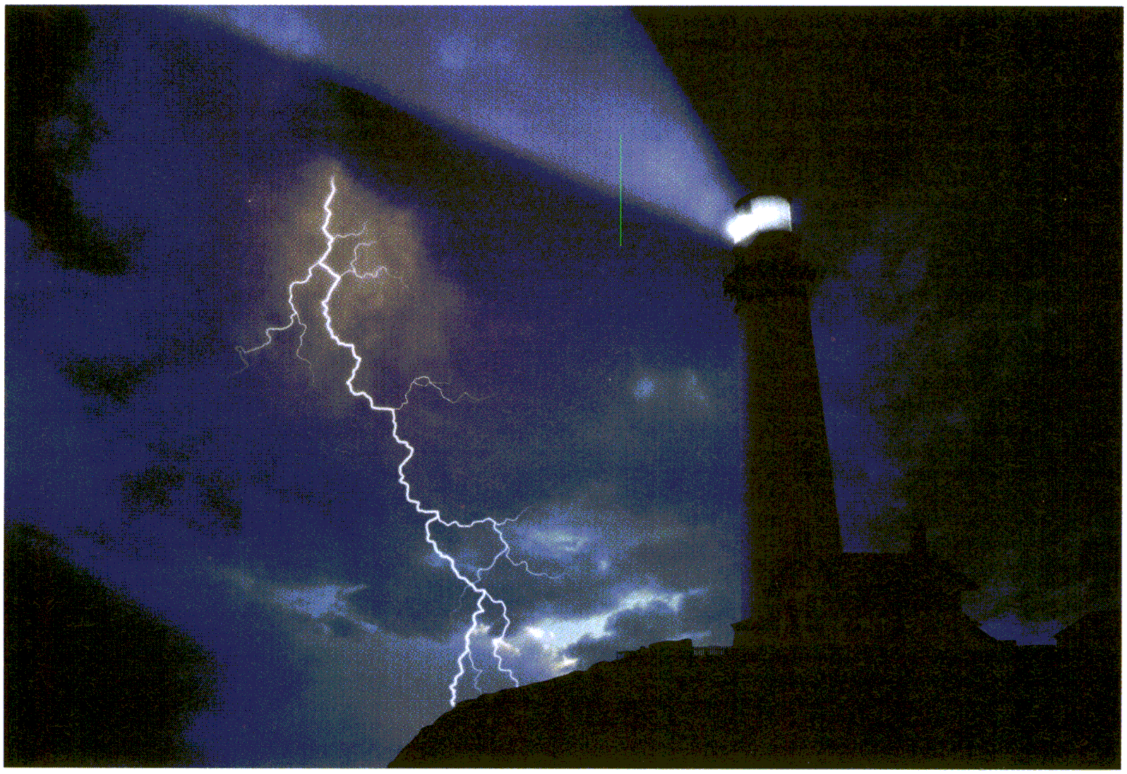

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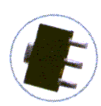
SPECIFICATION MATRIX

	SGA-6286 SGA-6289	SGA-6386 SGA-6389	SGA-6486 SGA-6489
Frequency (GHz)	DC-3.5	DC -3.0	DC-1.8
Gain (dB)	13.8	15.4	19.7
TOIP (dBm)	34.0	36.0	34.0
P1dB (dBm)	20.0	20.0	20.0
N.F. (dB)	3.9	3.8	2.9
Supply Voltage (Vdc)	4.2	5.0	5.2
Supply Current (mA)	75	80	75

All data measured at 1GHz and is typical. MTTF @ 150C T_j = 1 million hrs. (R_{TH} = 97C/W typ)

SiGe HBT MMIC features include:



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Circle 86

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TRB reviews proposed changes to procedures, assembly, test and screening specifications as they relate to product design, in addition to inspection criteria. While in the MRB mode, we discuss all new and open defective material reports (DMRs) awaiting resolution. As a group, we discuss strategies for failure analysis and corrective action to solve problems. Our Program Manager plays a role in this effort to create a direct link to our customers.

In addition, our TRB reviews critical sales orders, including all Class K orders where technical design or process challenges are likely. TRB members shepherd these orders until all outstanding issues are resolved or understood and finally released to production.

Critical production process controls are also reviewed during the weekly TRB sessions. Process review includes residual gas analysis (RGA) data from both sealer types; leak test data from all hermetic packages; foreign material in histogram format; and a rolling open DMR Pareto chart. While we do have SPC set up on all wire bonding and particle count processes, those processes are reviewed and acted upon real-time by shop floor personnel. TRB is also involved with establishing and running designed experiments (DOEs) for process characterization and improvement.

Detailed minutes from each meeting are ultimately copied to DSCC as part of our TRB Option certification. We keep a running list of open action requests and manufacturing notices (temporary process or documentation patches) that are also addressed each week. And if there is any time left, we cover miscellaneous or general business items. We retain all TRB records as part of our quality record retention program for customer or government review.

There is an important distinction between our version of the TRB and a management committee. The difference lies in how we make decisions and act on them. We quickly establish an owner for each problem we face, and that individual must find a solution to the problem. He is free to use company resources available to him, including the advice of other TRB members. His only restrictions are time and his ability to convince a majority of the TRB that his solution is permanent. The advantage of seven capable professionals discussing problems and solutions simultaneously cannot be replicated easily without these real-time working TRB meetings.

Of the objectives we've tasked our TRB with, continuous quality improvement, or CQI as we call it, is among the most important. We view each problem we're presented, regardless of the origin, as an opportunity to improve our overall production system in some way. The late Dr. Deming once said management is responsible for 85 percent of all problems since management designed the process (system). Our TRB is by definition our technology management structure for Cougar and therefore responsible for 85 percent of the problems that appear. This realization is a key motivator for our TRB members to solve problems intelligently and permanently.

We do business directly with some of the biggest microwave systems builders (satellites, radar, electronic warfare, etc.) in the industry, including Hughes Space and Communications, TRW, Lockheed Martin, Motorola, Boeing, Sanders and Raytheon. We are a significant supplier for the F-22 Raptor fighter, as an example. These companies are extremely sensitive to quality, performance and, of course, on-time delivery. They are not easily satisfied and tend to push the performance envelope. As a supplier, we owe it to our customers and ourselves to explore all creative means to support these companies to achieve their expectations and more. We feel that the TRB methodology, especially as we've implemented it here at Cougar, is an effective and creative measure to help attract and keep these customers. ■

Effective Quality Procedures are a Necessity

By Daniel L. Cheadle, Jr.
Cougar Components Corporation

Cougar Components Corporation is a manufacturer of hybrid microcircuits, primarily amplifier components and amplifier-based subsystems, operating from 10 MHz to 12 GHz. We focus on the space, military and high-end commercial wireless markets. While much of the industry emphasizes commercial wireless applications, the higher-performance systems addressed by Cougar, and the quality programs they require, are still a significant part of the microwave business. A review of our experience with these quality procedures should be useful to any supplier, whether they are required by their customers or not.

Dan Cheadle Jr. has been with Cougar Components in various capacities since his father founded the company in 1986. He has held the office of Vice President, Operations since 1994. In 1998, Dan was responsible for establishing Cougar's certified quality system to meet both ISO 9001 and MIL-PRF-38534 Class H and K, TRB Option. Cougar was the seventh company to achieve Class K TRB status through DSCC. Dan holds both bachelors and masters degrees in Industrial Technology from San Jose State University. He is a member of IMAPS and ASQ and serves on both the DeAnza/CACT and San Jose State Manufacturing Advisory Boards. He can be reached at Cougar Components Corporation, 290 Santa Ana Ct., Sunnyvale, CA 94086; tel: 408-522-3838; fax: 408-522-3839; e-mail: danny.cheadle@cougarcorp.com

With our recent certification from the Defense Supply Center Columbus (DCCC) in hand, we have more time to reflect on how our Technology Review Board (TRB) process actually works. We are now certified to MIL-PRF-38534 Class H and K, TRB Option and ISO-9001. Prior to certification, we spent much of our time in TRB ensuring that we had the appropriate documentation and controls necessary to validate our quality system's worthiness. There is strong evidence to suggest (primarily from our customer base) that our TRB process has many advantages over the typical "serial" or "function-to-function" problem-solving systems that are commonly found in our industry. The basis for our version of the TRB is the cross-functional weekly problem-solving meeting. In these weekly sessions, we review the quality and technical problems; we review critical process control documentation and data; we review critical technical contracts; and above all we continuously improve our entire quality system.

Our cross-functional TRB team consists of each discipline that materially affects the quality or reliability of our products or processes. We have select people in each of these roles and, since we are a small company of just over 100 people, they are all functional managers. Our TRB membership is as follows:

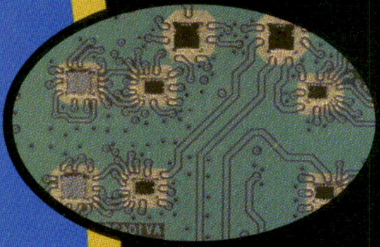
- Quality Assurance, TRB Chairman
- Electrical Engineering
- Production (Test) Engineering
- Process Engineering
- Manufacturing
- Program Management
- Sr. Management Representative

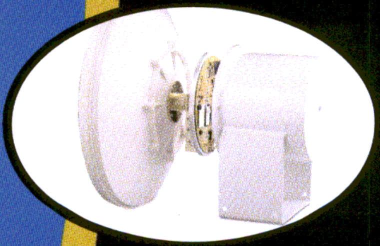
In broad strokes, Cougar's TRB charter includes the management of our entire Quality Management Portfolio. Our portfolio consists of six volumes containing our baseline QA manual and process procedures, as well as inspection and screening criteria. Cougar's Document Control department controls the binders for content and revision updates and requires a signature by the appropriate department representative to release each binder. The six volumes are placed throughout the company. Additionally, our off-shore assembly supplier has a set of the appropriate volumes from which to train and control their processes. The off-shore documents are updated along with our own in-house documentation as required. We have the six volumes organized by function:

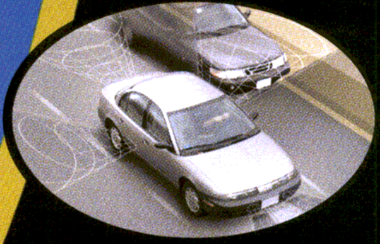
- QA Manual and top level procedures
- Quality Assurance procedures
- MIC Assembly procedures
- Mechanical Assembly procedures
- Administrative procedures
- Material verification and screening specifications

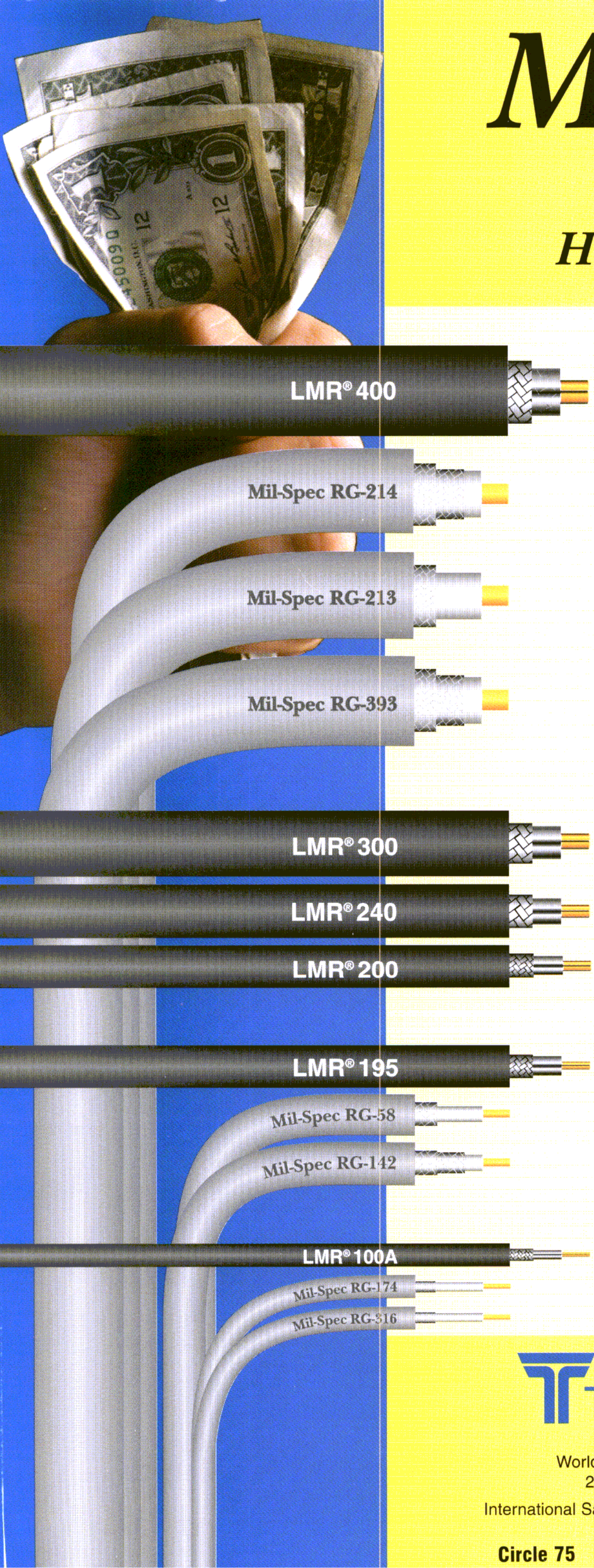
Our weekly TRB meeting involves handling the typical Change Control Board (CCB) functions as well as the familiar Material Review Board (MRB) activity. A Document Control representative joins the TRB for a period of time each week to coordinate the CCB activity for all change orders. The

continued on page 107









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