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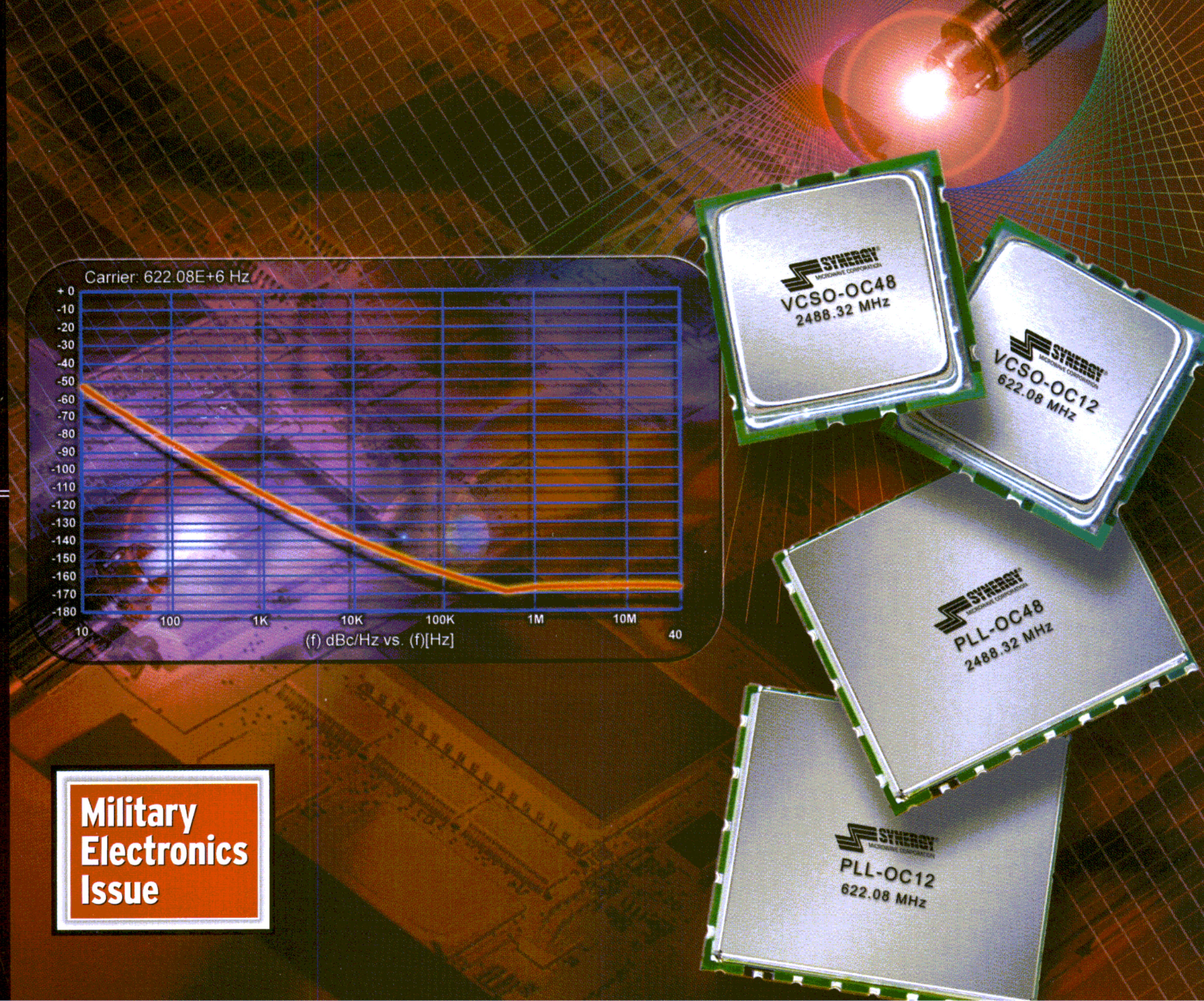
News
Military Electronics Show Unifies Designers

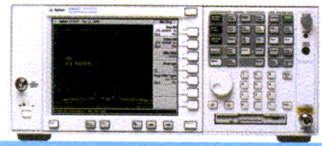
Design Feature
Wireless Testing With Multi-Tone Signals

Product Technology
Analyzer Reads Impedance To 3 GHz

SAWs Stabilize SONET Sources



Military Electronics Issue



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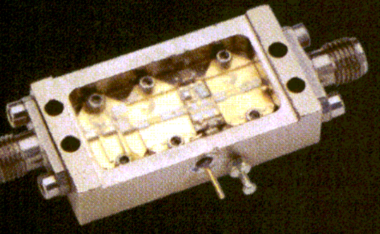
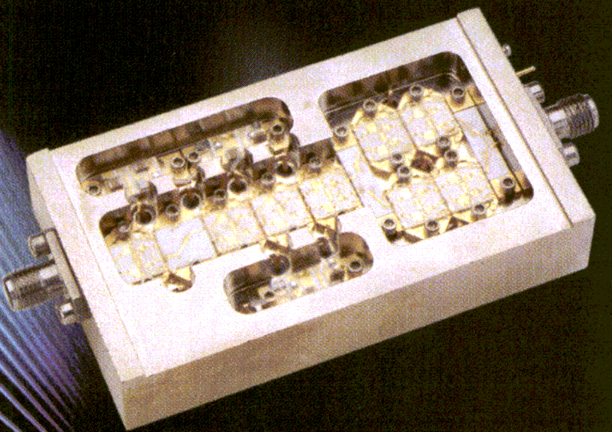
AMPLIFIERS for every application



ULTRA BROAD BAND

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Curr… mA
JCA018-203	0.5-18.0	20	5.0	2.5	7	17	2.0:1	250
JCA018-204	0.5-18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0-18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0-18.0	35	5.0	2.5	18	28	2.0:1	450
JCA218-407	2.0-18.0	30	5.0	2.5	21	31	2.0:1	500



MULTI OCTAVE AMPLIFIERS

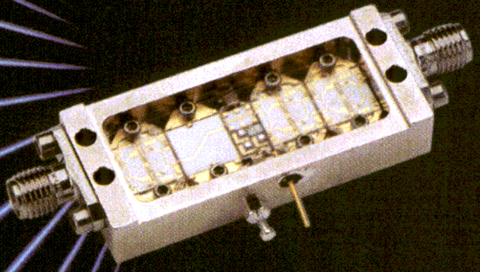
Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Curr… mA
JCA04-403	0.5-4.0	27	5.0	1.5	17	27	2.0:1	550
JCA08-417	0.5-8.0	32	4.5	1.5	17	27	2.0:1	550
JCA28-305	2.0-8.0	22	5.0	1.0	20	30	2.0:1	550
JCA212-603	2.0-12.0	32	5.0	3.0	14	24	2.0:1	550
JCA618-406	6.0-18.0	20	6.0	2.0	25	35	2.0:1	600
JCA618-507	6.0-18.0	25	6.0	2.0	27	37	2.0:1	800

MEDIUM POWER AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Curr… mA
JCA12-P01	1.35-1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1-3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9-6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0-12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0-18.0	22	4.0	2.0	25	35	2.0:1	700

LOW NOISE OCTAVE BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Curr… mA
JCA12-3001	1.0-2.0	40	0.8	1.0	10	20	2.0:1	200
JCA24-3001	2.0-4.0	32	1.2	1.0	10	20	2.0:1	200
JCA48-3001	4.0-8.0	40	1.3	1.0	10	20	2.0:1	200
JCA812-3001	8.0-12.0	32	1.8	1.0	10	20	2.0:1	200
JCA1218-800	12.0-18.0	45	2.0	1.0	10	20	2.0:1	250



NARROW BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Curr… mA
JCA12-1000	1.2-1.6	25	0.75	0.5	10	20	2.0:1	80
JCA23-302	2.2-2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7-4.2	30	1.0	0.5	10	20	2.0:1	90
JCA56-401	5.4-5.9	40	1.0	0.5	10	20	2.0:1	120
JCA78-300	7.25-7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-3000	9.0-9.5	25	1.2	0.5	13	23	1.5:1	150
JCA910-3001	9.5-10.0	25	1.2	0.5	13	23	1.5:1	150
JCA1112-3000	11.7-12.2	27	1.1	0.5	13	23	1.5:1	150
JCA1213-3001	12.2-12.7	25	1.1	0.5	10	20	2.0:1	200
JCA1415-3001	14.4-15.4	35	1.4	1.0	14	24	2.0:1	200
JCA1819-3001	18.1-18.6	25	1.8	0.5	10	20	2.0:1	200
JCA2021-3001	20.2-21.2	25	2.0	0.5	10	20	2.0:1	200

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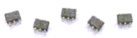

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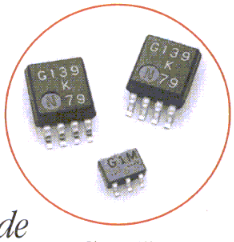
They can all be found in our *RFIC Selection Guide* under GaAs RFICs at:



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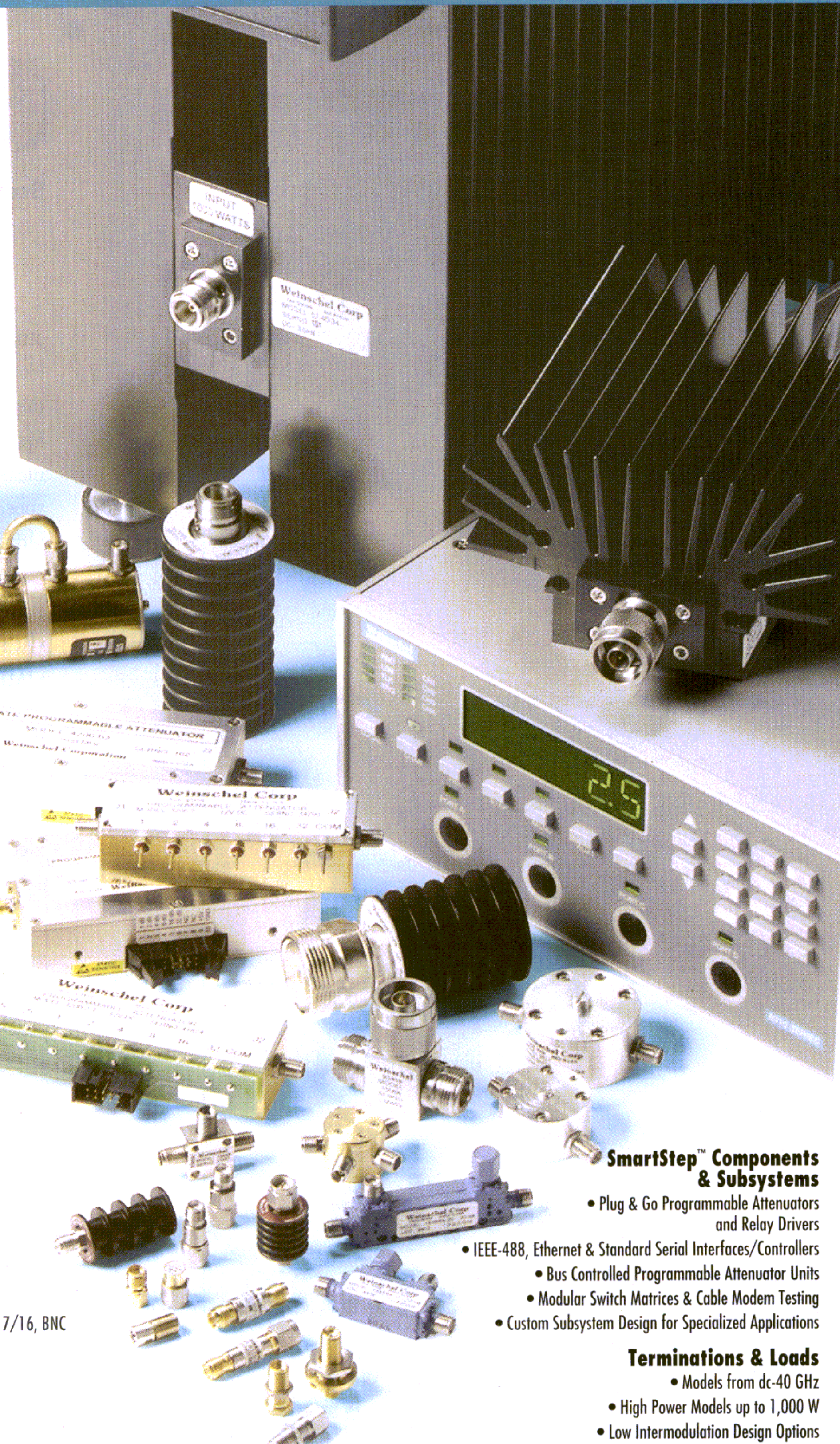

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Wrong Address

THIS LETTER IS IN RESPONSE to my article "Choosing Terrestrial Microwave Antennas For Extreme Environments" which ran as a Design Feature in the December 2000 issue (p. 115) of *Microwaves & RF*.

My e-mail address—donald.gardner@andrew.com—is correctly shown, but the Andrew website should be shown as http://www.andrew.com and not "http://www.garner.com." Also, the company address is 10500 West 153rd St. in Orland Park, IL. Your magazine listed it as 153rd St. Since Andrew is a well-known facility in this area, mail addressed to 153rd St. will be delivered here.

Thank you for taking note of this.

Donald Gardner
Product Line Manager
Terrestrial Microwave Antennas
Andrew Corp.

Beyond Fluff

I JUST WANT TO congratulate *Microwaves & RF* on the fine series of Design Feature articles that you ran in the January, February, and March issues. They certainly go beyond the usual "fluff" that we see in many publications these days.

While the first two, "Calculate Oscillator Jitter By Using Phase-Noise Analysis," were written by my competitor, I have to say that they are required reading for just about every components engineer in our industry. I have the utmost respect for someone who can put together the detailed analysis in these articles. We have used them many times in the last few weeks to define terms with our customers, so the benefit is many-faceted. I keep a copy of the articles on my desk at all times and I notice that many of the engineers I talk to do the same.

The March and April articles address a current topic in our industry as we move oscillators into the differential output structures to meet low-noise and high-frequency applications.

Thanks for the in-depth stuff.

James Fox
Sales & Marketing Manager
FOX Electronics

PLEASE COMMENT

Microwaves & RF welcomes mail from its readers. Letters should be typewritten and must include the writer's name and address. The magazine reserves the right to edit letters appearing in "Feedback." Address letters to:

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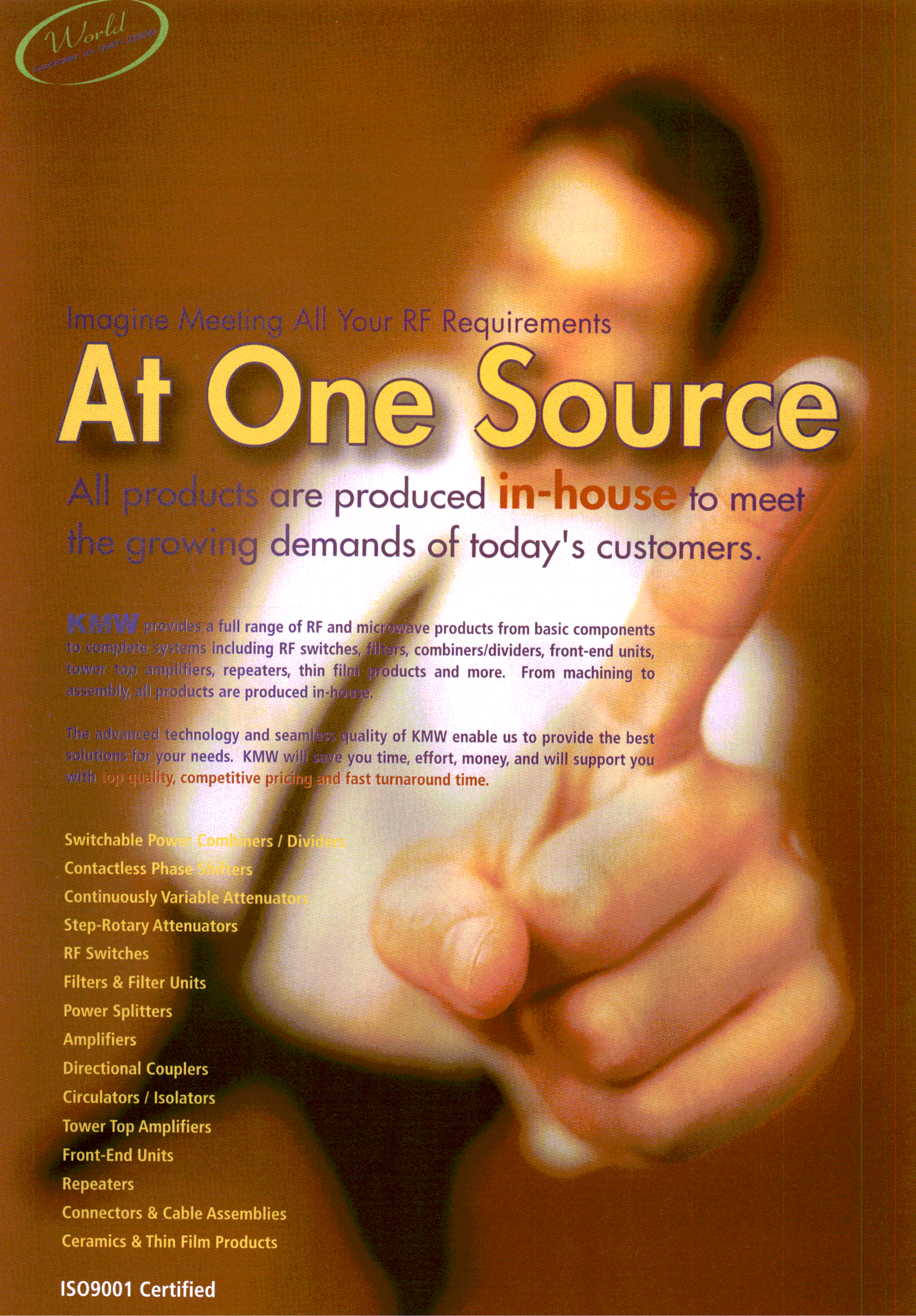
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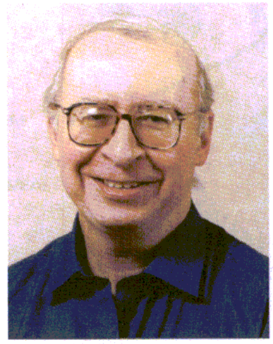
Making Amends For The Military



MILITARY ELECTRONICS HAVE generally represented the state of the art. The number of technologies that started with the military and are now common to commercial and consumer electronics is staggering. They include such things as code-division-multiple access (CDMA), the Global Positioning System (GPS), spread-spectrum communications, and even the encryption schemes that make our online Internet purchases secure. But with the growth in commercial markets over the last decade, the high-frequency industry no longer rushes to the needs of military customers.

The MES is not meant as another COTS show, but as an event that recognizes the needs of those working with military customers on their requirements.

From the 1960s through the 1980s, aggressive spending on military projects helped advance technologies such as phased-array radars, phase-locked loops (PLLs), gallium-arsenide (GaAs) and silicon (Si) semiconductors, superconductors, and vacuum tubes. But during the 1990s, the lure of commercial wireless markets pulled many suppliers away from the military markets, leaving military equipment designers and system integrators to compete with commercial customers.

The Military Electronics Show (MES) hopes to change all that. Think of it as an experiment in understanding the needs of military circuit and system designers. Scheduled for the Baltimore Marriott Waterfront Hotel (Baltimore, MD) during April 26-27, 2001, the MES is meant as a focal point for design engineers working on military projects. The conference and exhibition is designed as an educational forum for engineers to learn about the latest technological developments in components, software, test equipment, and as a meeting place for vendors and customers to exchange requirements.

True, there are other events that target military audiences, and several of the commercial-off-the-shelf (COTS) variety have sprung up in recent years to persuade those in military markets to adopt the use of commercial hardware. But COTS approaches do not truly meet the specialized needs of high-reliability, military circuit, and system designers. The MES is not meant as another COTS show, but as an event that recognizes the needs of those working with military customers on true military requirements.

The first time for any event is a challenge. Most would like to see what happens next year, and then come to the show. But for those who feel that this industry has abandoned the military customer during the last 10 years, the MES is a chance to make amends, as well as getting reacquainted with some former customers and old friends. We hope to see you in Baltimore.

Jack Browne
Publisher/Editor

Microwaves & RF

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Group Publisher Craig Roth, (201) 393-6225 • *croth@penton.com*
Publisher/Editor Jack Browne, (201) 393-6293 • *jbrowne@penton.com*
Managing Editor Peter Stavenick, (201) 393-6028 • *pstavenick@penton.com*
Senior Editor Gene Heftman, (201) 393-6251 • *gheftman@penton.com*
Senior Editor Don Keller, (201) 393-6295 • *dkeller@penton.com*
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Special Projects Editor Alan ("Pete") Conrad
Copy Editor Mitchell Gang • *mgang@penton.com*
Editorial Assistant Dawn Prior • *dprior@penton.com*
Contributing Editors Andrew Laundrie, Allen Podell

MANUFACTURING GROUP
Director Of Manufacturing Ilene Weiner
Group Production Director Mike McCabe
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Production Coordinator Eileen Slavinsky

ART DEPARTMENT
Group Art Director Peter K. Jeziorski • *pjeziorski@penton.com*
Associate Group Art Director Anthony Vitolo • *tvitolo@penton.com*

Reprints Sue McCarty—(845) 228-4896
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EDITORIAL OFFICE
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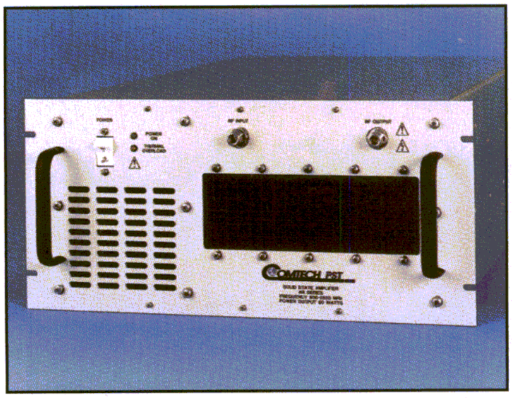

Model AR88258-100 provides a minimum of 100 Watts [@1dB compression] of output power over the 800-2500 MHz frequency band. With a nominal gain of 50 dB, two tone intermodulation products are -30 dBc (typical) @ 100 Watts PEP.

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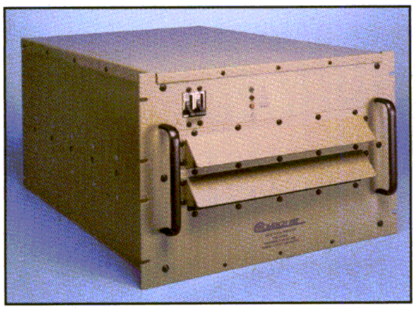

Model BHE27157-500 operates over the 20 to 150 MHz frequency range with 500 Watts minimum output power. This ruggedized power amplifier is powered from vehicular +22 to +32 VDC power and can operate over the -20° to +55° C temperature range with 100% condensing humidity. Output power is measured and controlled remotely as are the AM and FM automatic level controls (ALC).

Size is 12.25"H x 19"W x 26"D and weight is 110 lbs.

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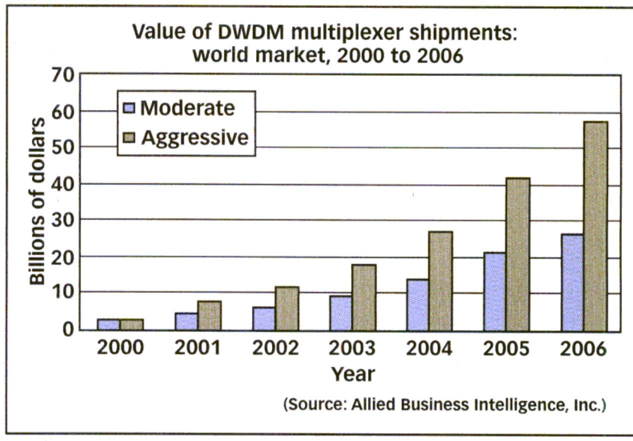
Multiwavelength Equipment Market Is Booming

OYSTER BAY, NY—Dense wavelength-division multiplexing (DWDM) is now the standard for long-haul fiber-optic networks. An Allied Business Intelligence, Inc. (ABI) report, "US and World Markets for DWDM Multiplexers and EDFAs," identifies fast-growing DWDM equipment markets for metro-area networks (MANs). It also quantifies the market opportunities for DWDM multiplexers (MUXs) and erbium-doped fiber amplifiers (EDFAs) in long-haul networks. The $3 billion DWDM market of 2000 is ready to grow to a minimum of $25 billion by 2006 **(see figure)**.

"The market for DWDM MUXs has the potential for more than doubling that amount if certain market conditions are fulfilled," notes Michael Kujawa, director of ABI's Emerging Technologies Research and the principal author of the report. Steady price declines and new technologies are spurring deployment of DWDM-powered networks for Internet data centers (IDCs), carrier hotels (CHs), enterprise systems connectivity (ESCON), storage-area networks (SANs), community-antenna television (CATV), and network access. These sites number in the tens of thousands worldwide.



The metro is the area of fastest network-traffic growth. The strongest network-demand surge is in the US, which was the first region to allow competition to enter the telecommunications marketplace. Western Europe, now experiencing a furious build out, is establishing a regional presence in the worldwide Internet infrastructure market.

Next-Generation Broadband Wireless Technology For MMDS Systems Is Introduced

MINNEAPOLIS, MN—ADC, a supplier of fiber optics, network equipment, software, and integration services for broadband multiservice networks, recently introduced the Axity Base Transceiver Station (BTS), an integrated, carrier-class transceiver station designed specifically for multicell deployments. With this technology, broadband wireless carriers can address capacity issues of super-cell network architectures and fill out coverage areas.

"The Axity BTS is the only product currently on the market that's specifically designed for mini-cell architecture, with both transmit and receive paths integrated within the system," says Sean Martin, vice president and general manager of ADC's Broadband Wireless Group. "It's important for our customers to move quickly and meet their customers' needs. This system enables them to do that as quickly as possible, at a relatively minimal expense."

The Axity BTS offers N+1 redundancy for carrier-class reliability, with one sector more than needed under full load to serve as a backup in case a primary sector fails. Its modular structure and hot-swappable components simplify repair and maintenance. It accommodates early deployments of single carriers and can expand to multiple carriers as capacity demand increases. The Axity BTS supports up to four sectors in downstream and upstream paths, and additional sectors or carriers can be added as needed. The unit is available for either outdoor or indoor deployment.

"The next generation of wireless phones holds great promise for consumers—everything from high-speed data communications to multimode phones that can be used practically anywhere in the world."

Next-Generation Wireless Phones Hold Much Promise

CANNES, FRANCE—The next generation of wireless phones holds great promise for consumers—everything from high-speed data communications to multimode phones that can be used practically anywhere in the world. But manufacturers will have to solve a variety of perplexing issues, ranging from current limitations in multimode transceiver operation, to manufacturing-yield problems and overheated handsets to insufficient battery life, before they can realize the promise of 3G.

Tropian, Inc. has addressed the multimode, power, and battery-life challenges of 2.5G and 3G wireless by taking an entirely different approach to the RF platform in handsets and base stations—an approach based on the Polar Impact™ transceiver technology.

"Linear modulation typically requires a linear power amplifier, which results in trade-offs between efficiency and linearity," says Richard Lodge, Tropian's director of marketing. "The latter causes adjacent-channel degradation, which can be a fundamental factor in determining network performance and capacity. There are also problems with device parametric restrictions, temperature instability, power-control accuracy, wideband noise, and production yield."

In response to the drawbacks of conventional linear architectures, Tropian's chip-set design uses Polar Impact, a polar-modulation technique. With Polar Impact, Tropian engineers implement RF components based on digital circuits, which are amenable to high levels of integration on bulk complementary-metal-oxide-semiconductor (CMOS) processes. Digital design also means that different modulation standards, including 3G, can be implemented in the same platform without changing the system architecture and simply by changing digitally encoded coefficients.

Communications-Equipment Providers Increase Demands For Ruggedized PC Products

NATICK, MA—According to studies from Venture Development Corp. (VDC) titled "The World Market for Fully Integrated Ruggedized Stationary PCs" and "The World Market for Modular Ruggedized PC Products," communications-equipment and service providers are almost insatiable in their demand for ruggedized personal-computer (PC) products as productivity tools for use in their businesses.

Communications applications are high-growth segments with the expansion of telephone and wireless network installations worldwide, expanding service features such as AIN, interactive voice-response platforms, and a host of other services being provided, and the rapid usage growth in the Internet, and related technologies.

Users in the communications industry also increasingly recognize that commercial office-grade PCs often lack the robustness and reliability needed in their operations. Downtime can be very expensive. For example, Internet service providers (ISPs) have learned from recent fiascoes such as that encountered by eBay, that it is more prudent to spend more upfront to ensure system uptime than face potential public-relations disasters and/or loose millions in lost income due to a system failure.

Physical-Verification Solution Is Optimized To Support Chips

SAN JOSE, CA—Cadence Design Systems, Inc., a supplier of electronic design products and services, announced that its new Assura physical-verification solution has been successfully optimized to support chips designed with IBM's silicon-germanium (SiGe) technology.

Assura helps IBM SiGe designers ensure that their RF and analog/digital mixed-signal chip designs meet the capacity and speed demands of emerging wired, wireless, and optical communications networking applications. IBM is currently offering the Cadence Assura Design Rule Checker (DRC) and Layout Versus Schematic (LVS) physical-verification tools to its SiGe customers. Customers can utilize Assura's batch and interactive capabilities in a unified environment for designs containing RF, analog, and digital components.

"We're committed to providing a complete set of verification tools to help our SiGe customers improve their design flow and meet time-to-market demands," says Dr. Gary Patton, director of wireless business for IBM Microelectronics. "Working with EDA suppliers like Cadence provides our customers with a comprehensive suite of tools that have been thoroughly tested and validated using stringent internal guidelines for complex SiGe chip designs."

RF Products And Services Using SOI Technology Make Their Debut

MINNEAPOLIS, MN—The Honeywell Solid State Electronics Center (SSEC) recently rolled out a variety of customized RF and microwave design and foundry services for designers and manufacturers in the wireless communication and high-speed fiber-optic networks. According to Grenville Hughes, Honeywell's product line manager, Honeywell leverages its experience with silicon-on-insulator (SOI) technology to develop high-performance chips. Hughes says, "With 15 years experience designing and producing SOI wafers, we're able to offer options specifically tailored for microwave applications that will result in lower costs."

In addition to producing a variety of digital attenuators and high-isolation switches designed by RF Integration, Inc. (Lowell, MA), Honeywell also offers customized options and foundry services using its 0.8-, 0.5-, and 0.35-μm complementary-metal-oxide-semiconductor (CMOS) process with a typical five-week proof-of-design turnaround cycle. "We're opening up a variety of foundry options for any size operation and will tailor services to meet our customer's specific needs," adds Hughes.

Customized features of the Honeywell packages include My SOI Foundry, My SOI Designer, My SOI Test, and My SOI Package.

Designers seeking an SOI CMOS foundry can partner with Honeywell for manufacturing services or with a designer or design team to either create designs or perform design translation. Beyond standard testing, Honeywell will perform DC, RF, and environmental testing. Die-packaging options, such as wafer thinning, backside gold (Au), bumping, and various packaging options are also available.

"The need for people in the telecom industry is stronger than ever, but there has been a definite shift in where the hires are occurring."

Employment Outlook In Telecommunications Is Strong

CLEVELAND, OH—The employment outlook for executive, professional, and sales people in the telecommunications industry is extremely strong, according to the latest hiring survey conducted by Management Recruiters International, Inc. (MRI), a search and recruitment organization. MRI is a subsidiary of CDI Corp., a staffing and outsourcing provider.

Of the executives with responsibility for hiring in the telecommunications industry, 74.2 percent indicated plans to increase their staffs in the first half of 2001, down 6.1 points from 80.3 percent for the second half of 2000. Another 21.7 percent plan to maintain current staff sizes, up by 5.8 points, and 4 percent plan decreases, down by 0.2 points.

By comparison, across all industries, 58.8 percent of the 3500 executives polled projected new hires for the first half of 2001. Another 35.2 percent plan to maintain their current staff sizes and 5.9 percent plan decreases.

"The need for people in the telecom industry is stronger than ever, but there has been a definite shift in where the hires are occurring," comments Allen Salikof, president of MRI. "Telecom professionals who jumped ship for dot coms are migrating back to brick-and-mortar companies because of the recent dot com bust. This should be another great year for the telecommunications industry."

Kudos

Intersil Corp. announced that its PRISM II wireless local-area-network (WLAN) chip set was honored as a Technology Award winner by *Wireless Design & Development* magazine, a wireless industry publication. *Wireless Design & Development* announced its Top 20 Technology Awards for 2000 on February 14 at a reception in San Jose, CA, site of the Wireless Portable Symposium and Exhibition...Scott Abrams has been named Reliability Engineer of the Year by the nation's leading electrical engineering association. Abrams is president of The Omnicon Group in Hauppague, NY, an engineering services firm. He recently received the award from the Reliability Society, part of the 350,000-member Institute of Electrical and Electronic Engineers (IEEE), an international professional association...Tyco Electronics Corp. announced that its Raychem Circuit Protection Division has completed the qualification process for the UL® Total Certification Program. Participation in this program will enable the company to accelerate product-development cycles and thereby reduce time to market for its PolySwitch® PPTC resettable fuse product line...Intersil Corp.'s Broadband Wireless Access facility in Scottsdale, AZ has earned registration/certification from National Quality Assurance (NQA) USA for meeting quality management ISO 9001:2001 standards. The registration covers all processes for the design, manufacture, and service of of electronic components, hardware, and software at Scottsdale. MRF

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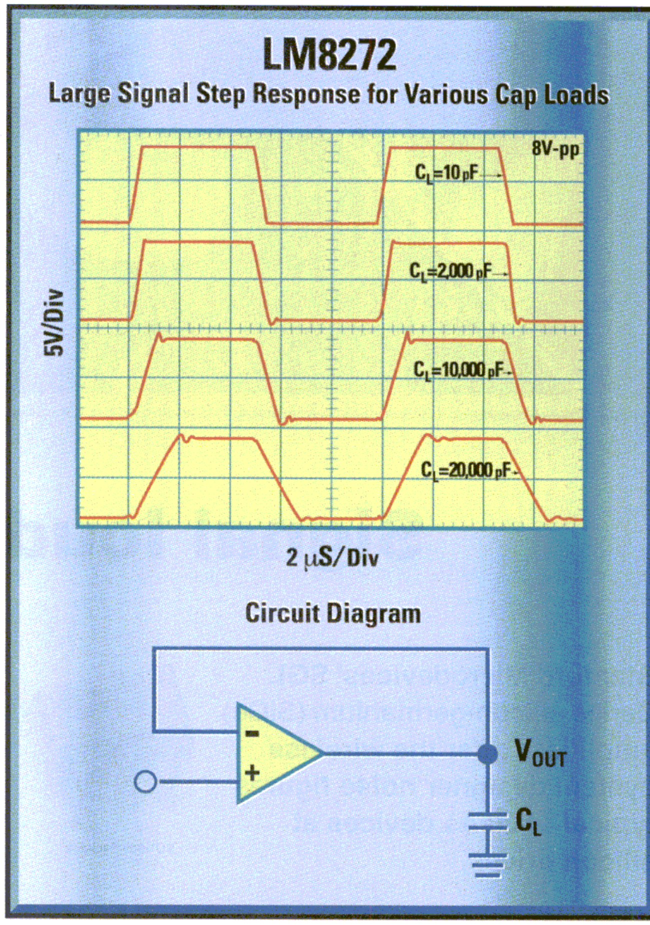

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Conference Unites Military Designers

The first-ever Military Electronics Show offers the opportunity for designers of military-grade electronic circuits and systems to compare notes.

JACK BROWNE
Publisher/Editor

Military designers once drove the high-frequency industry. In the 1970s and 1980s, this was especially the case, as defense-based funding accounted for a variety of technologies, including monolithic microwave integrated circuits (MMICs), direct digital synthesizers (DDS), and spread-spectrum communications. But with the explosion of wireless markets in the 1990s, less attention has been paid to the needs of military electronics designers—until, that is, the launch of the Military Electronics Show (MES). Scheduled for April 26th and 27th, 2001 at the Baltimore Marriott Waterfront Hotel (Baltimore, MD), the MES promises to minimize commercial topics and focus on military-grade hardware, software, and test equipment for designers and developers of military electronic circuits and systems.

Traditionally, military budgets have funded the research and development (R&D) of advanced electronics technologies, with many of these technologies eventually filtering to the consumer level. But with the growth and lure of global-communications markets, many of the former suppliers of military electronics have shifted their business plans away from the military and more toward commercial and consumer customers. Military system designers have made tremendous strides in adapting commercial-off-the-shelf (COTS) hardware to their designs, but COTS components do not fill all military design needs, especially for systems that must operate within hostile environments.

The MES has been developed as a single site where engineers can learn more about the technologies and products that impact their designs. It is not about COTS, but about fellow engineers and interested firms dedicated to the advancement of military electronics, from jammer amplifiers to radar-warning receivers (Rxs). The Military Electronics Show will present technical sessions on all levels of military component and system design, including software simulation and test techniques, and will offer an exhibition area for manufacturers to showcase their latest hardware, software, and test equipment for government and military applications.

The MES will open with a keynote breakfast address from Fred Levien, who retired in 1999 after 10 years as a Professor and Founding Chairman of the Information Warfare Dept. at the Naval Postgraduate School (Monterey, CA). Levien, a retired US Navy Commander, has authored books in the areas of microwave technology, directed-energy weapons, and information

Continued from page 29

warfare.

The MES will feature several two-day workshops produced by Besser Associates (Mountain View, CA), including an "Introduction to Digital Signal Processing" and "RF/Microwave Transmitters and Receivers." In the former, presenter Rick Lyons will provide a comprehensive and understandable introduction to digital signal processing (DSP). The course attempts to cover complex DSP topics through only sparse use of mathematics and equations, choosing to illustrate DSP theory through well-chosen examples. The first portion of the course covers lowpass and bandpass sampling, discrete Fourier transforms, and finite-impulse-response (FIR) filters that can be implemented with DSP techniques. The second portion of the course will highlight more advanced DSP topics, including fast Fourier transforms (FFTs) and infinite-impulse-response (IIR) filters.

In "RF/Microwave Transmitters and Receivers," presenter Ed Niehenke will provide an overview of the types and characteristics of modern transmitters (Txs) and Rxs. The two-day course will cover the underlying theory of operation and design techniques, as well as operational and performance parameters. The first portion of the course details Txs, including load-pull techniques for achieving optimal load conditions, different classes of amplifiers, power-combining techniques, nonlinear effects, and a power-amplifier (PA) computer-aided-design (CAD) example. The second portion of the course will cover Rxs, including Rx types, analog-to-digital-converter (ADC) considerations, noise-figure calculations, sensitivity, selectivity, spurious responses, frequency accuracy and stability, Rx nonlinearities, low-noise amplifiers (LNAs), filters, transmit/receive (T/R) switches, limiters, attenuators, phase shifters, and frequency synthesis.

Two additional two-day workshops, "Understanding Warfare in the Third Millenniium" and "Nonlinear Device, Circuit, and System Modeling with Additive Functions," provide different

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views of technology for modern military designers. In the former, Keynote Speaker Fred Levien returns to examine new concepts of modern warfare based on advanced technologies and how the US might plan to incorporate them in its armed forces in the next decade. Attendees will be able to identify key issues that will be moving the world toward information warfare and be able to learn why electronic warfare (EW) has become a more vital element of US strategy for the coming decade. In the nonlinear workshop, speaker Tom Turlington will discuss how new additive functions can be used to model nonlinear metal-semiconductor field-effect transistors (MESFETs) and bipolar transistors. The additive functions are then used to model amplifier behavior at various DC bias states and for signal levels ranging from very small to hard saturation. The course will show how trade-offs can be made in multistage amplifiers for third-order intercept performance, noise figure, and power consumption.

A variety of shorter technical presentations will be made at MES, with speakers hailing from some leading suppliers of military-grade equipment, including Agilent Technologies (Santa Clara, CA), Anritsu Co. (Morgan Hill, CA), and GHz Technology (Santa Clara, CA). Leonard Dickstein of Agilent, for example will describe measurements using digitally modulated test signals. He will detail the problems encountered in evaluating wideband systems, and will provide measurement approaches for measuring digitally modulated signals at bandwidths of 20 MHz, 36 MHz, 80 MHz, and 500 MHz.

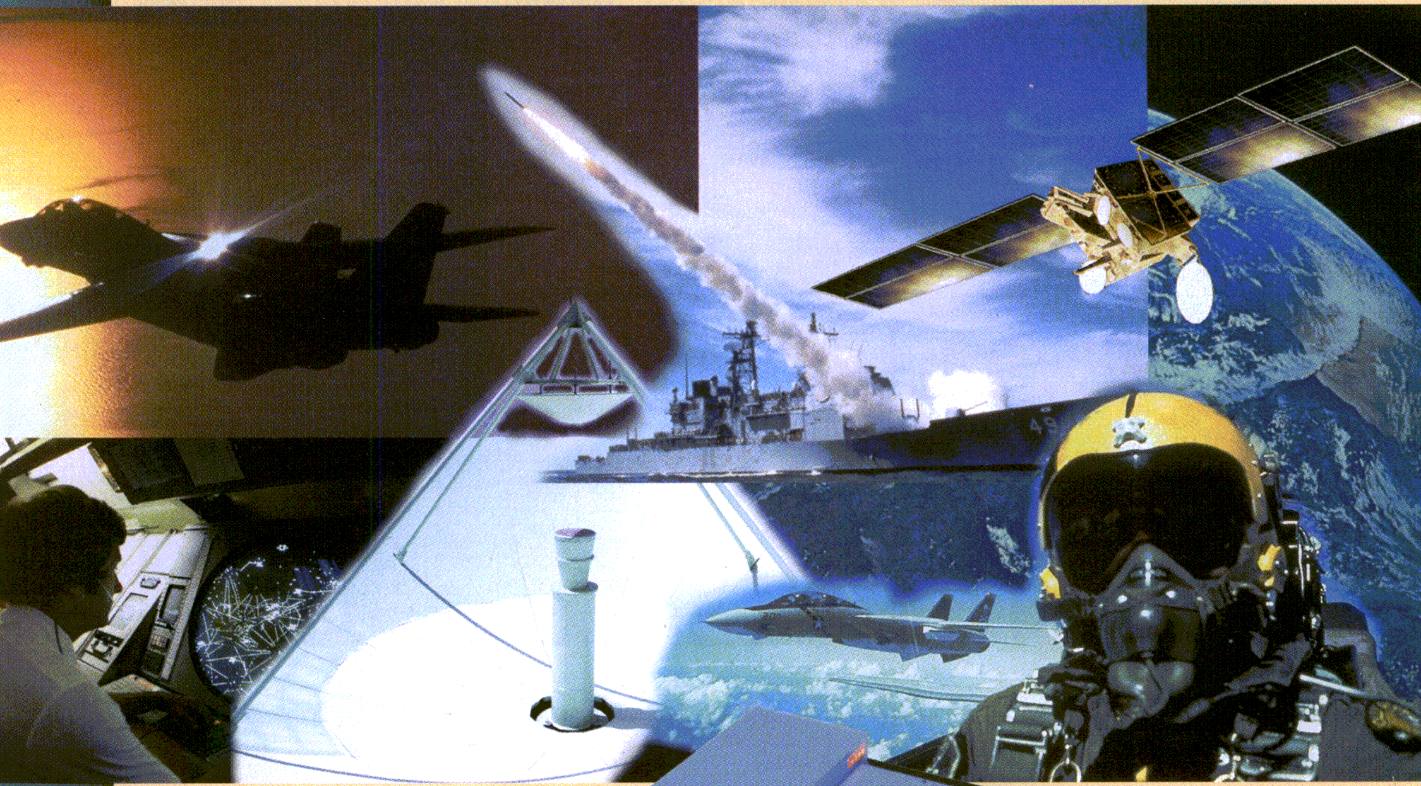
Martin Grace of Anritsu Company will highlight a 76-GHz radar target simulator and test system, and discuss how the military community can retrofit their vehicles with collision-warning-and-avoidance systems or adaptive cruise-control systems operating at 76 GHz.

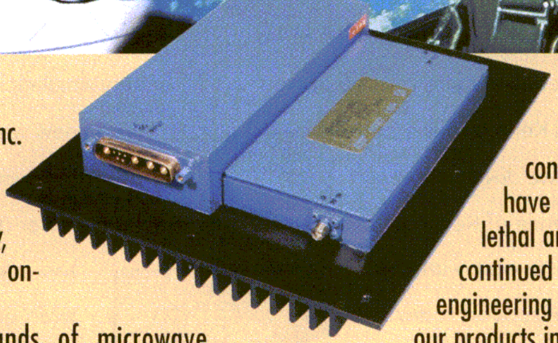
Mike Mallinger of GHz Technology will detail the use of laterally diffused metal-oxide-semiconductor (LDMOS) devices in high-power amplifier designs. The high gain, good efficiency, and excellent linearity of LDMOS FETs make them a suitable choice for a wide variety of RF and microwave power applications. In a military Identify Friend or Foe (IFF) system, configuring an entire PA (including the 500-W output devices) using high gain, Class AB linear transistors provides significant system advantages by providing the ability to handle newer signal modes. Designers of military IFF PAs have long desired an LDMOS device optimized for the high voltages (+40 VDC and higher) and high power levels (500 W and more) of IFF systems in 1030/1090-MHz pulsed applications. This presentation will describe the performance and reliability of such an LDMOS device that is optimized for IFF applications above 500 W.

Other technical sessions at MES will include a talk by TRW's (Redondo Beach, CA) Dwight Streit **(see sidebar)** on millimeter-wave developments in indium-phosphide (InP) descrete devices and ICs for terrestrial and space-based applications, a presentation by Jeff Gilling of Diamond Antenna & Microwave (Lowell, MA) on the use of roll rings as a high-performance alternative to slip rings in space-based and terrestrial applications, and a talk by Mike Geile of Nova Engineering (Cincinnati, OH) on how orthogonal-frequency-division-multiplexing (OFDM) techniques can be used to support spectrally efficient communications systems—even in environments with excessive multipath signal conditions. Mark Dapper, also of Nova Engineering, will highlight the use of techniques such as encryption and forward-error correction (FEC) in order to enhance the performance of Ground Sensor Systems, while Ray Nava of SSI Cable

Continued on page 153

Microwave Amplifiers and Subassemblies for Defense Electronics





More than a decade ago CTT, Inc. made a strong commitment to serve the defense electronics market with a simple goal: quality, performance, reliability, service and on-time delivery of our products.

Since then, tens of thousands of microwave amplifiers and assemblies have been delivered into applications including: ESM, radar systems, missiles, UAVs, seekers and decoys.

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As military budgets have continued to shrink, the threats have continued to become more lethal and diverse. CTT has, however, continued to incorporate excellence in engineering and production technology into our products in order to make your programs – whether new or upgrade – effective.

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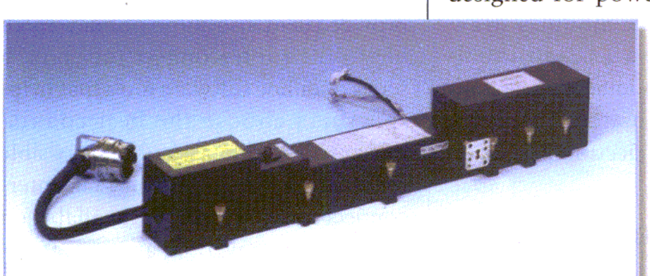
27th RF & Hyper Meeting Highlights New Products

One of Europe's leading high-frequency conferences/exhibitions brought thousands to Paris' La Defense district in search of the latest RF and microwave developments.

JACK BROWNE
Publisher/Editor

Paris in the springtime evokes romantic images. But Paris in winter can only mean one thing—the annual RF & Hyper Europe conference and exhibition. The 27th edition of this popular French conference and exhibition convened January 16-18 at CNIT in the La Defense section of Paris, France. Hundreds of exhibitors revealed the latest products from France and abroad to eager attendees. More than 200 exhibiting companies attended the 27th RF & Hyper Europe, with 31 of these companies hailing from outside of France. The exhibiting companies offered a representative cross-section of high-frequency technologies, from tiny integrated circuits (ICs) to sophisticated test instruments. For example, DeltaOhm (Taverny, France) displayed its extensive line of high-power stripline and coaxial components, including coaxial attenuators, directional couplers, and relays from DC to 6 GHz designed for power levels from 1 W to 2 kW. The firm also manufactures stripline loads, resistors, attenuators, and couplers for applications through 8 GHz at power levels up to 600 W.



1. Model TH3875 is a broadband TWT with dual-stage collector designed to provide 80-W continuous power from 18 to 40 GHz. (Photograph courtesy of Thales Electron Devices, Velizy, France.)

Thales Electron Devices (formerly Thomsom Tubes Electroniques, Velizy, France) displayed several high-power klystrons and traveling-wave tubes (TWTs) for telecommunications applications. The tubes provide up to 3-kW output power at frequencies from 1.5 to 44 GHz. Model TH 3875, for example, provides 80 W of continuous power from 18 to 40 GHz and is well-suited for millimeter-wave electronic-countermeasure (ECM) systems (**Fig. 1**).

The firm's model TH 2502 klystron has been developed for US and European direct-broadcast-satellite (DBS) applications. It provides 2.4-kW continuous output power from 17.3 to 18.1 GHz as well as 2.0-kW continuous output power ranging from 18.1 to 18.4 GHz.

Jacques Dubois (Barentin, France) offered a series of solutions for achieving electromagnetic compatibility (EMC), including strip gaskets, sheet gaskets, cable shielding, shielding panels, contact strips, and shielding coatings and adhesives. The firm also offers two sizes of transverse-electromagnetic (TEM) measurement cells for use from 100 to 400 MHz and a line of shielded rooms with 60-dB electric-field attenuation.

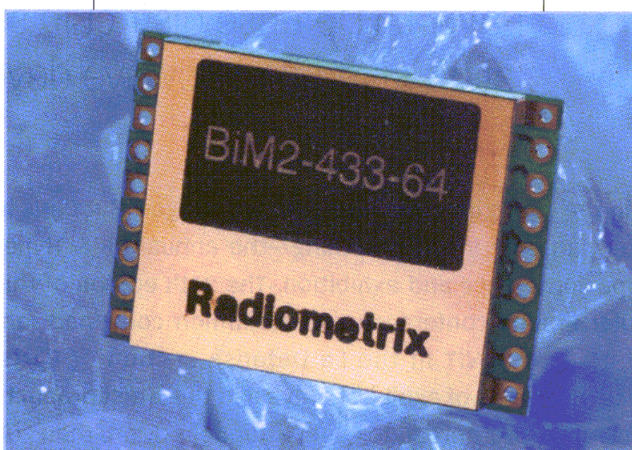
Continued from page 35

Memscap S.A. (Grenoble, France) showed some of its early component designs based on microelectromechanical-systems (MEMS) technology. The first designs are a set of high-quality-factor (Q) inductors ranging from 1.5 to 14 nH that are formed of copper (Cu)-on-insulator materials. They provide Qs of 50 to 80 at 2 GHz and are small enough for direct connection to ICs through flip-chip assembly.

Last November, the firm announced a licensing agreement with the Fujita Laboratory of the University of Tokyo (Tokyo, Japan) to develop optical components using their MEMS technology. The university laboratory is the primary research center for MEMS development in Japan. The company's MEMS fabrication process is a low-temperature process that is fully compatible with complementary metal-oxide semiconductor (CMOS).

Radiometrix Ltd. (Watford, England) introduced several radio modules, including the model BiM2-433-64 radio transceiver for use at 433 MHz. With a printed-circuit-board (PCB) height of only 4 mm, the transceiver module employs a surface-acoustic-wave (SAW)-filtered frequency-modulation (FM) transmitter (Tx) as well as a double-conversion superheterodyne receiver (Rx). The module is capable of handling data rates up to 64 kb/s over a usable range of 50 m within a building and 200 m over open ground. The unit draws 12-mA current at +3 and +5 VDC in the transmit mode and 17-mA current during receive mode. At +5 VDC, the Tx delivers +10-dBm output power. The Rx achieves −100-dBm sensitivity at a 1-PPM bit-error rate (BER). The overall image rejection is 60 dB. The 433-MHz transceiver measures 23 × 33 × 4 mm.

The firm also launched a series of Tx and Rx modules for the United Kingdom's license-exempt 173-MHz band. The modules are suitable for use in battery-powered portable equipment applications and handheld data-terminal devices. The standard frequencies are 173.225 and 173.250 MHz, although frequencies from 135 to 225 MHz are also possible. The Tx modules feature two-stage crystal-frequency control with narrowband frequency modulation (FM) to 10 kb/s and 25-kHz channel spacing. The DC-to-RF efficiency is approximately 35 percent at +3 VDC. The transmit power of 10 mW (+10 dBm) provides a usable communications range in excess of 10 km, depending upon the choice of data rate and antenna.



2. The BiM2-433-64 high-speed FM radio transceiver conforms to EN300 220-1 and ETS 300 683 regulations for data transmissions at 433.92 MHz. (Photograph courtesy of Radiometrix Ltd, Watgford, England.)

The single-conversion Rx modules feature a narrowband FM superheterodyne design with a sensitivity of −116 dBm for a BER of 1 PPM. The image rejection is better than 50 dB. The Rx modules draw approximately 12-mA current from a +2.7- to +10.0-VDC supply while the Tx modules draw about 9.5 mA from a +2.2- to +10.0-VDC supply. Both module types feature built-in power regulators to ensure good supply noise rejection (**Fig. 2**).

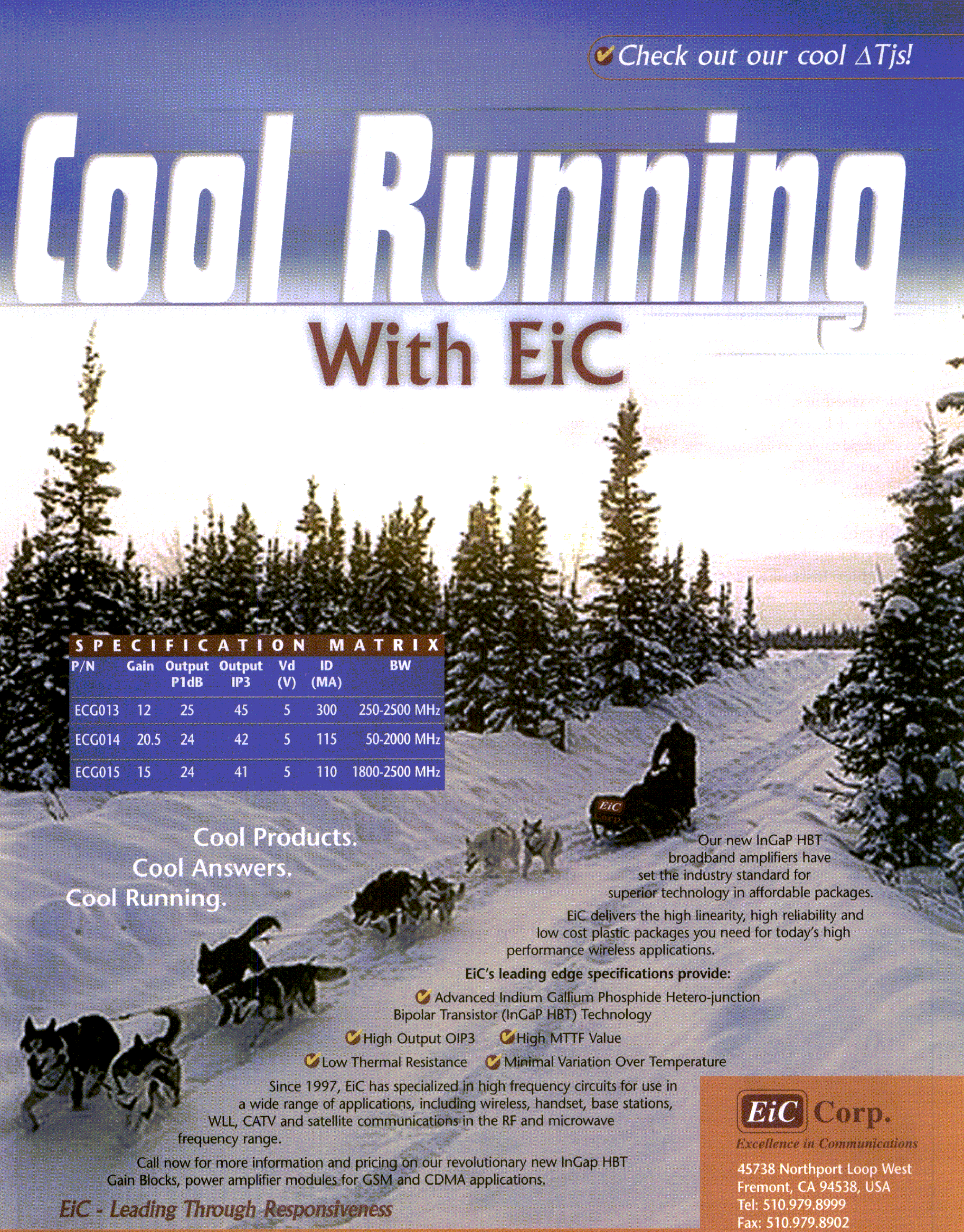
Quadrature Modulator

RF Micro Devices (Greensboro, NC) announced the availability of the RF2485 quadrature modulator for Terrestrial Trunked Radio (TETRA) systems (**Fig. 3**). The IC, which is designed for TETRA use in the 200-to-600-MHz band, achieves a typical noise floor of −149 dBm/Hz offset 5 MHz from the carrier and a typical adjacent-channel power ratio (ACPR) of −48 dBc at 25 kHz. The gallium-arsenide (GaAs) metal-semiconductor-field-effect-transistor (MESFET) IC contains two balanced mixers, a degree hybrid phase splitter, limiting local-oscillator (LO) amplifiers, two differential input amplifiers, a combining output amplifier, and an output RF amplifier. The quadrature modulator operates from a single +5-VDC supply.

Mitel Semiconductor (Kanata, Ontario, Canada) offered Smart OSA optical-communications technology. The technology is based on a modular concept that provides customers with a wide choice of Tx and Rx configurations. The firm's 623 family includes 4-, 8-, and 12-channel Txs capable of 2.5 Gb/s per channel for transmission rates of 10, 20, and 20 Gb/s over lengths to 300 m.

The company also demonstrated their model MT1020 Bluetooth baseband controller with full-duplex audio codec. The low-power processor performs full voice and data processing for 2.4-GHz Bluetooth personal wireless-connectivity systems using a proprietary architecture optimized for voice while addressing the power, cost, and form-factor requirements of the Bluetooth standard.

Axon Cable SA (Montmirail, France) provided demonstrations of a new module to their interconnect tool box, a series of online software tools that helps specifiers choose the best coaxial microwave cable assemblies possible for a particular application. The interconnect toolbox, which is available on the company's website at www.axon-cable.fr, provides utility programs that allow users to calculate the maximum acceptable current inside a wire with a Cu conductor, based on the ambient temperature, the insulation material, and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SPECIFICATION MATRIX

P/N	Gain	Output P1dB	Output IP3	Vd (V)	ID (MA)	BW
ECG013	12	25	45	5	300	250-2500 MHz
ECG014	20.5	24	42	5	115	50-2000 MHz
ECG015	15	24	41	5	110	1800-2500 MHz

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EiC delivers the high linearity, high reliability and low cost plastic packages you need for today's high performance wireless applications.
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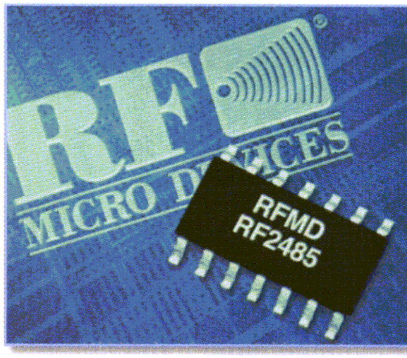
Since 1997, EiC has specialized in high frequency circuits for use in a wide range of applications, including wireless, handset, base stations, WLL, CATV and satellite communications in the RF and microwave frequency range.
Call now for more information and pricing on our revolutionary new InGap HBT Gain Blocks, power amplifier modules for GSM and CDMA applications.
EiC - Leading Through Responsiveness

Continued from page 36
the type of environment. Another program allows users to determine the average life cycle of a wire according to the ambient temperature and the insulating material chosen. It can also determine the maximum acceptable ambient temperature based on a specific life cycle.

The firm also introduced a new cable at the show, the QUASI-FLEX handformable coaxial cables which are meant as direct replacements for semirigid cable assemblies. The dimensions of the QUASI-FLEX cables are identical to semirigid cables, as defined by the MIL-C-17 standard. The brass tube of semirigid cables has been replaced with a tin (Sn)-plated braided shield in the QUASI-FLEX cables. A protective jacket can be added over the braid.

Keithley Instruments (Cleveland, OH) offered their model 2500 dual photodiode meter for testing laser-diode modules. The instrument includes a photodiode detector that is used to monitor the output of laser diodes, a Peltier thermoelectric cooler with thermal sensor for control of the temperature of a module under test, and a picoammeter which can resolve currents as low as 10 fA. This sensitivity supports precise measurements of laser-diode dark currents (the current that flows through an unilluminated photodetector). The dual-channel model 2500 features a built-in ±10-VDC/±100-VDC voltage source. A variety of software drivers is available for use with LabVIEW and LabWindows software programs.



3. Model RF2485 is a quadrature modulator for TETRA systems operating in the 200-to-600-MHz band. (Photograph courtesy of RF Micro Devices, Greensboro, NC.)

Mepax (Sevres Cedex, France) offered insight into their unique website at www.mepax.com, a site where research and development (R&D) and purchasing departments can express their specification needs at the beginning of a development cycle and take advantage of a staff of more than 150 experts who are part of the mepax.com site. As part of the site's Mercury Engineering Process Accelerator, these advisors will analyze the market for the project in development and objectively select the best suppliers for the project.

The site's advisors offer expertise in

Continued from page 38

a variety of different disciplines, including in electronics, energy, automotive technology, processing technology, medical science, building management, as well as test and measurement. The company's co-founder, Sofiane Jedidi, notes that the company's philosophy is straightforward: "Our vocation is to simplify the development process of the R&D department by selecting suppliers who have already handled, or are the most suitable in handing, a functional need in a particular application environment."

APLAC Solutions Corp. (Helsinki, Finland) demonstrated their powerful APLAC Simulator, which combines circuit, system, and EM simulation capabilities within a single platform. The latest version of the program, Version 7.6, provides a variety of analysis methods, including analysis of DC and AC currents, frequency and time domains, noise, sensitivity, harmonic balance, and optimization with automatic statistical support.

The object-oriented software covers applications ranging from ICs to board- and system-level simulations, and from the DC level to RF and microwave analysis. The APLAC simulator actually consists of several separate but interactive tools. The front-end APLAC Editor automatically generates an input file, containing the nodes, branches, and model parameters of the components, from a circuit schematic or block diagram.

The APLAC RF Board Module extends APLAC's PCB-level modeling capabilities with an extensive library of microwave components and special nonlinear-analysis methods for RF applications. The APLAC RF IC Module extends APLAC's IC-level modeling potential for using semiconductor vendors' proprietary component models as well as special nonlinear analysis methods for RF IC applications. The APLAC System Simulation Module is optimized for path analysis of digital communication signals, including fading and multipath, while the APLAC Electromagnetic Module incorporates an integrated finite-difference-time-domain (FTDT) simulator, the most versatile EM scheme currently known for the analysis of arbitrary, dynamic field problems.

The 28th RF & Hyper Europe conference and exhibition is scheduled for January 15-17, 2002 at CNIT, Paris La Defense, France. **For more information, please contact Sylvie Cohen, BIRP, 17 Avenue Ledru-Rollin, 75012 Paris, France; (33) (0) 153171140, FAX: (33) (0) 153171145, e-mail: hyper@birp.fr, Internet: http://www.birp.com/hyper.** MRF

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The broadband units also offer exceptional IP3 performance and superior linearity for the power consumed.

Part Number	Bandwidth (GHz)	Gain @ 1 GHz (dB)	Gain @ 2 GHz (dB)	P1dB (dBm)	OIP3 (dBm)	Noise Figure (dB)	Vd (V)	Id (mA)
Low Voltage Gain Blocks								
SGA-0163	DC-4.5	13	12	-2	+9	4.7	2.1	8
SGA-0363	DC-5.0	20	17	+2	+14	3.0	2.5	11
High Reverse Isolation Gain Blocks								
SGA-1163	DC-6.0	12	11	-3	+8	3.1	4.6	12
SGA-1263	DC-4.0	16	15	-8	+3	2.7	2.8	8
General Purpose Gain Blocks								
SGA-2163	DC-5.0	10	10	+7	+21	4.2	2.2	20
SGA-2263	DC-3.5	15	14	+8	+20	3.2	2.2	20
SGA-2363	DC-2.8	17	16	+8	+19	2.9	2.7	20
SGA-2463	DC-2.0	20	17	+9	+20	2.7	2.7	20

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An Interview With Dr. K. "Ram" Ramachandran

Dr. K. "Ram" Ramachandran is president and one of the founders of Filtran Microcircuits, located in Ottawa, Ontario. The company is a leading manufacturer of high-resolution microstrip, heat-sunk microstrip, and multilayer printed circuits for microwave and millimeter-wave systems. The company was founded in 1983 and acquired by Merrimac Industries in February 1999. It is one of the few microwave printed-circuit manufacturers with fine-line, high-resolution photolithography that approaches semiconductor industry levels of intricacy.

MRF: How did you and Filtran come to focus on the precision end of the circuit-board industry?

Ram: When I left the Canadian National Research Council to found the company, I actually intended to develop thin film on ceramic. However, it became obvious that there were few companies serving the microwave industry that could produce really-high resolution circuits on Teflon. Since that was an area in which I had experience, we gradually shifted our efforts there.

MRF: What differentiates Filtran from others in your part of the circuit-board industry?

Ram: Of the 750 or so circuit-board companies around the world today, there are only a few with the ability to produce fine-line detail like ours. Filtran has also developed a reputation for working with customers to review designs to ensure their suitability for manufacturing, and for solving very complex circuit-fabrication problems. Of course, we're not unique in that regard, but I think we've been able to demonstrate a really uncommon ability to apply specialized techniques to circuit designs that otherwise would have ended their lives in R&D for lack of a viable solution. By viable, I mean not only meeting or exceeding the requirements presented to us by our customers in terms of electrical performance, but being manufacturable as well. Many of these circuits have resolution near that of semiconductors.

MRF: Are there specific techniques that you have developed over the years?

Ram: Our major strengths are in high-resolution, tight-tolerance circuits, in gold plating, and in finding solutions for producing complex circuits that have eluded others. One of the techniques we've developed, which we call the "sputtered blind hole process," adapts the sputtering techniques used for decades by the semiconductor industry to plated-through holes in metal-backed circuits. It provides the thermal management that high-power, metal-backed circuits require, and eliminates many of the problems you encounter with chemical plating processes, which are messy, and grounding pins, which provide a questionable bond.

MRF: How has your acquisition by Merrimac affected your business?

Ram: The association is allowing us to achieve our true value as a company. I have worked since the acquisition with (Merrimac Chairman and CEO) Mason Carter to make broad improvements in infrastructure, management, and process equipment that were simply beyond our reach before. The support provided by Merrimac is allowing us to pursue high-volume applications with a much higher degree of focus on establishing solid customer relationships. The momentum for growth and customer intimacy comes directly from Mason.

MRF: What do your fabricated circuits require that your lower-frequency counterparts do not?

Ram: Basically, everything becomes more difficult at higher frequencies. Most of the lower-frequency work requires 5-mil lines and spaces, but millimeter-wave circuits get that down to 3 mil or so. We've developed the ability to produce features of less than 2 mil, which is necessary for circuits up to 100 GHz.

MRF: What applications need this level of precision?

Ram: Most of the circuits that we create operate anywhere from 15 to about 100 GHz. We've traditionally done a lot of work for satellite-communications systems, wireless backhaul, and other high-frequency applications. However, we're now getting requests for adaptive cruise control and vehicle radar systems that operate around 77 GHz, as well as for LMDS, which operates just below 30 GHz. Right now, the system builders aren't looking for really large quantities of circuits in these applications, but we're confident that they will be. For example, LMDS shows promise for business applications, and adaptive cruise control is being offered on cars and trucks in lower-price ranges, rather than just on the near-luxury and luxury vehicles. I think that because of developments in semiconductor technology, as well as the limited amount of spectrum available at lower frequencies, we may finally see some high-volume applications at millimeter wavelengths.

MRF: Since these markets are just now developing, isn't it difficult to project the company's future needs?

Ram: We concentrate our efforts on satisfying key customers with whom we have built long-standing relationships, as well as on developing new business in our target markets.

MRF: Nevertheless, if your projections for LMDS, adaptive cruise control, and other millimeter-wave applications are correct, you'll need to deliver very large quantities of circuits sometime in the near future. How are you planning to accommodate this demand?

Ram: We have prepared and are now implementing a comprehensive plan that will dramatically increase our manufacturing capabilities in a very short time. In Ottawa, we've instituted second and third shifts, and last year Merrimac invested more than $1 million in new processing equipment and infrastructure at Filtran. Our new general manager, who was vice president for materials and business processes of Merrimac, has been transferred to Filtran and is coordinating our expansion plans. This allows me to spend more time refining processes and developing new techniques, which is where I can contribute most effectively.

MRF: With the level of precision that these circuits require, is there a high level of labor involved in manufacturing? If so, how will you deal with this in a high-volume environment?

Ram: Combining engineering talent with the right automated equipment makes it possible to produce large numbers of very complex circuits with very little "hands-on" labor. Talented people are always a benefit as well. MRF

RF digitizer suits signal processing

THE MODEL 2319E is an RF digitizer for second-generation (2G), intermediate-generation (2.5G), and third-generation (3G) digital cellular testing. The digitizer operates across a frequency range of 500 MHz to 2.5 GHz and provides a 20-MHz digitization bandwidth. It converts complex modulated broadband RF signals into digitized data for external processing on a personal computer (PC). The digitizer can handle 50 W of RF power, sample 65.28 MSamples/s, and offers 12-b resolution. Phase noise is −121 dBc/Hz and sensitivity is −153 dBm/Hz. It has a built-in Fast Fourier transform (FFT) spectrum monitor and 1-MSamples/s internal in-phase/quadrature (I/Q) data memory.

IFR Corp., 10200 West York St., Wichita, KS 67215-8999; (800) 835-4981, Internet: http://www.ifrsys.com.

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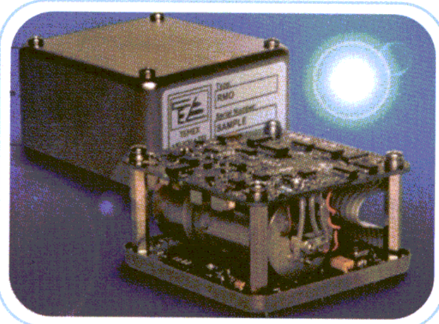

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Mini RMOs reduce space and cost

A SERIES OF miniature rubidium master oscillators (RMOs) occupies 200 cc of space, is 40 mm tall, and is said to cost up to 20 percent less than competitive RMOs. These devices have identical pinouts and functions of ultrastable double-oven oscillators, yet claim to have twice the stability. Typical long-term stability is less than 5×10^{-11}/month, while typical temperature stability is $\pm 5 \times 10^{-11}$ from −5 to +55°C. They are available in standard frequencies of 5, 10, and 20 MHz. Other available frequencies include 8.192 and 4.096 MHz for integrated-services digital network (ISDN), 13 MHz for Global System for Mobile Communication (GSM) base stations, and 10.23 MHz for Global Positioning System (GPS).

Temex Electronics, Inc., 3030 West Deer Valley Rd., Phoenix, AZ 85027; (623) 780-1995, FAX: (623) 780-2431, Internet: http://www.temex-az.com.

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Portable RF meter targets low-power uses

THE MODEL 7100 handheld RF power meter measures average RF power levels to 500 mW continuous, or to 1 W for 10 s, at frequencies from 10 to 2000 MHz, for low-power test and troubleshooting applications. The meter has four measurement ranges: 1.999 mW, 19.99 mW, 199.9 mW, and 1999 mW (500 mW maximum) full scale. Measurements are displayed on a 3-1/2-digit liquid-crystal display (LCD). Accuracy is ±10 percent of full scale from 10 MHz to 1 GHz, and ±15 percent of full scale from 1 to 2 GHz. The meter measures 3.5 × 6.3 × 1.8 in. (89 × 160 × 45 mm) and weighs 2 lbs. (900 g). It is powered by two +9-VDC batteries.

Tegam, Inc., Ten Tegam Way, Geneva, OH 44041; (440) 466-6100, FAX: (440) 466-6110, Internet: http://www.tegam.com.

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Test receivers measure EMI compliance

TWO ESPI TEST-receiver models offer the precision of a test receiver (Rx) with the high speed of a spectrum analyzer for electromagnetic-interference (EMI) pre-compliance and diagnostic measurements. One model operates from 9 kHz to 3 GHz. The other operates from 9 kHz to 7 GHz. In the Rx mode, the operator can select one of four measurement bandwidths: 200 kHz, 9 kHz, 120 kHz, and 1 MHz. Detectors in this mode include peak, quasi-peak (CISPR), root-mean square (RMS), and average. In the analyzer mode, the operator can select measurement bandwidths from 10 Hz to 10 MHz in 1-3 sequence. Detectors in this mode include max peak, mini peak, auto peak, sample, RMS, and average.

Rohde & Schwarz GmbH & Co., Muhldorf str. 15, D-81671 Munich, Germany; +49 89 4129-11765, FAX: 48 89 4129-13208, Internet: http://www.rohde-schwarz.com.

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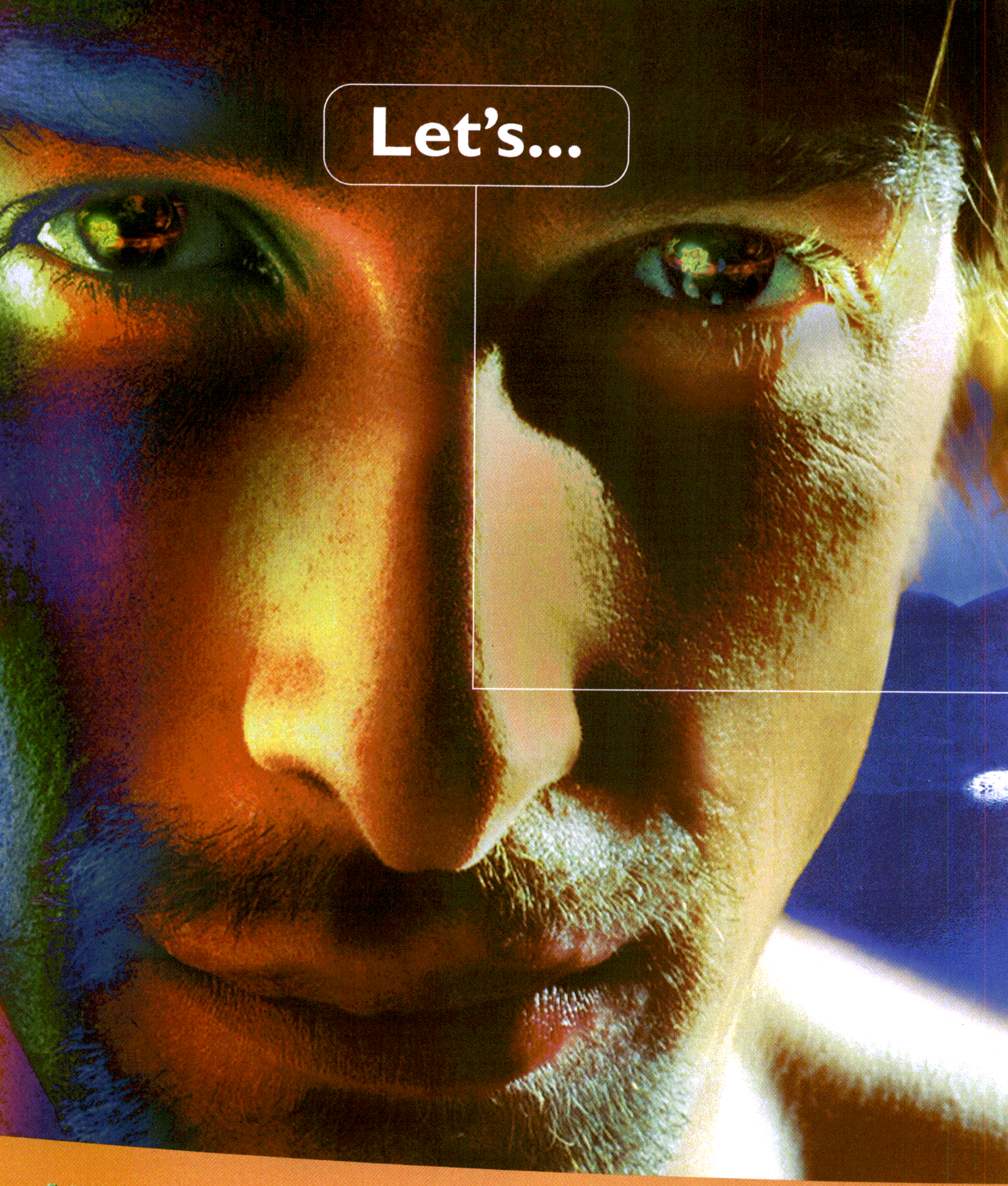
What Generation Is It Anyway?

DEPENDING ON WHO is doing the defining, and what part of the world they are speaking about, it is a toss-up as to what generation of the wireless revolution—second generation (2G), second-and-a-half generation (2.5G), third generation (3G)—we are in. Japan and Asia are generally regarded as the most advanced, with NTT DoCoMo, Japan's biggest mobile carrier, set to roll out 3G services in the next month or two. But not all Asian wireless providers are following suit, according to a recent CNN report out of South Korea that says that some analysts think 3G wireless is not just around the corner, despite hyped expectations.

Re-evaluating their 3G launch is SK Telecom, South Korea's largest wireless telecommunications provider with 11 million users, 44 percent of the country's market. The company is delaying its 3G introduction until at least 2003, to recoup the costs of its current 2G and 2.5G systems. Along with that, Asian providers such as SK are taking a hard look at the experience of European telecommunications companies that spent huge amounts—estimated at approximately $90 billion—in the United Kingdom and Germany to purchase the licenses for 3G spectrum. The giant outlay is forcing these companies to introduce 3G services earlier in an effort to recover costs. However, analysts believe that the Europeans will pay a high price to build the infrastructure, and coupled with the large licensing expenditure, profitability will be pushed many years into the future. By delaying its entrance into 3G services, SK believes that its spectrum, as well as the equipment needed to run the advanced wireless networks, will cost far less in Asia. This will enable Asian companies to turn a profit in a shorter time.

While 3G is in its infancy (at best), a group of the top European mobile communications equipment manufacturers has joined together to plan for fourth generation (4G), an as yet undefined wireless world that is expected to come into existence around 2010. Alcatel SA, L.M. Ericsson Telephone, Nokia, and Siemens AG have founded the Wireless World Research Forum (WWRF) to explore wireless communications beyond 3G. However, some of its engineers believe that developing a viable 3G is more important. MRF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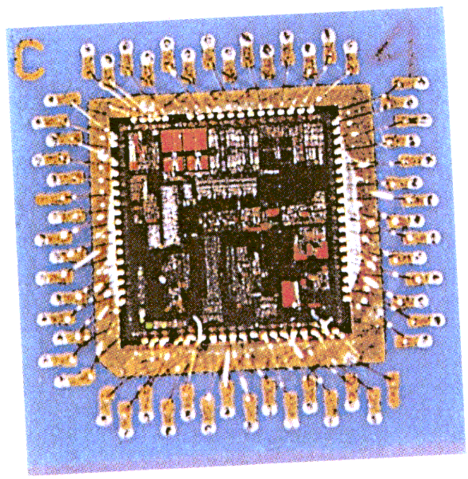
communications a reality.

Application Profile

How to make Cell Phones Smaller and Lighter? BGA with Integrated Components using DuPont Green Tape™.

National Semiconductor is a leader in applying the LTCC advantages of high-density interconnect capability, ability to integrate passive components and functions, and low-loss performance. In a recent design, National chose to combine its advanced ICs for wireless communications with Green Tape™, DuPont's brand of LTCC tape dielectric material, to provide optimum performance in the smallest possible package.



Challenge: Decreased Size and Cost, Improved Performance for Wireless Devices

Portable wireless applications have quickly become the main driver for smaller, more cost-effective packaging and interconnects. For example, in the last few years, cell phones have evolved into lightweight, palm-size devices with a host of new functions. Their weight has decreased by a factor of 10, and the wholesale selling price by 75 percent.

OEM designers are now learning that integrating IC and package design to take advantage of the unique properties of Low Temperature Co-fired Ceramic (LTCC) technology can yield decreased size and improved performance in wireless devices.

Solution: Green Tape™ LTCC Allows for High I/O Counts in Chip Scale Package

National's newest chipsets use Green Tape™ packaging capabilities to provide a chip scale package that can accommodate the high I/O counts of a highly integrated RF analog front end using micro BGA (ball grid array) technology. The current package, only 9 x 9 mm, can provide 81 I/Os in a micro BGA array, plus topside pads for wire-bonding that interconnects to the BGA pads on the backside. The high number of I/Os allows for multiple grounds to improve RF performance, while the embedded multilayer structure contains 14 RF bypass capacitors constructed using a combination of high-K and low-K dielectrics.

The performance of the frequency synthesizer function can be enhanced through the use of an embedded VCO resonator that provides a high Q, and therefore lower phase noise, than that available using a VCO resonator located on the silicon.

This approach, co-designing the silicon and LTCC elements to achieve optimized size and performance, demonstrates the use of co-integration for wireless applications requiring smaller package size and higher performance at the lowest possible cost.

For more information, call DuPont at 1-800-284-3382, press 3, or visit the DuPont Microcircuit Materials website at http://www.dupont.com/mcm.

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CONTRACTS

Cell-Loc, Inc.—Received a federal government grant in the amount of $141,600 to study the collection and dissemination of real-time traffic information for traffic-monitoring purposes. The objective of this closed trial is to determine the technical feasability of developing a traffic-monitoring application based on vehicle probes using Cell-Loc's Cellocate™ wireless location technology. In this study, cellular devices in vehicles will be used to determine traffic flow which is currently performed through the use of stationary vehicle-detecting sensors.

Motorola, Inc.'s Global Telecom Solutions Sector (GTSS)—Has signed a major contract valued at more than $130 million with Maxis Communications Bhd., a Malaysian communications and information-services company. This expansion program is being designed to increase network capacity to accommodate in excess of three million subscribers within the next two to three years and to further enhance the overall system performance of Maxis' national Global System for Mobile Communications (GSM) network.

EMS Technologies, Inc.—A Canadian unit of EMS has entered into a $23 million US contract that will supply Russian satellite operator and builder Khrunichev State Research and Production Center of Moscow with three flight satellite repeaters and one engineering model. The satellite repeaters will provide fixed satellite service communications throughout Russia, Eastern Europe, and Western Asia and are baselined to fly on board the Dialog satellites.

Sanders—Has received a 14-month, $6 million award from the Defense Advanced Research Projects Agency (DARPA) to conduct an Advanced Technology Demonstration for a new Space Operations Architecture known as "Orbital Express." DARPA's Orbital Express program is designed to provide a cost-effective, autonomous capability for on-orbit pre-planned electronics and hardware upgrades, satellite refueling, and reconfiguration of spacecraft components to support a broad range of future US national-security, civil, and commercial-space programs.

Andrew Corp. and Multiradio S.A.—Have secured a $2 million contract with NEC Argentina. The contract is for the supply of 82 synchronous-digital-hierarchy (SDH) backbone links to be used in the construction of the Transportadora de Gas del Sur S.A. SDH microwave network. The network will provide capacity for telecommunication services across half of Argentina, from Tierra del Fuego to Buenos Aires.

FRESH STARTS

RF Micro Devices, Inc.—Has started production shipments of its RF2173 gallium-arsenide (GaAs) heterojunction-bipolar-transistor (HBT) power amplifier (PA) to be used in Motorola's Talkabout™ T900 two-way data pager.

Intersil—Announced the development of Point Coordination Function (PCF) technology for its PRISM® wireless local-area-network (WLAN) chip set. Sony Corp. and Intersil have worked together to develop PCF technology. PCF technology, in combination with a Sony-developed communication protocol, supports fast, wireless streaming of high-quality audio and video content over IEEE 802.11b wireless networks.

Alpha Industries—Is delivering additional volume shipments of gallium-arsenide (GaAs) and RF components for Metricom, Inc.'s high-speed Ricochet™ mobile data network. Ricochet provides 128-kb/s wireless Internet access to users in nine major metropolitan areas across the US and is under construction in approximately one dozen additional markets.

Qualcomm, Inc. and Spirent Communications—Have entered into a code-division-multiple-access (CDMA) test-equipment license agreement. Under terms of the agreement, Qualcomm has granted Spirent Communications a royalty-bearing license to use Qualcomm's CDMA technology and patents to design and market test-equipment products for current and third-generation (3G) CDMA and 1xEV (HDR) applications.

Flarion Technologies—Has successfully conducted its first field trial demonstrating the capabilities of its flash-OFDM* system. The tests were conducted in the 700-MHz RF band, for which Flarion has an experimental license from the Federal Communications Commission (FCC). During the trial, Flarion demonstrated reliable wireless connectivity for broadband Internet content, such as interactive multimedia applications, at highway speeds.

Elanix, Inc.—Announced the signing of Sony/Tektronix Corp. as the exclusive Japanese distributor of Elanix's system-design and simulation-software, SystemView by ELANIX®. This signing enables Elanix to grow its business in the Japanese market with an established company.

Altra Broadband, Inc.—Has opened a research-and-development (R&D) facility in Burlington, MA. The Boston Technology Center will focus on mathematical modeling and algorithim development for broadband fiber-optic and wireless communications.

Amplifier Research (AR)—Has announced the acquisition of Kalmus, a Bothell, WA manufacturer of RF power amplifiers (PAs) and amplifier modules. The acquisition results in a corporation with annual sales of over $40 million.

Merrimac Industries, Inc.—Will expand its US and Central America Multi-Mix® production facilities to meet the growing demand for wireless telecommunications products. It is anticipated that the new Multi-Mix facility in Costa Rica will be fully operational by July while the West Caldwell, NJ expansion should be completed by the end of this year.

Tektronix, Inc.—Has reached an agreement with Ultra Fast Optical Systems, Inc. (UFOS) for an option to license its patented optical switching inventions that address future high-speed optical measurements critical to communications customers developing next-generation optical networks. The agreement included a cash payment and an equipment grant from Tektronix to UFOS.

The NEC Corp.—Intends to spin off its Compound Semiconductor Device Division (CSDD) into a new company, effective in October. MRF

REUSS

Reuss Named Vertex RSI's Director of Operations

BRIAN A. REUSS has been appointed director of operations at the Vertex RSI facility in State College, PA, which is part of the Electronics Products Division. Reuss joined MAXTECH, Inc., a predecessor company, in 1999 as manufacturing manager.

Telephia, Inc.—BEN SWIGGETT to chief marketing officer; formerly vice president of sales and client services at Primary Knowledge, Inc. Also, ANDY FESSEL to vice president of wireless Internet intelligence; formerly senior vice president for new media at Jupiter Media Metrix, Inc.

QUAKE Global—CHRIS JOHNSON to vice president of sales; formerly vice president of supplier sales and business development with Ensera, Inc.

Cell-Loc, Inc.—JAMES M. HILL to CFO; formerly CFO at DALSA.

IPC—CHRIS JORGENSEN to director of printed-wiring-board (PWB) standards and technology; formerly project coordinator.

Classwave Wireless, Inc.—CHARLOTTE BURKE to vice president of global marketing and business development; formerly vice president of mass market data/IP at Bell Canada.

Intense Photonics—DAVID LOCKWOOD to CEO; formerly head of the Sensor Systems Division at BAE Systems. Also, DR. IAIN ANDERSON to chairman; formerly strategy and technology director at Unilever.

@Road—DAVID J. LEBEDEFF to director of investor relations; formerly investor relations director for Legato Systems, Inc.

Vettro—MARC JORRENS to vice president of delivery; formerly client manager for Context Integration. Also, BJORN KALDEREN to director of carrier intelligence; formerly director of mobile Internet applications for Ericsson. In addition, SANJI FERNANDO to executive vice president of human capital; formerly vice president of delivery.

Gabriel—RICARDO NASCIMENTO to sales manager for Brazil; formerly commercial manager with CONNECT.

Agere Systems—MARK GREENQUIST to executive vice president and CFO; formerly vice president of finance and CFO at General Motors Europe. Also, MATTHEW RILEY to senior vice president and controller; formerly CFO of Lucent's Microelectronics and Communications Technologies units.

ITT Industries, Cannon—AMIR SAKET to director of manufacturing for connector products in the Americas; formerly manager of manufacturing engineering.

SAKET

BORTON

Trompeter Electronics—MARK BORTON to the position of product manager for video broadcast products; formerly marketing analyst.

The Cellular Telecommunications & Internet Association (CTIA)—BRUCE COX to vice president for regulatory policy and law; formerly vice president of congressional and regulatory affairs. Also, DR. ROBERT ROCHE to vice president for policy and research; formerly head of the research department.

Touch America—CORTLAND L. (CORT) FREEMAN to vice president of corporate communication; formerly director of corporate communication at Montana Power. MRF

SHORT COURSES

Antennas: Principles, Design and Measurements
May 21-24 (Orlando, FL)
Northeast Consortium for Engineering Education (NCEE)
1101 Massachusetts Ave
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(407) 892-6146, FAX: (407) 892-0406
e-mail: stcloudofl@alo.com
Internet: http://www.usit.com/antenna

RF and Wireless Principles and Practice
May 21-25 (Atlanta, GA)
Continuing Education
Georgia Institute of Technology
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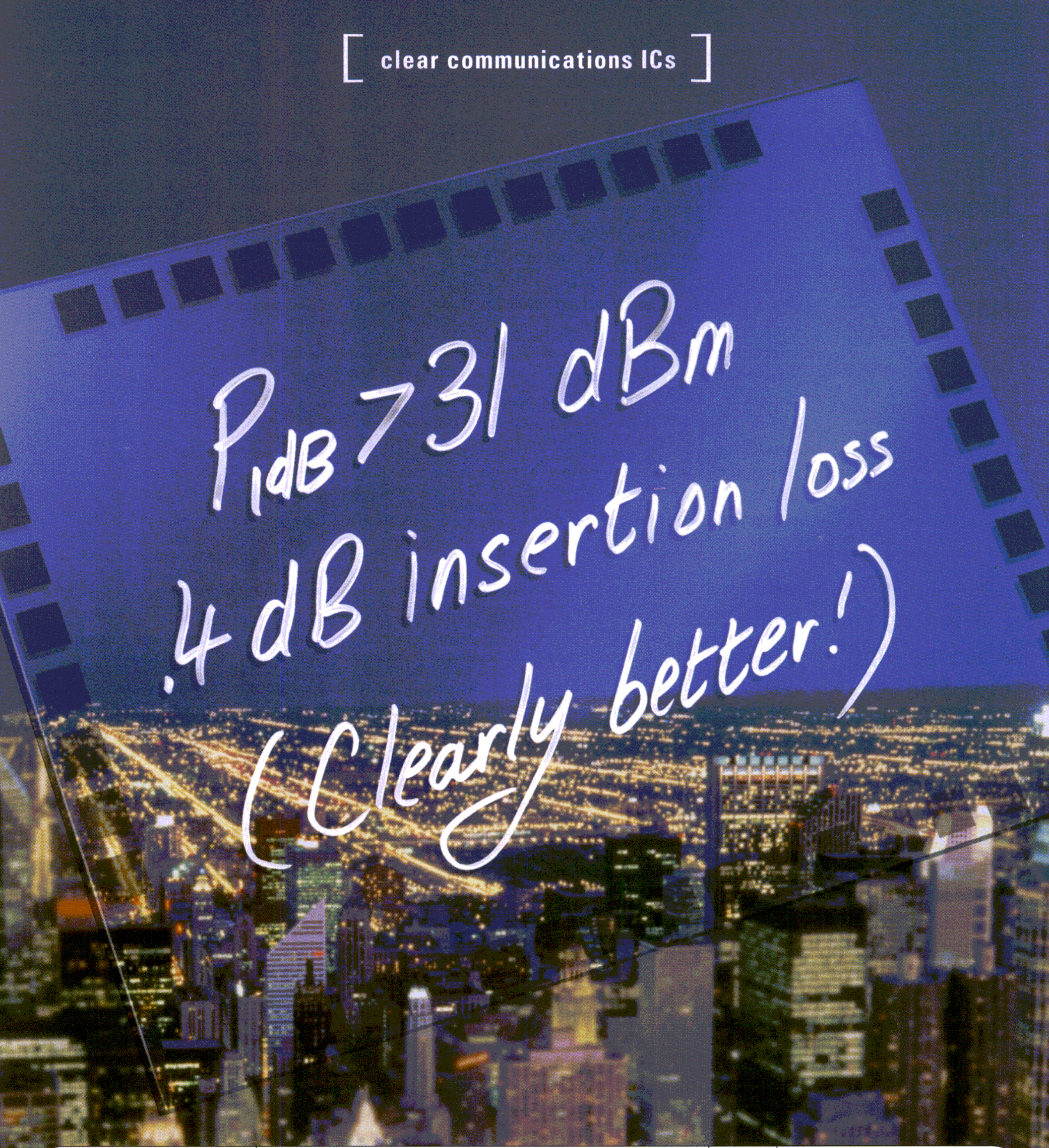

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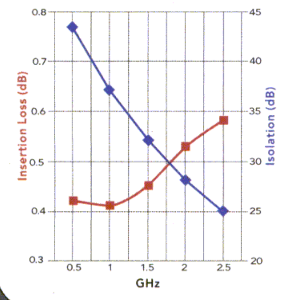

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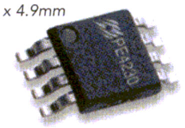

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Study of Rain's Effect on Microwaves Helps Develop Attenuation Model

THE ATTENUATION OF microwaves by rainfall is a common problem faced by telecommunication service providers worldwide. It is common knowledge that this attenuation is strongly affected by the rate of rainfall and the size of the raindrops, which, of course, vary widely according to where on earth the rainfall occurs. Thus, to accurately predict attenuation, researchers must develop models for specific climates and locales. To develop an accurate attenuation model for Singapore, Senior IEEE members Tat-Soon Yeo, Mook-Seng Leong, Le-Wei Li, and IEEE member Pang-Shyan Kooi conducted a 10-year study of vertically and horizontally polarized microwave attenuation in the 10-to-40-GHz band. In 1988, a six-month trial study over a 7-km link operating at 21 GHz recorded 200 times as many outages as predicted by the link's service provider. Subsequently, the link distance was reduced from 7.0 to 1.1 km to keep it within the size of an average Singapore rain cell, which is approximately 2 km in diameter. Thermometers and rain gauges were installed within the link. In 1995, the study added two additional links, one at 15 GHz and another at 38 GHz. Using the data from the study, the authors developed an attenuation model suitable for use in links using horizontal, vertical, or circular polarization in tropical climates. See "Tropical Raindrop Size Distribution for the Prediction of Rain Attenuation of Microwaves in the 10-40 GHz Band," *IEEE Transactions on Antennas and Propagation,* January 2001, Vol. 49, No. 1, pp. 80-83.

Research Estimates Eye's Absorption of Cell-Phone Radiation

OVER THE PAST few years, cell phones have become nearly as commonplace and pervasive as automobiles. But unlike automobiles, whose safety aspects have been studied for decades, the effect of cell-phone use on human health is a relatively new area of research. In particular, there is concern about the effect of cell-phone electromagnetic (EM) radiation on biological tissue. M. Martinez-Burdalo, L. Nonidez, A. Martin, and R. Villar of the Consejo Superior de Investigaciones Cientificas (Madrid, Spain) have contributed to this research by studying the specific absorption rate (SAR) of cell-phone radiation in a human eye. The researchers focused their attention on the eye after reading about a suggested link between temperature rises in the eye and the formation of cataracts. They used the finite-difference time-domain (FDTD) method to analyze SAR variations in situations where the cell-phone antenna is close to the eye. Their research also included the effect that a metallic wall near the cell-phone user would have on the SAR. The study reveals that if the cell-phone antenna were situated directly in front of the eye, the American National Standards Institute (ANSI) limits for EM-radiation exposure would be exceeded only if the distance between the antenna and the eye became less than 2 cm, which would be a very unusual and awkward placement. If the cell-phone user were standing next to a metalic wall, the ANSI limits for EM exposure would only be exceeded if the eye-to-antenna distance fell below 2.5 cm. See "FDTD Analysis of the Maximum SAR when Operating a Mobile Phone Near a Human Eye and a Wall," *Microwave and Optical Technology Letters,* January 20, 2001, Vol. 28, No. 2, pp. 83-85.

Radar Images Reveal Hidden Power Lines for Low-Flying Aircraft

HELICOPTERS ARE EXPERIENCING increasing use for civilian and military applications. Unfortunately, helicopter accidents are on the increase as well. High-voltage power lines are a particular threat. A millimeter-wave-radar-based collision-warning system might reduce accidents, but power lines have a very small cross section and are often situated near trees and other foliage, making them difficult for the helicopter's radar to detect. With traditional radar detection algorithms, the reflection from the power lines must be stronger than the reflection from the background foliage. But that happens only when the power lines are at or near 90 deg. to the helicopter's direction of travel. To circumvent this limitation, Kamal Sarabandi and Moonsoo Park of the University of Michigan (Ann Arbor, MI) propose the of use radar polarimetry and a statistical detection algorithm to improve the signal-to-clutter ratio. The authors demonstrate the usefulness of this algorithm in extracting maps of high-voltage power lines using existing millimeter-wave synthetic-aperture-radar (SAR) aerial images. Their study also investigates the possibility of using this algorithm on helicopter-borne radar systems. See "Extraction of Power Line Maps from Millimeter-Wave Polarimetric SAR Images," *IEEE Transactions on Antennas and Propagation,* December 2000, Vol. 48, No. 12, pp. 1802-1809.

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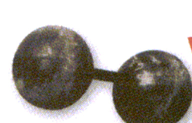

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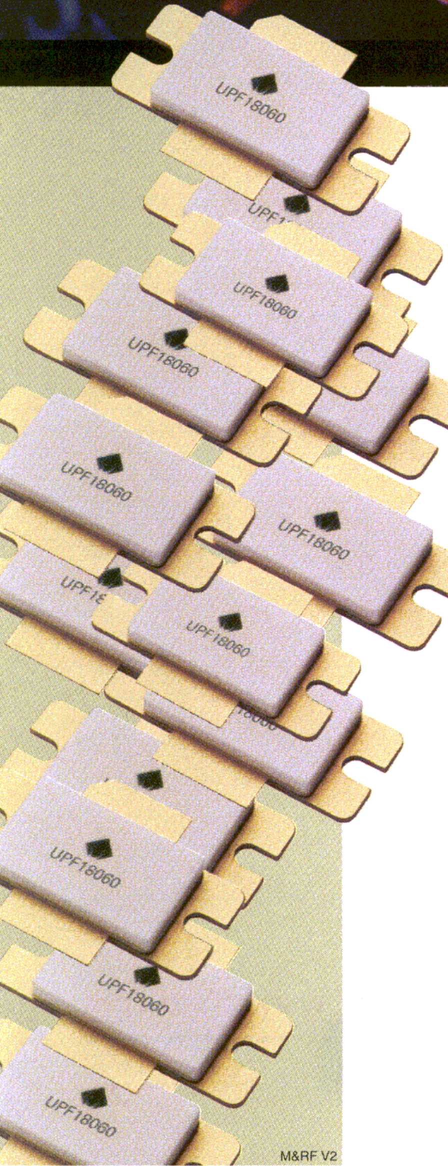

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With the proliferation of modern digital modulation formats supporting wireless services—cellular, personal communications services (PCS), International Mobile Telecommunications(IMT-2000), Bluetooth, wireless local-area networks (WLANs), local multipoint-distribution systems (LMDS) and others—it is becoming uneconomical and logistically difficult to provide sufficient "true waveform" generators to support the development, production, and maintenance phases of the lifecycle of telecom RF based products. Because of the non-constant envelope characteristics of modern digital-modulation signals, the key challenge is to provide a very linear channel, over wide bandwidths and with high dynamic-range requirements, while maintaining power efficiency, reliability, and cost at very competitive levels.

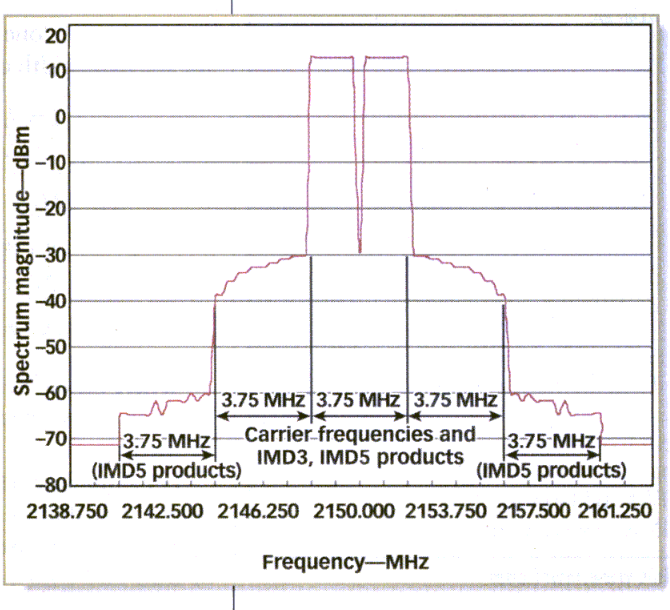

Fig. 1 This is the simulated composite signal spectrum of the test signal--carriers, IMD3 and IMD5 products--based on a 496-term frequency distribution.

Traditionally, noise, intermodulation distortion (IMD), and spurious tests were conducted using noise-power ratio (NPR) and two-tone techniques. While these procedures were acceptable for narrowband, mostly analog signals, they cannot adequately test wideband channels designed for non-constant envelope, digitally modulated signals.

In the last few years "true waveform" generators have become available. These generators reproduce the actual digital signal. However, when considering actual testing requirements, several limitations arise which demand the consideration of alternate techniques. These limitations become apparent when considering that most modern communication channels, are multicarrier—and possibly multi-standard—in nature and that spurious-free dynamic ranges (SFDRs) greater than 75 to 80 dB are usually required from digitally modulated RF generators to be

Continued from page 63

able to measure the performance of the component, circuit, subsystem, and system themselves without interference from the noise floor and IMDs associated with the test equipment. Moreover, in multicarrier systems, several digital waveform RF generators would be required for a single test. Considering multiple tests and product throughput associated with high quality, and high-volume manufacturing environment, the number of signal generators required becomes economically prohibitive.

Considering in-band and out-of-band noise and IMD tests, a possible alternative is to provide a stimulus composed of a multi-tone composite signal occupying the same bandwidth and with average power, peak factor, and complementary-cumulative-distribution-function (CCDF) distribution representative of the original broadband, digitally modulated RF signal.

As reported in the literature, it is possible to associate adjacent and next-to-adjacent channel adjacent-channel power-ratio (ACPR) measurements with IMD3 and IMD5 results, respectively[1-4]. Specifically, in the adjacent channel measurements, the IMD3 and IMD5 distortion terms are both present unless the device under test (DUT) is operated several (approximately 10 to 20) dB below its compression point.

From a theoretical point of view, the IM3/IM5 and adjacent and next-to-adjacent channel ACPR relationship can be established by considering frequencies generated by a power series terminating with the highest power of interest (i.e., x^5 for IMD5 products) for a signal of the following type:

$$x = A_1 \cos 2\pi f_1 t + A_2 \cos 2\pi f_2 t + \ldots + A_n \cos 2\pi f_n t \qquad (1)$$

Considering a multicarrier composite signal, of all possible resulting fundamental, harmonic, and IMD product terms, the only ones to be considered for the bandwidth of interest are:

$$f_i,\ i = 1,\ldots n,$$
$$f_j,\ j = 1,\ldots n,$$
$$\pm f_i \pm 2f_j,\ i = 1,\ldots n,$$
$$j = 1,\ldots n, i \neq j, (IM3)$$
$$\pm 3f_i \pm 2f_j,\ i = 1,\ldots n,$$
$$j = 1,\ldots n, i \neq j, (IM5) \qquad (2)$$

Where the difference frequency must be positive; two negative signs cannot be used.

For simplicity, **Table 1** gives the frequency distribution of a 16 tone/carrier signal. In this case, the total number of IM3 and IM5 products generated

Continued from page 64

from Eqs.1 and 2 is 496. In graphic form, Fig. 1 illustrates the simulated composite spectrum (based on compression operation with −22.1-dBm/tone input power) resulting from the discrete power levels associated with the 496-term distribution. These data suggest that this particular scheme does indeed provide a composite waveform exhibiting a bandwidth and frequency distribution analogous to that of a typical, broadband, digitally modulated, single or multicarrier communication signal. Moreover, **Fig. 1** also shows the two pedestals, starting at −30 and −60 dBm, indicating the third and fifth, and fifth-alone IMD terms associated with adjacent and next-to-adjacent channel noise measurements, respectively.

According to this theory, a fairly simple and rapid test oriented toward verifying the linear and non-linear operation of a DUT under realistic load conditions could then include three types of stimuli:

· Multi-tone input signal with average power, spectral occupancy, and statistics typical of a "true" digital signal under minimum peak conditions,

· Multi-tone input signal with average power, spectral occupancy, and statistics typical of the "true" digital signal under maximum peak conditions,

· Multi-tone input signal with average power, spectral occupancy, and statistics typical of the "true" digital signal under continuous-random-phase (CRP) operation conditions statistically spanning all peak amplitude and phase values between peak and null operations.

As an example, a ZHL-42 amplifier from Mini-Circuits was tested (**Fig. 2**) under linear and nonlinear conditions for CDMA 2000 direct spreading (DS) and multi-tone operation.

The CDMA 2000 (3.6864 Mc/s) DS signal was generated with a Rohde & Schwarz SMIQ 03B signal generator. Multi-tone generation was realized with an Aeroflex RDL MTG-2000. Spectrum evaluation and analyses were conducted with an HP8562E spectrum analyzer, while average and peak power, and statistical readings were performed with a Boonton 4500 power meter equipped with a 57318 broadband power sensor. The setup procedure in either case consisted of selecting average input signal powers for linear and nonlinear operation, while ensuring that the MTG-2000 would cover the bandwidth of interest with composite signal characteristics (including average and peak power, and CCDF characteristics) oriented toward satisfying the "true" digital waveform requirements.

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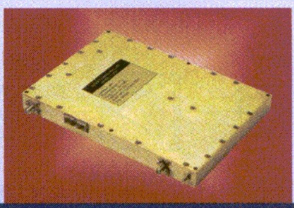

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Continued from page 66

eters and values associated with the CDMA 2000 DS (with the ZHL-42 amplifier, operating at 2150-MHz center frequency), tests and analyses are briefly reported in **Table 2**.

Three increasingly higher power levels were used as input signals to the ZHL-42 to drive the device from linearity into compression. The relative changes in noise-floor levels (Table 2) for discrete offsets through adjacent and next-to-adjacent channel frequencies are reported and compared both for the SMIQ 03B and the MTG-2000.

Given the resolution bandwidth (RBW)—30 kHz—the actual signal trace levels for the 3.75-MHz wide waveform generated with the SMIQ 03B should be 20.97 dB higher (**Fig. 3**). As an example, for the linear case in Table 2 (−24.1-dBm input power), for a measured amplifier gain of approximately 34.57 dB, the output signal level is −24.1 + 34.57 = +10.47 dBm. Considering Fig. 3, the signal level is −10.5 dBm. Adding the correction factor, the actual signal trace level is −10.5 + 20.97 = +10.47 dBm, as expected.

Since individual tones are spaced 234.4 kHz apart in the MTG-2000 waveforms, no correction factor is necessary and the values displayed by the spectrum analyzer (SA) with a 30-kHz RBW correspond to actual output signal power levels. For relative (dBc) val-

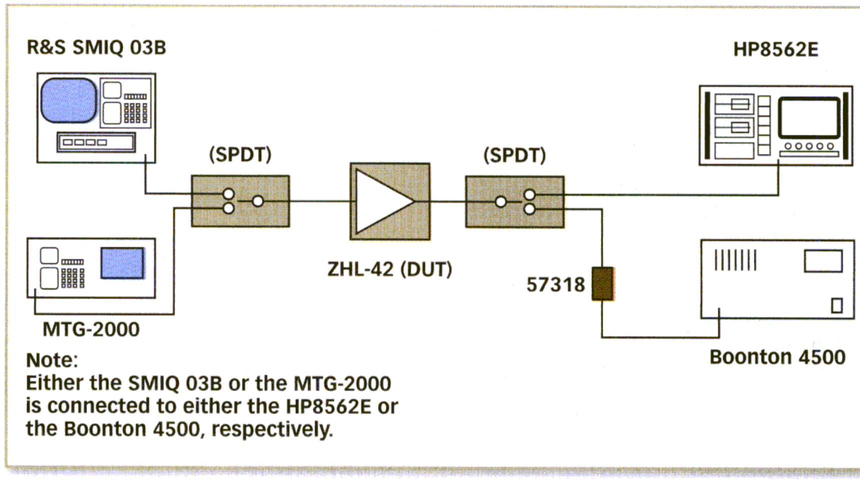

Fig. 2 The test setup for measuring the linear and nonlinear operation of the ZHL-42 amplifier uses either the SMIQ 03B or the MTG-2000 as the signal source.

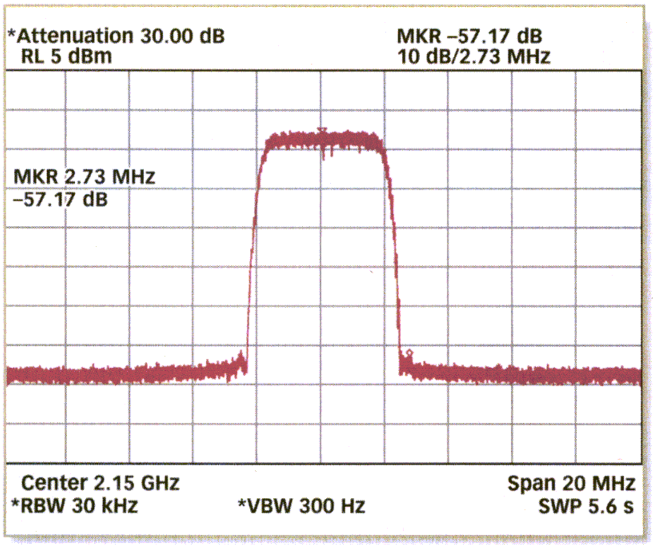

Fig. 3 This is the output of the ZHL-42 amplifier when driven by a −24.1-dBm signal from the SMIQ 03B signal generator. The output signal level is +10.47 dBm.

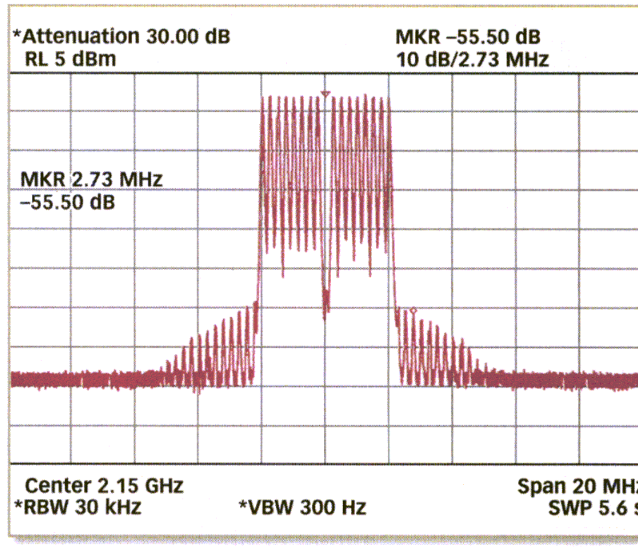

Fig 4 When the ZHL-42 is driven by a −36.1-dBm/tone input from the MTG-2000, its peaked output can be used to determine the amount of in-band distortion.

Continued from page 68

ues, no correction factor is needed when that part of the signal trace selected by the marker delta (with respect to the carrier center frequency) is significantly higher (10-15 dB) than the analyzer noise floor.

Figures 4 and 6 illustrate other cases. At approximately 2.7 MHz offset (**Fig. 3**), the SMIQ 03B reading (**Fig. 6**) is −57.17 dBc while the MTG-2000 reading is −69.84 dBc. Given that the same average power is used for both waveforms, an equivalent bandwidth must be chosen to compare the results. The MTG-2000 carriers are spaced 3.75 MHz/16 = 234.4 kHz apart. Centering this spacing about a carrier, the bandwidth of interest is then 234.4 kHz. With a 30-kHz RBW, the peak value for each carrier, as displayed by the SA, does not change since no other energy is contained within the 234.4-kHz bandwidth. For the SMIQ 03B, however, the reading must be adjusted by 10log (234.4/30) = 8.93 dB. Considering the SA itself, since the CDMA 2000 DS detected signal is broadband and noise-like instead of sinusoidal, a 2.0 (2.5-dB adjustment must be included. Finally, in **Fig. 3**, it can also be seen that the SMIQ 03B contributes approximately 1 to 2 dB to the DUT's noise floor. Accounting for all these factors, the total correction factor is equal to 11.93 to 13.43 dB. Hence, the actual "dBc" reading for the SMIQ 03 B (CDMA 2000 DS) case is −69.1 to −70.6 dBc, which correlates fairly well with the −69.84 dBc MTG-2000 reading.

Figure 3 illustrates the CDMA 2000 DS waveform, generated by the SMIQ 03B during linear operation (i.e., −24.1-dBm input power), at the output of the ZHL-42. Figure 4 depicts the output deriving from the peaked MTG-2000 waveform.

If a simple arc is drawn joining the peaks of the IMD product spectral lines (**Fig. 5**), from either side of the waveform, through the central IMD spectral line, the complete noise distribution for the associated mode of operation can be quickly evaluated, compared to the overall signal power.

Figure 7 illustrates the CDMA 2000 DS waveform, generated by the SMIQ 03B during (DUT) compression operation (i.e., −5.1-dBm input power), at the output of the ZHL-42. Comparing this signal with the simulated waveform in **Fig. 1**, the main signal plus IMD3/IMD5 products, IMD3/IMD5 products, and IMD5 only products 3.75-MHz-delimited frequency bands are clearly visible. **Figure 8** depicts the MTG-2000 waveform under CRP (with peak hold) operation for a −22.1-dBm/tone input power. Again, comparing this waveform with those in Figs. 1 and

Table 1: Two-tone frequencies of a multicarrier composite signal

2148.125 MHz	→	Tone/carrier 1
2148.359 MHz	→	Tone/carrier 2
2148.594 MHz	→	Tone/carrier 3
2148.828 MHz	→	Tone/carrier 4
2149.063 MHz	→	Tone/carrier 5
2149.297 MHz	→	Tone/carrier 6
2149.531 MHz	→	Tone/carrier 7
2149.766 MHz	→	Tone/carrier 8
	(2150-MHz notch)	
2150.234 MHz	→	Tone/carrier 9
2150.469 MHz	→	Tone/carrier 10
2150.703 MHz	→	Tone/carrier 11
2150.938 MHz	→	Tone/carrier 12
2151.172 MHz	→	Tone/carrier 13
2151.406 MHz	→	Tone/carrier 14
2151.641 MHz	→	Tone/carrier 15
2151.875 MHz	→	Tone/carrier 16

Table 2: CDMA 2000 DS signal generation, simulation, and testing with R&S SMIQ 03B and Aeroflex RDL MTG-2000 signal generators

SIGNAL GENERATOR	ROHDE & SCHWARZ SMIQ 03B					AEROFLEX RDL MTG-2000						
Measurement type/DUT conditions	CDMA 2000 DS AWGN Δ f_o (MHz) dBc (with respect to noise floor)			At f_o dBc (with respect to central IMD at peak)	At f_o dBc (with respect to central IMD at null)	16-carrier group Δ f_o (MHz) dBc [with respect to the pertinent intermodulation-distortion (IMD) product component magnitude]						
						Peak	CRP	Peak	CRP	Peak	CRP	Power MTG carrier
Op. mode (P avg. input)	2.73 MHz	3.80 MHz	5.93 MHz	2.15 GHz	2.15 GHz	2.73 MHz	2.73 MHz	3.80 MHz	3.80 MHz	5.93 MHz	5.93 MHz	
Linear (–24.1 dBm)	–57.2 dBc	–59.0 dBc	–60.2 dBc	–50.0 dBc	–70.0 dBc	–55.5 dBc	–59.8 dBc	–59.7 dBc	–63.0 dBc	–70.3 dBc	–70.5 dBc	–36.1 dBm
Compression (–14.1 dBm)	–52.7 dBc	–56.3 dBc	–63.7 dBc	–36.7 dBc	–43.0 dBc	–41.5 dBc	–44.0 dBc	–46.8 dBc	–48.6 dBc	–65.7 dBc	–66.8 dBc	–26.1 dBm
Compression (–5.1 dBm)	–22.0 dBc	–27.3 dBc	–51.2 dBc	–14.0 dBc	–21.8 dBc	–19.2 dBc	–20.0 dBc	–25.7 dBc	–26.7 dBc	–39.0 dBc	–39.7 dBc	–17.1 dBm

Continued from page 70

7, the main signal plus IMD3/IMD5 products, and IMD5-only products, 3.75-MHz-delimited frequency bands are clearly visible. Consequently, Figs. 1, 7, and 8 show the applicability and relative accuracy of the proposed IMD3 and IMD5 versus in-band and ACPR distortion measurements technique/concept.

Moreover, from an observability and amplifier noise-floor evaluation point of view, the waveform in Fig. 8 exhibits approximately 20 dB more dynamic range than the "true" signal counterpart depicted in **Fig. 7**. Additionally, as previously discussed, the signal structure illustrated in Fig. 8 supports in-band noise measurements (see 2.15 GHz notch). This is not possible with "true" modulated signals.

One characteristic of modern, broadband, digitally modulated signals is their noise-like nature. Consequently, statistical approaches need to be used to characterize these signals while giving special consideration to their distribution functions. The mostly widely used distribution for this type of analysis is the CCDF. Basically, for this specific application, the CCDF indicates for what percentage of time of a signal's activity that the associated waveform can be expected to exhibit a peak power factor of greater than or equal to a certain value. Consequently, the parameters of interest are the peak-to-average ratio for each waveform (which describes the highest possible crest factor for a given signal) and the CCDF associated with it.

This probability of exceeding certain power levels can then be used as a gating parameter for the characteriza-

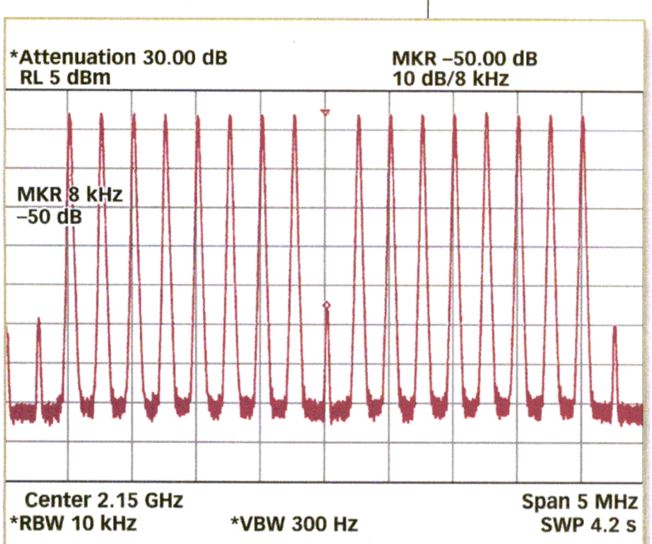

Fig. 5 The noise distribution of a particular operating mode can be determined by connecting the peaks of the IMD-product spectral lines through the central IMD spectral line.

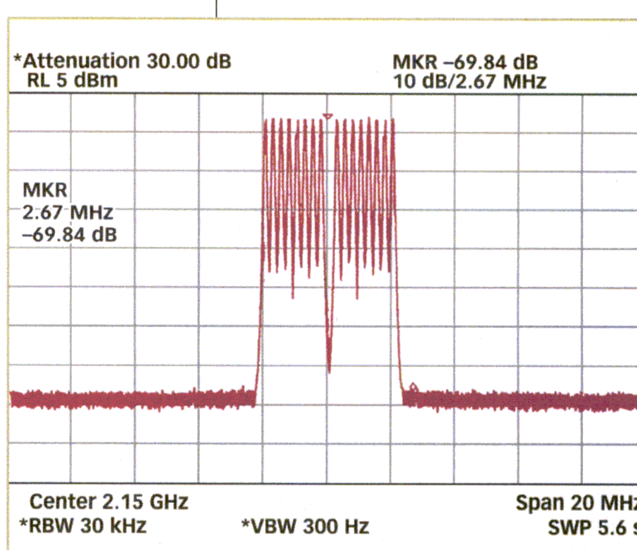

Fig. 6 To compare the results of this ZHL-42 response with that of Fig. 4, an equivalent bandwidth must be used since the same average power is used to generate both waveforms.

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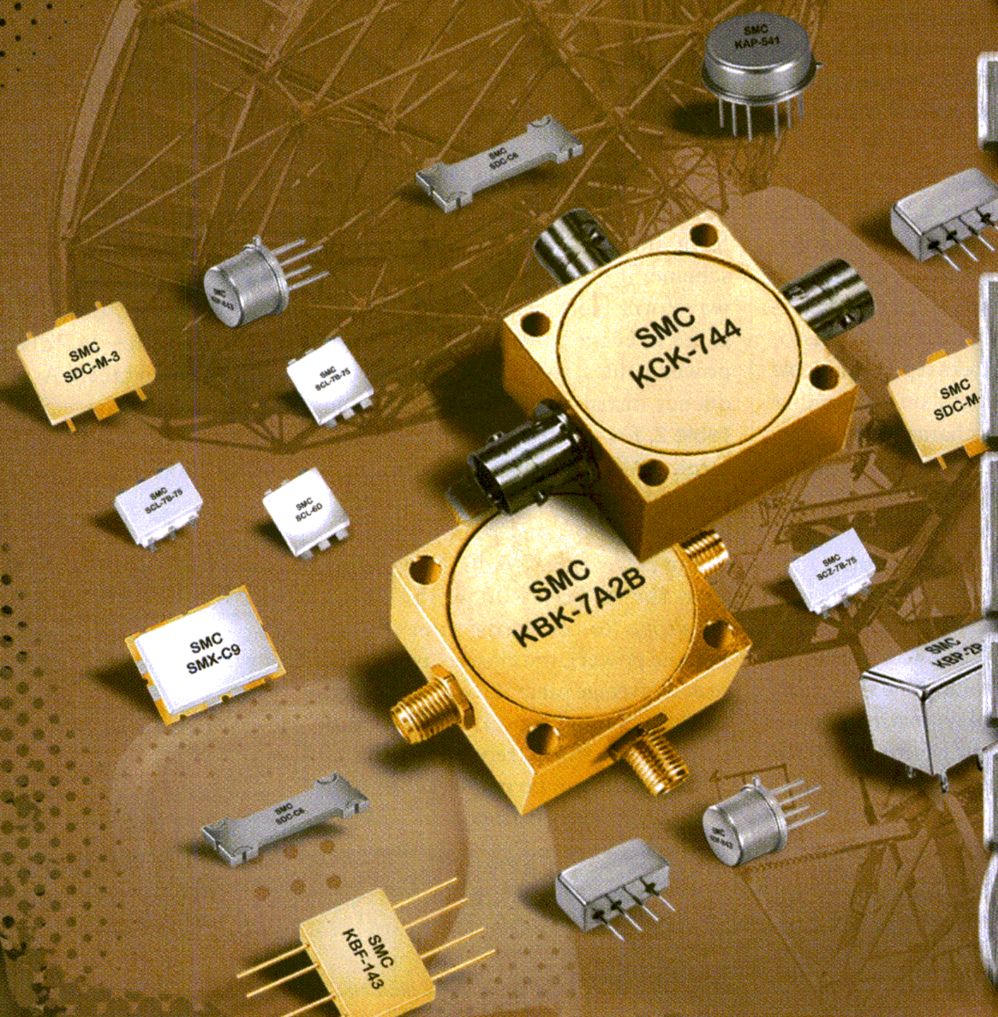

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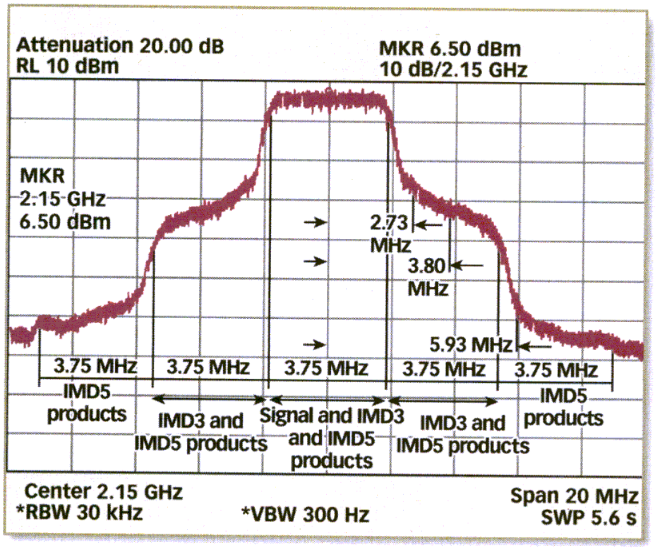

Fig. 7 The output of the ZHL-42 for a −5.1-dBm input from the SM IQ 03B shows close correspondance with the simulated waveform of Fig. 1. The separation of the IMD3/IMD5 and IMD5-only products is clearly visible.

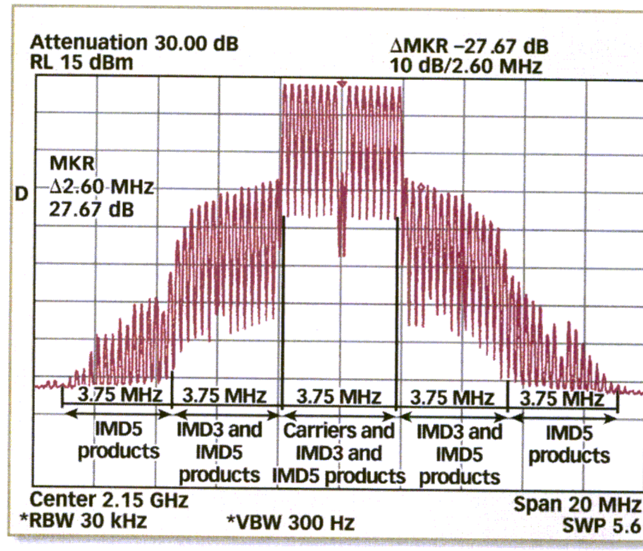

Fig. 8 This ZHL-42 output response seen above is generated by a − 22.1-dBm/tone CRP-mode input that is from the MTG-2000. Similar to Fig. 7, the 3.75-MHz delimited frequencies are clearly visible.

Continued from page 72

tion of the DUT as far as linear operation, peak factor, and IMD generation, and stress and reliability are concerned.

Table 3 describes the peak-to-average values for all signal levels and associated operational modes reported in **Table 2.** These values depend on the number and type of channel characteristics (e.g., Walsh codes) used in CDMA signaling and on the number of tones and phase alignment for the MTG-2000. It is extremely important to notice that as the DUT operates more and more into compression, the peak-to-average value changes (decreases) due to saturation. Due to the discrete multi-tone approach, the MTG-2000 displays this trend more vividly and with a (displayed) higher dynamic range than a standard digital signal generator.

To compare and correlate results obtained with the "true" digital waveform and the MTG-2000 multi-tone scheme, it is first necessary to select waveform pairs characterized by the same average and peak-to-average power values, as well as similar frequency distribution. For example, in **Table 2**, for a CDMA 2000 DS waveform, AWGN modulated, and an average input power to the DUT of −5.1 dBm, the associated peak-to-average output power value is 4 dB. Considering now the MTG-2000 with −17.1 dBm/tone (to obtain the same overall average power), the closest (to 4.0 dB) peak-to-average value (4.6 dB) is obtained during CRP operation. Taking into account the three frequency offsets, comparisons can be made (**Table 2**):

At a frequency offset of 2.73 MHz, and −5.1-dBm compression, the SMIQ 03B has a power value of −22.0 dBc versus −20 dBc for the MTG-2000 (yellow in table). Similarly, at 3.80 MHz, the SMIQ 03B power is −27.3 dBc, compared with −26.7 dBc for the MTG-2000 (cyan in table). At 5.93-MHz offset, the values are −51.2 dBc for the SMIQ 03B, and −39.7 dBc for the MTG-2000 (blue in table). MRF

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Table 3: CDMA 2000 DS adjacent-channel noise-measurement comparison correlation with R&S SMIQ 03B and Aeroflex RDL MTG-2000 signal generators

SIGNAL GENERATOR	ROHDE & SCHWARZ SMIQ 03B					AEROFLEX RDL MTG-2000			
Measurement type/DUT conditions	CDMA 2000 DS AWGN Δ f_o (MHz) dBc (with respect to noise floor)			Peak factor (dB)	Peak factor (closest value—dB)	16-carrier group Δ f_o (MHz) dBc [with respect to the pertinent intermodulation-distortion (IMD) product component magnitude]			
Op mode (P avg. input)	2.73 MHz	3.80 MHz	5.93 MHz			2.73 MHz	3.80 MHz	5.93 MHz	Power/MTG carrier
Linear (–24.1 dBm)	–57.2 dBc	–59.0 dBc	–60.2 dBc	5.8	6.1	–69.8 dBc	–70.7 dBc	–70.7 dBc	–36.1 dBm
Compression (–14.1 dBm)	–52.7 dBc	–56.3 dBc	–63.7 dBc	5.7	4.5	–50.0 dBc	–55.8 dBc	–69.2 dBc	–26.1 dBm
Compression (–5.1 dBm)	–22.0 dBc	–27.3 dBc	–51.2 dBc	4.0	4.6	–20.0 dBc	–26.7 dBc	–39.7 dBc	–17.1 dBm

A

B

C


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Raise Bandwidth Efficiency With Sine-Wave-Modulation VMSK

A new version of VMSK uses a sine-like waveform for the modulating signal, resulting in high-bandwidth efficiency, good signal-to-noise ratio (SNR), and low bit-error rate (BER).

K. H. SAYHOOD AND WU LENAN,
Radio Engineering Dept., Southeast University, Nanjing 210096, P. R. China; +86-25-379 2443, FAX: +86-25-771 2719, e-mail: khsay57@yahoo.com, wuln@seu.edu.cn

Transmitting digital information through existing analog channels has led to the development of various transmission techniques. And the growing demand for transmission capacity has forced designers to develop various bandwidth-reduction methods. One type of modulation method that can reduce transmission bandwidth is called non-return-to-zero (NRZ) linecode modulation. Some examples of NRZ modulation methods include frequency modulation (FM), binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), minimum phase-shift keying (MPSK), Gaussian minimum-shift keying (GMSK), and quadrature amplitude modulation (QAM). The most popular one is QAM, which can reduce bandwidth usage to as little as 1/8 of the original amount required.

However, these modulation schemes also result in a tremendous loss in transmitted power. Another class of modulation, known as "biphase," is transmitted using a well-known technique called "single sideband (SSB) with suppressed carrier." Examples include Manchester coding, Miller coding, and very minimum-shift keying (VMSK). The main difference between biphase and NRZ linecode modulation is that the biphase methods reduce bandwidth without sacrificing power. For example, con-

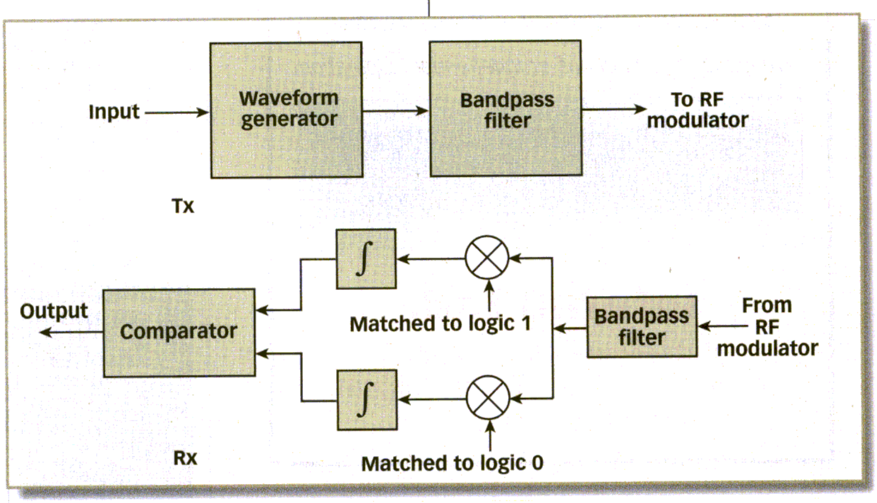

Fig. 1. This is the block diagram of the VMSK system.

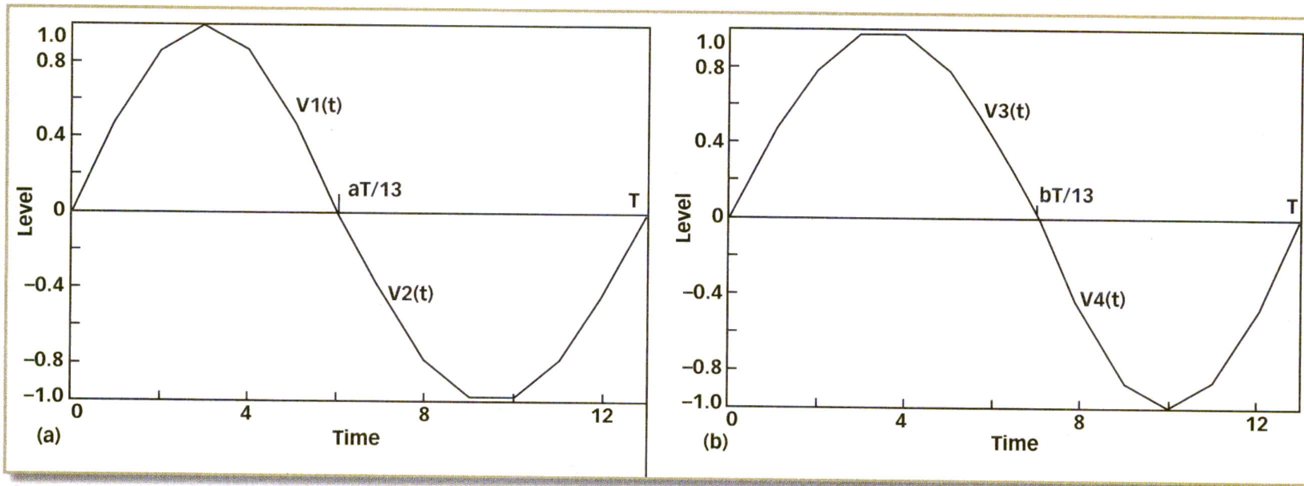

Fig. 2. This plot shows the waveforms for (a) logic 1, and (b) logic 0.

Continued from page 79

ventional VMSK achieves bandwidth efficiencies to 15 b/s/Hz.[1]

This article introduces a new version of VMSK that reduces bandwidth usage even further. The new version substitutes a sine-like waveform for the original rectangular modulating signal, resulting in high-bandwidth efficiency, good signal-to-noise ratio (SNR), and low bit-error rate (BER). The article describes the new modulation format and offers some simulation results.

The SSB-with-suppressed-carrier modulation spreads its spectrum above and below the carrier frequency by an amount equal to the highest modulation frequency (as long as there is no phase encoding). For example, if the data are encoded using the Miller coding for double-density disk recording, or the

Continued from page 80

Manchester coding used for Ethernet transmission, the spectrum becomes suitable for a biphase code. It splits into two islands—one located above the carrier and one located below. The bandwidth required in each island depends on the encoding method. Using the Miller code, for example, the bandwidth is only 1/4 of the full spread, or the Nyquist RF bandwidth. Thus, it would have a bandwidth efficiency of 4 b/s/Hz. VMSK is unique among biphase modulation techniques in that it can compress the bandwidth. By using the proper coding technique, VMSK can concentrate the transmitted information in a very-narrow spectral spike.

Figure 1 shows a block diagram of a transmitter (Tx) and receiver (Rx) using the new version of VMSK modulation. The Tx uses a waveform generator to modulate the binary input message according to the following algorithm:

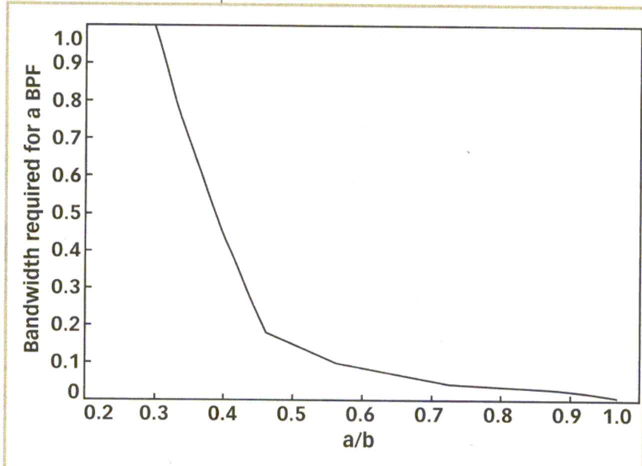

Fig. 3. This plot shows the bandwidth versus a/b ratio of the new version of VMSK modulation.

When logic 1 is sent, the generator creates the output waveform shown in **Fig. 2a,** where:

$$V_1(t) = \sin[\pi(13/aT)] \quad 0 \le t \le aT/13 \qquad (1)$$

$$V_2(t) = -\sin\{\pi(13/bT)[t - (aT/13)]\} \quad aT/13 \le t \le T \qquad (2)$$

$$(aT/13) + (bT/13) = T \qquad (3)$$

T, the bit-timing interval, = 1/bit rate (assuming a 13-aperture code segment is used).

When logic 0 is sent, the generator creates the output waveform shown in **Fig. 2b,** where:

$$V_3(t) = \sin[\pi(13/bT)t] \quad 0 \le t \le bT/13 \qquad (4)$$

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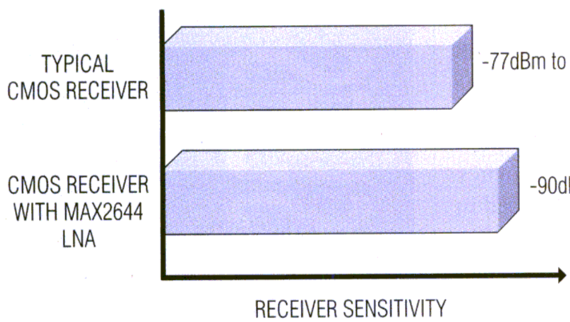

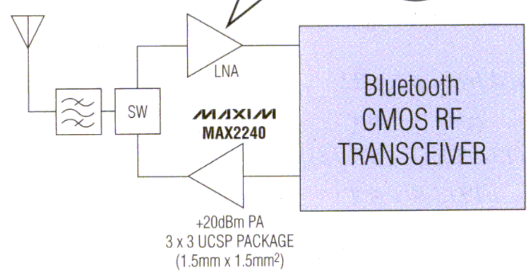

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NEW	MAX2654	1575	15	1.5	-7	—	GPS
NEW	MAX2655	1575	14	1.7	+3	Yes	GPS in cellular phones
NEW	MAX2656	1960	13.5	1.9	+1.5	Yes	PCS, DCS, WLL

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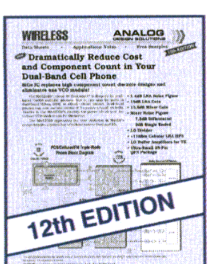

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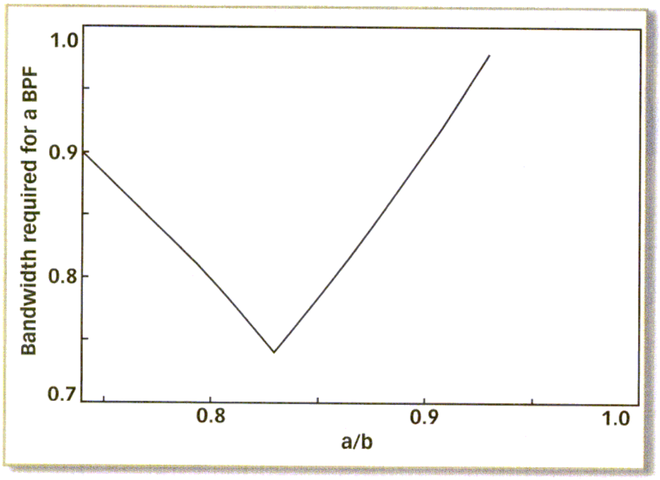

Fig. 4. This plot shows the performance of the new version of VMSK modulation using a fixed bit interval.

Continued from page 82

$$V_4(t) = -\sin\{\pi(13/aT)[t - (bT/13)]\} \quad bT/13 \leq t \leq T \qquad (5)$$

Notice that, except for their different domains,

$$V_3(t) = -V_2(T - t) \qquad (6)$$

$$V_4(t) = -V_1(T - t) \qquad (7)$$

The bandpass filter is centered on the bit-rate fundamental frequency with variable bandwidths to account for the amount of energy inside the filter bandwidth. The Rx consists of a coherent demodulator that matches to the logic-1 or logic-0 formats.

In the Tx, the output spectrum of the generator appears as a single line rising above the Fourier noise.[2] More than 96 percent of the information is contained in this line. When the noise is filtered out, only the line remains. Since this line is at the modulating frequency above the carrier, it is easy to restore the carrier from the SSB alone by making the carrier a multiple of the bit rate.[3]

In conventional VMSK, the encoder uses a rectangular pulse that spreads the spectrum around the bit-rate frequency. In the new VMSK method described here, the encoder uses a sine wave, which results in a narrow, large-amplitude spike in the spectrum if "a = b," or a narrow, small-amplitude spike if "a ≠ b." This modulation format is easy to implement.

The proposed modulation format shown in Fig. 1 is simulated for a 13-aperture-code segment as proposed in reference 2. The code segments (a, b) have been changed to achieve the performance of a fixed bit rate of 22.5 kb/s with variable zero-crossing intersections. As expected, if a = b, the result is a pure sine wave of fundamental frequency 1/T. This means that the filter used in the Tx would have to be a bandpass type with zero bandwidth to pass the fundamental bit-rate frequency. As shown in **Fig. 3**, the bandwidth approaches zero when the values of "a" and "b" are nearly equal, and gradually increases as "a" diverges from "b."

In addition, with a fixed bit interval, the zero-intersection point can be adjusted for optimum aperture segments of the a/b ratio **(Fig. 4)**. These results show that, to improve the performance, a smaller separation time performs better than larger separations, significantly reducing bandwidth. On the left side of the curve, the time separation between samples remains too large for the low difference-signal variances that are involved, thus requiring a larger bandwidth. However, as the ratio a/b is increased, the matching between the input variance and the time separation improves until a minimum bandwidth point is reached. As the ratio of a/b increases further, the situation reverses, that is, the input variance becomes too large while the ratio of available a/b is not well-matched to the variance, requiring more bandwidth. MRF

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Theory Enables Locking-Band Widening Of Injection-Locked IMPATT Oscillators

Theory and experiments produce design techniques to widen the locking range of millimeter-wave IMPATT oscillators.

DR. LEONID KASATKIN
Scientific Secretary of State,
Research and Industrial
Institute "Orion"
Kiev, Ukraine; e-mail:
kas@carrier.kiev.ua

Modern injection-locked impact-avalanche-transit-time (IMPATT) coherent oscillators are the most powerful pulsed-semiconductor electromagnetic (EM) sources in the millimeter-wave range. These oscillators are characterized by levels of output pulse power of more than 50 W and locking gain levels above 30 dB. They also have high amplitude and phase stability during the pulse-width output, from pulse to pulse, and within a wide range of ambient temperatures.[1,2] At the same time, the locking band of single-stage injection-locked IMPATT oscillators—described in the literature—with locking gain exceeding 10 dB, is less than 4 to 5 percent. This restricts many applications of pulsed IMPATT oscillators. The published methods of locking-band widening describe idealized models without proper consideration of the real performance of diodes and RF circuits and do not solve the problem.

Solutions to the problem of essential locking-band widening involve consideration of two key tasks:

1. The definition of general correlation between a stable locking band and a microwave circuit, as well as diode parameters without any usual assumptions about small locking signals, constancy of a diode's RF voltage amplitude, and mutual disposition of the diode's and circuit's impedance characteristics.

2. The definition of an oscillator's construction for decreasing the stored energy in a microwave circuit, optimal circuit mounting of the diode, and packaging the semiconductor chip.

In this article, the general methods of locking-band widening of diode RF oscillators are based on theory. These methods are applied to locking-band widening of the most widespread implementations of IMPATT oscillators in the millimeter-wave range with the microwave circuit made as a waveguide-to-coaxial T-junction. As a result of theoretical and experimental investigations, a locking-band widening of three times can be achieved in pulsed IMPATT oscillators. These results can

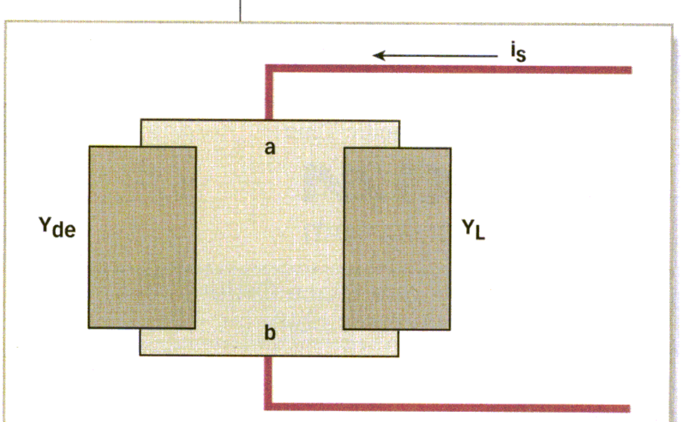

Fig. 1 The basic model of an injection-locked diode oscillator is based on the equivalent admittance (Y_{de}) and load admittance (Y_L) of a diode between terminals ab.

Continued from page 86

be applied across the total millimeter-wave range, to different diode's structures, and to microwave circuits.

The conceptual model of an injection-locked diode oscillator is shown in **Fig. 1**. In this model, the equivalent admittance of the diode $Y_{de}\omega$, U_m, I_0, θ, and load admittance $Y_L\omega$ are connected to terminals ab, where ω = the signal frequency, U_m = the voltage amplitude at equivalent diode terminals ab, I_0 = the diode bias current, and θ = the diode structure temperature.

This system is affected by input signal current with amplitude i_s, defined by the level of the input locking power P_s: $i_s = [8P_s G_0]^{0.5}$, where G_0 = a characteristic admittance of the line joined to points ab.

According to the equivalent linearization method, the stationary condition of injection-locked mode may be written as:[3]

$$H_1(\omega, U_m, I_0, \theta) = H(\omega, U_m, I_0, \theta)\, U_m = i_s \exp(j\chi) \qquad (1)$$

and criteria of injection-locked mode stability are:

$$\frac{\partial}{\partial U_m}|H_1(\omega, U_m)|_0 > 0, \quad \frac{\partial}{\partial U_m} H_2(\omega, U_m)|_0 \times \frac{\partial}{\partial \omega} H_2(\omega, U_m)|_0 > 0 \qquad (2a)$$

where:

$$H(\omega, U_m) = H\exp(j\chi) = [\dot{Y}_{de}(\omega, U_m, I_0, \theta) + \dot{Y}_L(\omega)]$$

$$H_1 = U_m H$$

$$H_2 = U_m^2 H \qquad (2b)$$

Indexes of 0 for derivatives

$$\frac{\partial}{\partial U_m}|H|_0, \quad \frac{\partial}{\partial \omega} H_2\Big|_0, \quad \frac{\partial}{\partial \omega} H_2|_0 \qquad (2c)$$

denote that they are taken at an injection-locked stationary point with the frequency ωs and voltage amplitude U_{ms} at points ab. The complex reflection coefficient $\cdot\Gamma \exp j\chi$ at points ab may be written as:

$$\Gamma(\omega_s, U_{ms}) = \frac{2G_0 - H(\omega_s, U_{ms})}{H(\omega_s, U_{ms})} \qquad (3)$$

And the output power is $P_{out} = \Gamma^2 P_s$.

The graphic presentation of the injection-locked stationary mode condition is seen in **Fig. 2**, with the circle $i_s \exp j\chi$.

Cont. from page 88

Curves I and II define the complex functions H_1 (U_m) for two fixed frequencies ω_1 and ω_2, k and constant values of bias current I_0, and temperature θ_0. The arrows on curves I and II correspond to increasing the voltage amplitude U_m. Curves I and II cross the circle $i_s \exp j\chi$ at points m and n. The transition from point m to point n is related to changes of the locking signal frequency on $\delta\omega$ and the voltage amplitude at points ab on $\Delta U_m = U_{m2} - U_{m1}$, where U_{m1} and U_{m2} are the voltage amplitudes of output signals at frequencies f_1 and f_2, respectively.

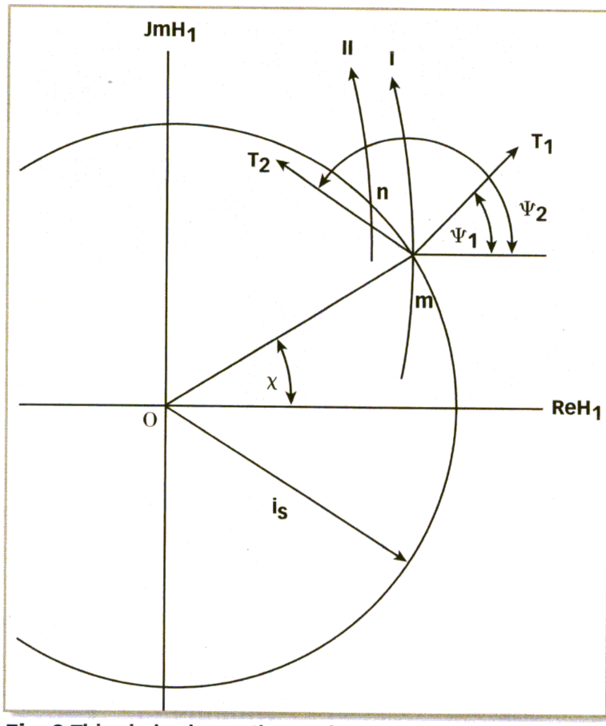

Fig. 2 This circle shows the stationary condition of the injection-locked mode through curves (I and II) that define the change of voltage amplitude (U_m) at fixed frequencies, bias current and temperature.

If P_s is constant within the locking band, the values ΔU_m and $\delta\omega$ are connected by the relationship,

$$\frac{\Delta U_m}{U_m} = -\delta\omega \left[\frac{T_2 \cos(\psi_2 - \chi_0)}{T_1 \cos(\psi_1 - \chi_0) + H_0}\right] \quad (4a)$$

Here, the following notations are used:

$$T_1 \exp(j\psi_1) = \left[U_m \frac{\partial H(\omega, U_m, I_0)}{\partial U_m}\right]\Bigg|_0 \quad (4b)$$

$$T_2 \exp(j\psi_2) = \frac{\partial H(\omega, U_m, I_0)}{\partial \omega}\Bigg|_0 \quad (4c)$$

where:

H_0 = the modulus of complex function at the stationary mode point. As a first approximation for transition

Continued from page 90

from point m to point n the segment mn (Fig. 2) can be defined as:

$$L_{mn} = [\Delta H_1] \Big|_m^n =$$

$$[\Delta H\, U] \Big|_m^n =$$

$$\delta U_m [T_1 \exp(j\psi_0)] + H_0 \exp(j\chi_0) + \delta\omega U_m T_2 \exp(j\psi_2) \qquad (4d)$$

From Eq. 4a,

$$|L_{mn}| = \delta\omega T_2 U_m [\sin(\psi_2 - \chi) - (T_1 / 2_q) \sin(\psi_1 - \chi) \cos(\psi_2 - \chi)] \qquad (4e)$$

where:

$$q = T_1 \cos(\psi_1 - \chi) + H_0 \qquad (4f)$$

and the locking band can be defined as:

$$\Delta\omega_s = \int_{\chi_1}^{\chi_2} i_s d_\chi \,/\, T_2 U_m [\sin(\psi_2 - \chi) - (T_1 / 2_q) \sin(\psi_1 - \chi) \cos(\psi_2 - \chi)] \qquad (5)$$

where:

χ_1 and χ_2 = the phase angles on the plane H_1 that define the limits of the locking band. From the derivation presented here it follows that the validity of Eq. 5 is not restricted by the condition of a small locking signal and any requirements for a diode's amplitude-frequency performance.

When $\psi_1 - \chi = 0$ and $\psi_2 - \chi \approx$ a constant,

$$\Delta\omega_S \approx \omega_0 \frac{(P_s / P_a)^{0.5}}{Q \sin(\psi_2 - \psi_1)} \qquad (6a)$$

$$Q = \omega_0 \frac{\partial H}{\partial \omega} \frac{1}{G_0} \qquad (6b)$$

is a generalized quality of the RF circuit (together with the diode), and P_a = the output power of the free-running mode. This equation coincides with that presented in ref. 3 and when $\psi_2 - \psi_1 = 0.5\pi$, it takes the form of the well-known Adler's formula. The following methods of locking band widening can be defined from Eq. 5.

1. Decrease the generalized quality, Q.

2. Extend the range of angle χ on the complex plane H_1, inside of which the stable stationary injection-locked mode exists.

3. Design the microwave circuit of the oscillator that makes it possible to decrease the modulus.

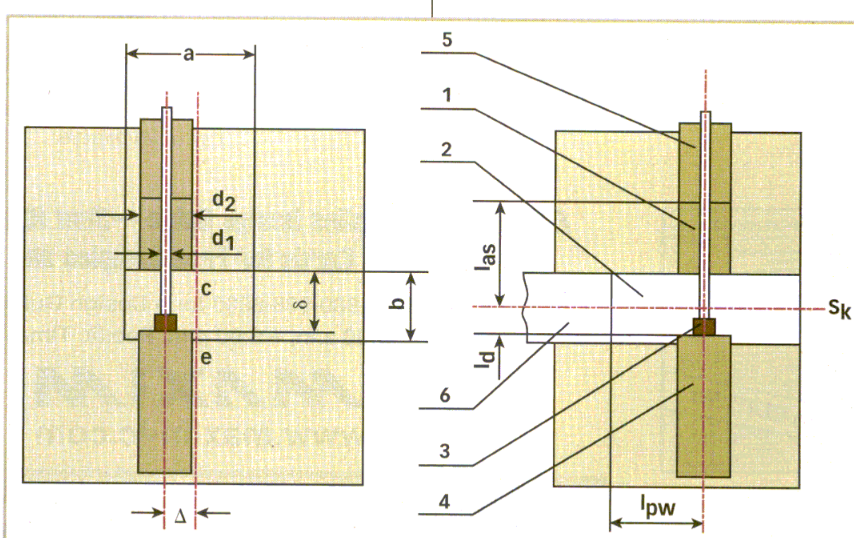

Fig. 3 Most millimeter-wave IMPATT oscillators are based on the waveguide-to-coaxial system with the IMPATT diode (3) mounted on a heat sink (4). An antispurious resistance (5) in the coaxial line (1) supports oscillator adjustment.

$$|S(\psi_1,\psi_2,\chi)| = |\sin(\psi_2 - \chi) - (T/2_q)\sin(\psi_1 - \chi)\cos(\psi_2 - \chi)| \qquad (7)$$

For $\psi_1 = \chi$,

This design is in agreement with the decreasing of the angle $\psi_2 - \psi_1$ that is equivalent to the small frequency stability of a free-running oscillator.

4. Increase the input locking-signal amplitude that is equivalent for other equal conditions to a decrease in the locking gain.

Adherence to these principles increases the probability of successful broadband injection-locked-diode oscillator designs.

An Oscillator Design

The most widespread implementations of injection-locked IMPATT oscillators at millimeter-wave range use a waveguide-to-coaxial microwave system **(Fig. 3)**. The axis of coaxial line (1) is shifted from the axis of the waveguide (2) on the value Δ. The IMPATT diode (3) mounted on the heat sink (4) and the antispurious resistance (5) are installed in the coaxial line and the location of their independent displacements

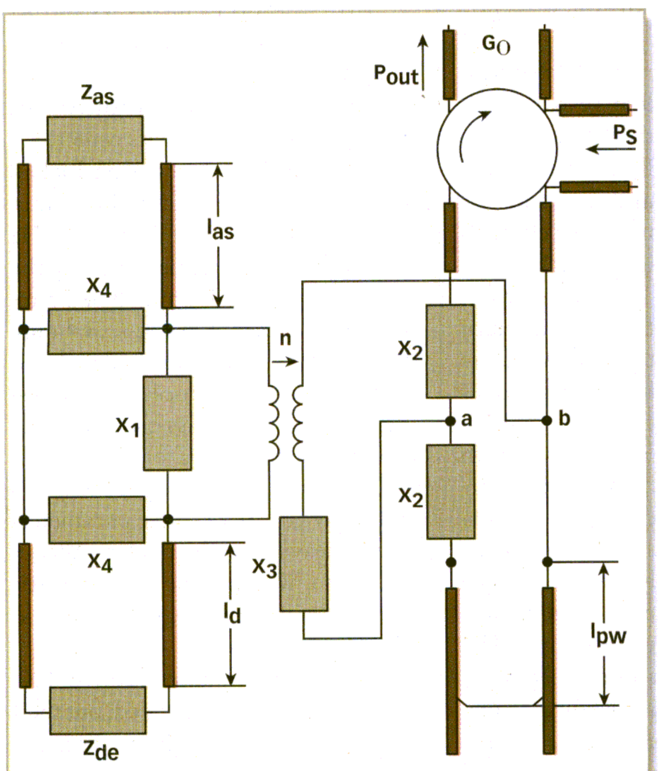

Fig. 4 The equivalent circuit of the system is provided here, where Z_{de} and Z_{as} are complex impedances of the packaged diode and the X_n are the reactive two-port elements of the coax and waveguide.

Continued from page 93

along the coaxial-line axis permits oscillator adjustment. The mounting elements of the diode package are designed in a way so that the resonant transformation of structure impedance is realized. At resonant frequency,

$$\omega_0 \approx \left[\frac{C_d + C_k}{L_p C_d C_k}\right]^{0.5} \quad (8)$$

and the module of packaged diode negative resistance is:

$$|R_{0d}| \approx [(\omega_0 C_k)^2 (|r_d(\omega_0, U_{m,} I_{0,} \theta)| - r_s)]^{-1} \quad (9)$$

where:

L_p = the inductance of the mounting strip that connects the semiconductor structure with the metal end of the ceramic package bushing,

C_k = the capacitance of the ceramic package bushing,

C_d = the equivalent capacitance of the semiconductor structure,

r_d $(\omega, U_m, I_0, \theta)$ = the negative resistance of the semiconductor structure, and

r_s = the equivalent resistance of the structure's heavily doped regions and the structure mounting elements in the package.

The resonant transformation of the diode-structure impedance makes the diode and RF load matching with high values of circuit efficiency possible and is a widely used technique in the millimeter-wave range. The sliding piston (6) is installed at one end of the waveguide section (2) and the other end is connected with the load and the locking source by a ferrite circulator. The equivalent oscillator microwave circuit is illustrated in **Fig. 4**.

The parameters of this scheme are defined in the results of experimental and theoretical investigations.[5,6] Z_{de} is an equivalent complex impedance of the packaged diode. The reactive two-port elements X_1 and X_4 are inserted in coaxial-line section S_k which coincides with the middle waveguide section parallel to the wide side of the waveguide. The reactive two-port elements X_2 and X_3 and second transformer winding are connected to points ce on the line that is perpendicular to the waveguide wide side and passes through its center.

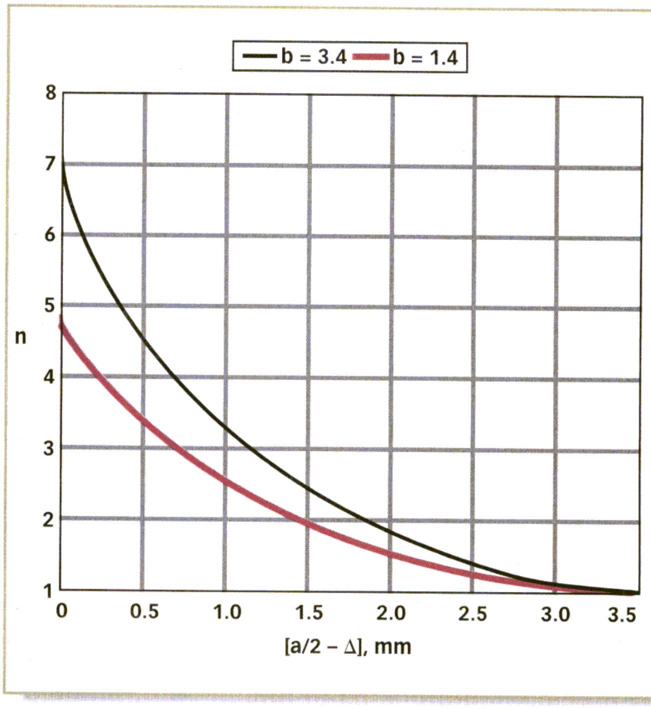

Fig. 5 By changing the value of the transformation coefficient (n), enables diode and load impedance matching without additional reactive discontinuities at the oscillator output.

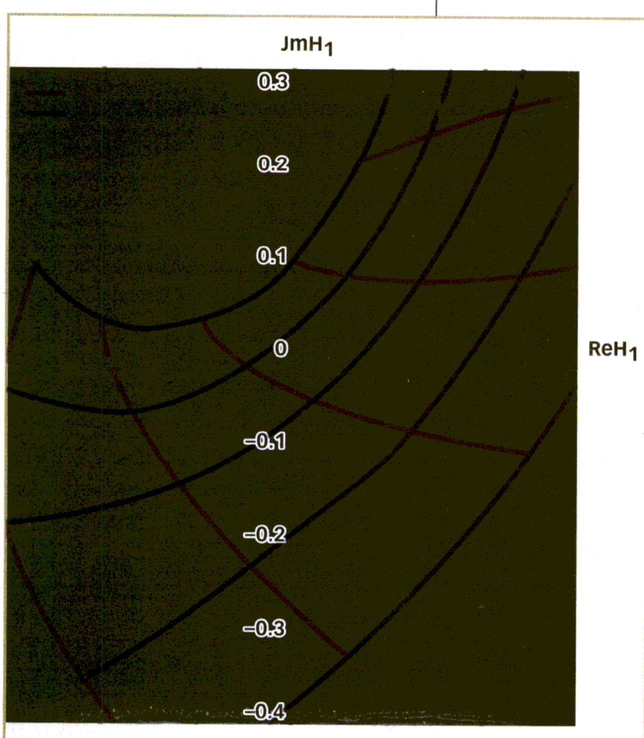

Fig. 6 These curves describe locking-band widening without a series compensating circuit as a function of voltage (U_m)—blue curves, and frequency (f_i)—red curves.

This analysis of injection-locked oscillator characteristics holds within the frequency range of 30 to 40 GHz for the following dimensions of the construction: d_1 = 1.3 mm, d_2 = 3 mm, Δ = a/4, a = 7.2 mm, b = 1.4...3.4 mm. Parameters l_d, l_{as}, l_{pw} are regulated during the adjustment process for the best energetic and bandpass oscillator performances. For the aforementioned construction dimensions, $X_4/W_{0K} > 8$ and $X_2/W_{0W} < 0.12$, these parameters are not heavily weighted. Here, W_{0W} = 1 /G_0 and W_{0K} are the characteristic impedances of the waveguide and coaxial line, respectively.

The reactive parameters X_1 and X_3 also are not heavily weighted, but their influence is considered by changing positions of the waveguide piston (l_{pw}) and antispurious resistance l_{as}, respectively. The characteristic property of this construction is the possibility of the adjustment of the transformation coef-

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7921B	2.4mm Q (f)	2.4mm Q (m)	
7921C	2.4mm Q (f)	2.4mm Q (m)	
8714A1	2.92mm K (f)	2.92mm K (f)	DC — 4.0 GHz, 1.05 4.0 — 20.0 GHz, 1.08 20.0 — 40.0 GHz, 1.12
8714B1	2.92mm K (m)	2.92mm K (m)	
8714C1	2.92mm K (f)	2.92mm K (m)	
8021A2	3.5mm (f)	3.5mm (f)	DC — 18.0 GHz, 1.05 18.0 — 26.5 GHz, 1.08 26.5 — 34.0 GHz, 1.12
8021B2	3.5mm (m)	3.5mm (m)	
8021C2	3.5mm (f)	3.5mm (m)	

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ficient n by changing a shift value Δ and dimensions b and δ of the construction **(Fig. 5)**.

The transformation coefficient n versus shift value Δs shown in Fig. 5 for a frequency f = 35 GHz, a = 7.2 mm, b = 1.4 mm and 3.4 mm. Changing the value n over a wide range makes diode- and load-impedance matching possible without using the additional reactive discontinuities at the oscillator output. As a result, the principal frequency-selecting unit of the microwave circuit is a packaged diode with resonant impedance transformation. Due to the small stored energy in the packaged diode volume, the generalized quality of the RF circuit takes the minimum value, that decreases with increasing values of equivalent load admittance $G_L + G_0 0n^2$.

As a result of theoretical and experimental investigations, a locking-band widening of three times can be achieved in pulsed IMPATT oscillators.

Numerical calculations of injection-locked performances are carried out over the frequency range 33 to 40 GHz for Si semiconductor structure p^+- p-n -n^+, a junction diameter d_{pn} = 160 μm, optimum doping profile at an 8-mm wavelength (the lengths of p and n layers l_p = 0.8 μm, l_n = 1.0 μm, doping concentration in p and n layers $N_a = 3.5 \times 10^{16}$ cm^{-3}, $N_d = 3.0 \times 10^{16}$ cm^{-3}, respectively). The impedance characteristics of these semiconductor structures of IMPATT diodes in a wide range of voltage amplitudes, U_m; densities of diode bias current, J_0; and semiconductor temperatures, θ, are available **(Fig. 6)**.[7] In the second part of this article, the construction principles of IMPATT oscillators will be explained. MRF

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DESIGN

Design An Equal-Element Lowpass Filter

This article compares the performance of a typical equal-element lowpass filter to that of a similar Chebysheff lowpass filter, and explores its use as a bandpass filter.

Many techniques and technologies exist for filtering RF signals. Engineers decide which filter technique and technology to use according to requirements such as electrical, mechanical, and environmental specifications, performance, and production volume. For many applications, L-C filters are still the preferred solution, particularly for demanding applications (such as a radar receiver's (Rx's) downconversion chain) and situations that require small production lots (where the cost of a surface-acoustic-wave (SAW)-filter photo mask would be prohibitively high).

NORBERT KRAUSSE
Falchen-St. 48, D-89233 Neu-Ulm, Germany; +49 731 710786, FAX: +49 892 443 15173, e-mail: Norbert.Krausse@t-online.de.

One such L-C filter is the equal-element lowpass filter, which has only one value for all inductors and one value for all capacitors. This simplifies component procurement, filter assembly, and component mounting because it eliminates the confusion associated with using different-value inductors and capacitors. An additional advantage is its high stopband rejection—higher than can be obtained with a comparable Chebysheff lowpass filter. The properties of equal-element lowpass filters also can be applied to bandpass filters—especially for filtering continuous-wave (CW) signals—but the advantages with respect to component values are less pronounced. This article compares the performance of a typical equal-element lowpass filter to that of a Chebysheff lowpass filter, and explores the equal-element filter as a bandpass filter.

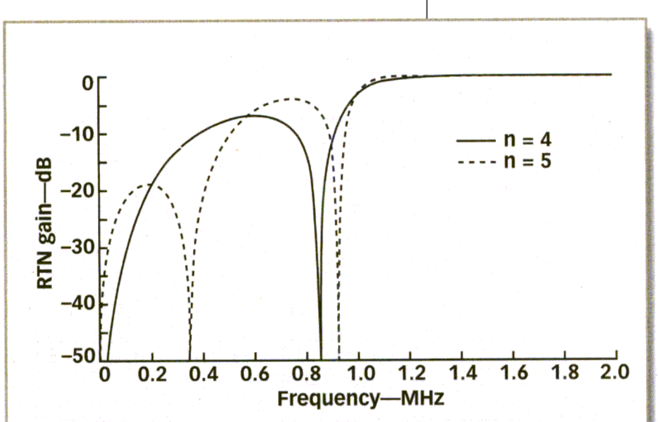

Fig. 1 This graph shows the return gain of four- and five-element, equal-element lowpass filters.

In RF transmit/receive (T/R) systems, there are typically two types of analog signals with which filters must contend: one carries some form of modulation and the other—usually CW—is used for upconversion, downconversion, and clocking. When a modulated carrier signal is demodulated to a frequency at or near 0 Hz (DC), a lowpass filter is used to reject the local-oscillator (LO) frequency in front of the video and matched-filter stages. Since the last LO frequency to be attenuated is much higher than the signal bandwidth, the lowpass filter's 3-dB bandwidth can be made relatively wide. In a radar Rx, for example, downconverting the last intermediate frequency (IF) yields a signal frequency near 0 Hz. A lowpass filter is required to reject the LO fre-

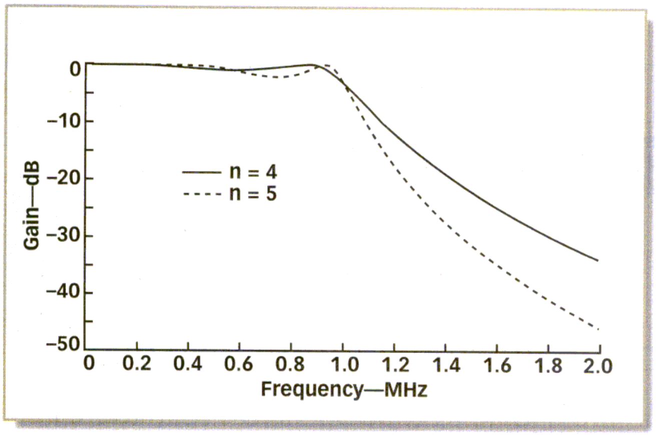

Fig. 2 The gain of four- and five-element, equal-element lowpass filters can be seen above.

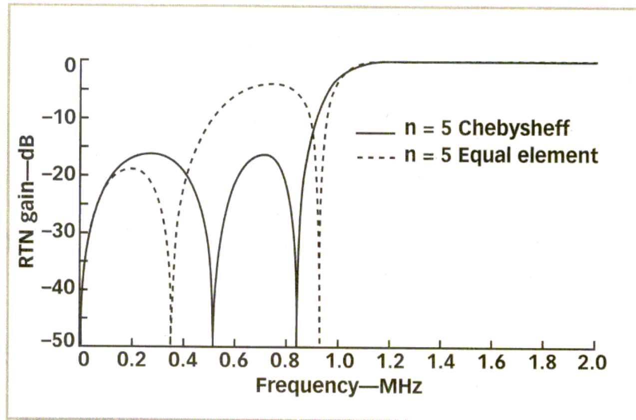

Fig. 3 This graph shows the return gain of five-element, equal-element, and Chebysheff (with 0.1-dB ripple) lowpass filters.

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quency, which is typically in the range of 60 to 1500 MHz.

Lowpass Prototypes

L-C filters are widely covered in the literature, starting with S.B. Cohn's classical report, followed by numerous articles and several books. Most filters are based on the maximally flat (Butterworth) or Chebysheff response.[1] The values of the resonant elements for these filters can be calculated using the well-known formulas in Ref. 1. For applications requiring a maximally flat group delay, the Bessel prototype is a possible solution. The resonant-element values for this type of filter appear in Ref. 2.

A fourth L-C filter is the equal-element filter. All of the resonant elements (g's) in this filter have the same value. The literature on this type of filter is scarce. Matthaei, Young, and Jones[3] and, prior to this publication, S.B. Cohn,[4] have shown that an equal-element filter has the lowest center-frequency insertion loss of the four L-C filters with respect to a required rejection at a certain out-of-band frequency. Reference 3 points out that bandpass filters based on this prototype are suitable for signals having a narrow bandwidth compared to the carrier frequency.

According to section 11.07 of Ref. 3, all resonant elements in an equal-element filter must have the value 1 for minimum insertion loss. However, the literature on equal-element filters offers no information about attenuation roll-off, group-delay performance, useful bandwidth in the passband (e.g., a return gain of < −20 dB), or the filter-element values (g's) normalized to the −3-dB corner frequency. These characteristics will be discussed.

The equal-element lowpass filter's closest relative is the Chebysheff lowpass filter. The main difference between the two is that the equal-element lowpass filter's passband attenuation maxima do not have identical values, but rather increase significantly toward the corner frequency ω' = 1.

One can define the equal-element lowpass filter's corner frequency ω' equal to 1 for a transmission loss (A) of 3 dB with a monotonous attenuation increase for frequencies ω' greater than 1. It should be noted that an equal-element lowpass filter having a degree greater than 5 has passband-loss maxima greater than 3 dB. The **table** shows the lowpass prototype g values (calculated with the aid of a short computer program).

The equation for the attenuation versus frequency is:

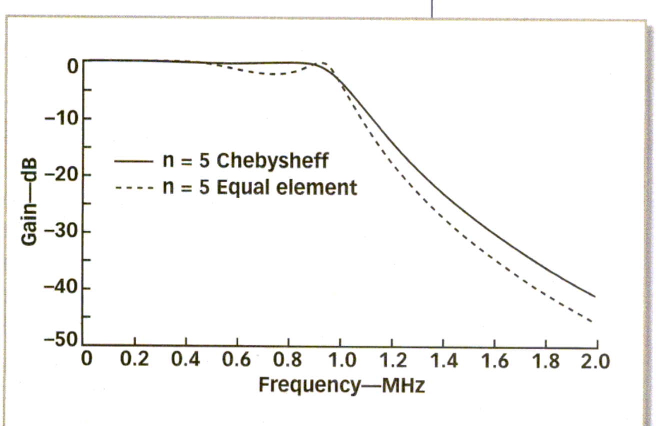


Fig. 4 This graph shows the gain of five-element, equal-element, and Chebysheff (with 0.1-dB ripple) lowpass filters.

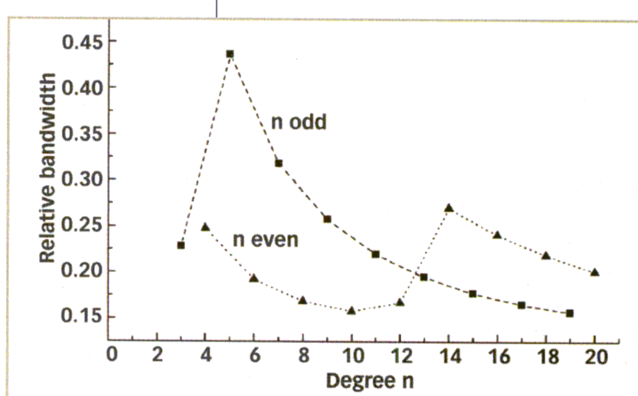
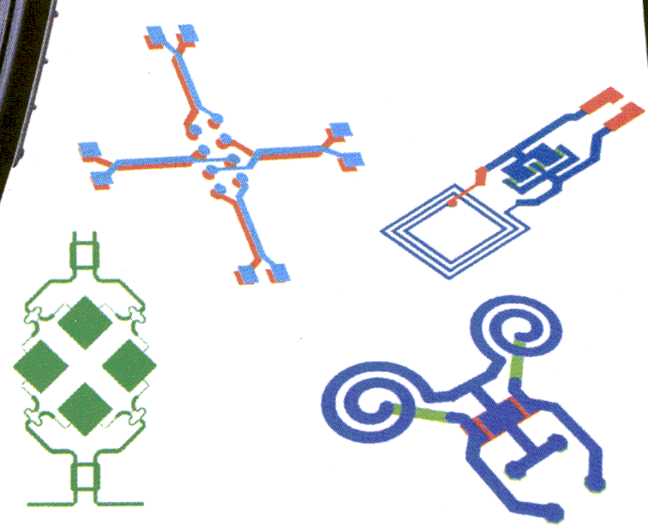


Fig. 5 This graph shows the useful relative bandwidth of equal-element lowpass filter with a return gain of -16.43 dB (transmission gain of -0.1 dB).


CLR



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$$A(\omega') = 10\log(1 + G_n^{\,2})\ [dB] \quad (1)$$

The Gn are polynomial expressions. For n = 3 to 7:

$$G_3 = -0.7607\omega' + 1.7607\omega'^3 \quad (2a)$$

$$G_4 = -2.732\,\omega'^2 + 3.732\,\omega'^4 \quad (2b)$$

$$G_5 = \omega' - 8\,\omega'^3 + 8\,\omega'^5 \quad (2c)$$

$$G_6 = 5\,\omega'^2 - 21\,\omega'^4 + 17\,\omega'^6 \quad (2d)$$

$$G_7 = -\omega' + 19\omega'^3 - 54\,\omega'^5 + 37\,\omega'^7 \quad (2e)$$

The equal-element lowpass filter's passband shows that the attenuation/reflection maxima increase toward the −3-dB corner frequency.

Prototype-element values for equal-element filter where A = 3 dB at ω'=1

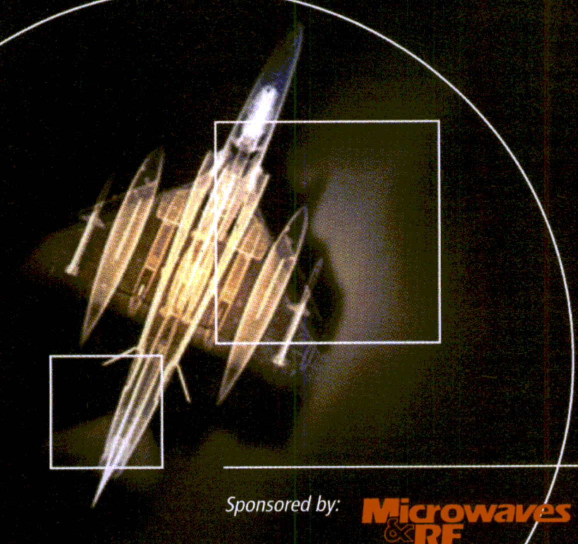
n	2	3	4	5	6	7	8
g	1.4142136	1.5213796	1.6528916	1.7457884	1.8081843	1.8509196	1.8811208
n	9	10	11	12	13	14	
g	1.9031295	1.9196131	1.9322555	1.9421532	1.9500411	1.9564261	
n	15	16	17	18	19	20	
g	1.9616651	1.9660159	1.9696677	1.9727626	1.9754076	1.9776859	

Note: The n = 2 of the equal-element prototype is identical to the n = 2 maximum of the flat prototype.

Figure 1 shows the return gain for equal-element lowpass filters of degree n = 4 and n = 5. The −3-dB frequency is 1 MHz. Assuming a 50-Ω impedance, the element values for n = 4 are: C1 = C3 = 5.2613 nF, and L2 = L4 = 13.153 µH. For n = 5, C1 = C3 = C5 = 5.5570 nF and L2 = L4 = 13.893 µH

Similarly, **Fig. 2** shows the associated transmission gain. In contrast to the Chebysheff lowpass filter, the even- and odd-degree equal-element-lowpass filters are matched at frequency 0. This is also obvious from Eq. 1.

Figure 3 compares a five-element, equal-element lowpass filter to a five-element Chebysheff lowpass filter (with a ripple of 0.1 dB), both having a transmission gain of −3 dB at 1 MHz. The Chebysheff lowpass filter must be computed for a −0.1-dB corner frequency of 0.88129 MHz to achieve −3 dB at 1 MHz. Again, assuming a 50-Ω impedance, the element values for this Chebysheff lowpass filter are: C1 = C5



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= 4.1422 nF, C3 = 7.1335 nF, and L2 = L4 = 12.381 μH.

The "useful-bandwidth" portion of the equal-element lowpass filter's passband depends on the tolerable return loss. For a return gain of −16.43 dB (which corresponds to a transmission gain of −0.1 dB), the useful bandwidth is 0.881 MHz for the Chebysheff lowpass filter and 0.436 MHz for the equal-element lowpass filter.

Figure 4 shows the rejection of both lowpass filters, and indicates that the equal-element lowpass filter is modestly superior in this respect.

Maintaining the definition that was mentioned before of useful bandwidth, namely, a return gain of −16.43 dB, one can generate the graph shown in **Fig. 5**. It shows the useful bandwidth as a function of the equal-element lowpass filter degree for n = 3 to 20, with a rather pointed optimum for n = 5 elements. Note, however, that the return gain of −16.43 dB is an arbitrary choice and that considerably different sets of curves would be obtained for other return gains.

Group Delay

For f = 0, the equal-element lowpass filter has the greatest group delay of the four lowpass-filter responses. **Figure 6** compares the group delay of the n = 5 equal-element lowpass filter to the n = 5 Chebysheff 0.1-dB lowpass filter, both with A = 3 dB at 1 MHz.

Since a filter's insertion loss is proportional to its group delay, the equal-element lowpass filter also has the highest insertion loss of the four responses. However, comparing the equal-element lowpass filter to a Chebysheff-lowpass filter with identical out-of-band rejection (as in section 11.07[3]) instead of on the basis of the -3-dB frequency, one finds that the equal-element lowpass filter has a slightly lower group delay.

For example, according to Fig. 4, the −40-dB bandwidth is 1.772 MHz for the equal-element lowpass filter, and 1.951 MHz for the Chebysheff-lowpass filter. According to **Fig. 7**, the group delay at 0.1 MHz is 0.691 μs for the equal-element lowpass filter and 0.630 μs for the Chebysheff-lowpass filter. If the −40-dB bandwidth of the equal-element lowpass filter is extended to 1.951 MHz (the Chebysheff value), the −3-dB frequency of the equal-element lowpass filter is now 1.101 MHz, and the group delay at 0.1 MHz becomes 0.627 μs, compared to the 0.630 μs of the Chebysheff-lowpass filter.

• Component spread. With the equal-element filters (lowpass and bandpass), the element values of inductors and

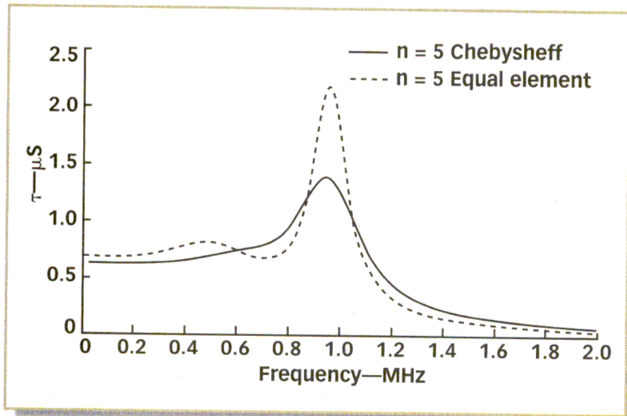

Fig. 6 The group delay of five-element, equal-element, and Chebysheff (with 0.1-dB ripple) lowpass filters can be seen above.

Continued from page 104

capacitors are in the same range as for the corresponding maximum flat or Chebysheff response. This feature is also obvious from the g values in the table.

• Standard component values. In order to keep the actual component number as low as possible, it might be possible to modify the lowpass filter's bandwidth to achieve a standard value for either the inductors or capacitors (preferably the inductors).

• Equal-element bandpass filters. The term "equal-element" bandpass filter is not quite appropriate. A better term is "minimum- element-type" bandpass filter, as the following example illustrates: For a 5-pole pi-filter[5] with a maximum-flat or Chebysheff response, one needs, in addition to five equal inductors, the following set of capacitors: three values (two each) for coupling capacitors, one value (two pieces) for resonators 1 and 5, and two values (four each) for resonators 2, 3, and 4.

Compare this to the equivalent minimum-element-type bandpass filter. Here one needs, in addition to five equal inductors, the following set of capacitors: one value (two pieces) for input- and output-coupling capacitors, one value (four pieces) for the interior coupling capacitors, one value (two pieces) for resonators 1 and 5, and one value (eight pieces) for resonators 2, 3, and 4. With this filter, one saves two capacitor values. The filter designer has to decide if this is worth pursuing for his or her application.

The electrical characteristics of a Chebysheff and a minimum-element-type bandpass filter are not very different when computed for required out-of-band rejection. As an example, consider a five-resonator pi-filter for a center frequency of 500 MHz with a rejection of approximately 50 dB at 450 MHz. In Fig. 7, the attenuation versus frequency is shown for the minimum-element-type bandpass filter and the 0.1-dB Chebysheff bandpass filter. Both filters exhibit the same insertion loss. MRF

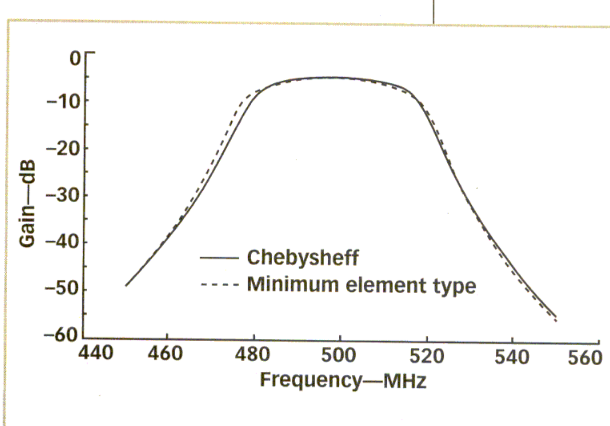

Fig. 7 This graph shows the gain of five-resonator, minimum-element, and Chebysheff (with 0.1-dB ripple) bandpass filters.

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Scrutinizing Single-Ended S-Parameters

Single-ended S-parameter measurements are useful in analyzing the forward and reverse transmission and reflection characteristics of two-port networks.

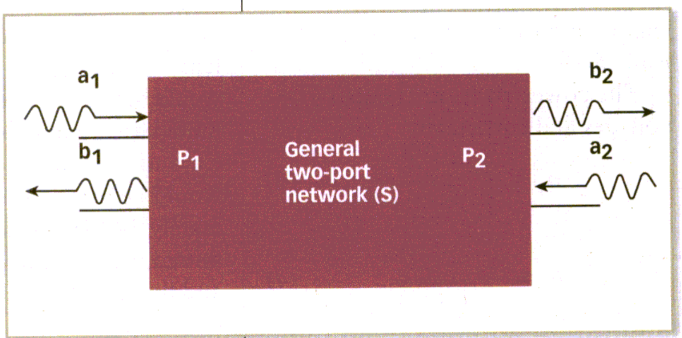
Integrated circuits (ICs) have been important components in communications systems for many years. In the past, these communications circuits have operated at low frequencies. At these low frequencies, the circuit can be designed and analyzed using lumped-element models and techniques. With the frequency of operation increasing beyond 1 GHz (and equivalently, above 1 Gb/s for digital communications), this lumped-element approach is no longer valid since the physical size of a circuit element approaches a significant portion of a wavelength.

GARTH SUNDBERG
Member of the Technical Staff
Technology, Research, and Development, Maxim Integrated Products, 120 San Gabriel Dr., Sunnyvale, CA 94086; (408) 737-7600, FAX: (408) 737-7194, Internet: http://www.maxim-ic.com.

To deal with the shortcomings of lumped-element techniques, distributed models and analysis techniques are used. In these models, the resistance of a resistor, for example, is distributed across the length of a transmission line.

Last month, the opening installment of this four-part article series introduced the concept of scattering (S)-parameters and how they have been developed for the analysis and measurement of distributed circuit models.[1] As was seen in Part 1, S-parameters could be developed in several versions, with single-ended S-parameters well-suited for analysis of two-port networks, and mixed-mode S-parameters better used for the analysis and measurement of differential or balanced lines and components common to digital circuits. What follows is a review of single-ended S-parameters.

The name "scattering parameters" comes from how the parameters represent a scattering, or separation, of a signal by a device under test (DUT). These scattered signals are the reflected and transmitted waves that are produced when a device is struck with an incident wave. S-parameters become important when the operating frequencies are high



1. This simple diagram can be used to visualize the four S-parameters of single-ended scattering-parameter measurements.

Continued from page 109

enough so that circuit elements become a significant fraction of a wavelength (approximately one-tenth of a wavelength) and a lumped-element approach must be discarded in favor of a distributed model.

Also, when the frequency increases to the microwave range, it is difficult to measure voltages and currents (as is required for impedance measurements). To overcome this problem, a ratio of the incident and outgoing wave is used. This is represented in Fig. 1 and defined in Eq. 1 (from Part 1 and repeated here for convenience):

$$S_{ij} = (b_i / a_j) /_{a_k = 0 \, for \, k \neq j} \qquad (1)$$

In matrix form, Eq. 1 becomes Eq. 2 (from Part 1 and repeated here for convenience):

$$[b] = [S][a] \qquad (2)$$

where:

n = the number of ports in a network of interest (i.e., n = 2 in Fig. 1),

[b] = an n × 1 column matrix,

[a] = an n × 1 column matrix, and

[S] = an n × n matrix.

Equation 1 states to measure S_{ij}, energize port j, and measure the response on port i. It is important to note that all ports, except the stimulus port, must be terminated with that port's characteristic impedance. For example, to calculate S_{21} for the network in Fig. 1, energize port 1, take the power out of port 2, and divide it by the power incident on port 1 when there are not any incident voltages on port 2. To ensure that there is no incident power waves on port 2, terminate port 2 with its characteristic impedance, which is typically 50 Ω.

The power waves are related to the voltages and currents by:

$$a_n = \frac{v_n + i_n Z_n}{2\sqrt{Re(Z_n)}} \qquad (3)$$

$$b_n = \frac{v_n - i_n Z_n^*}{2\sqrt{Re(Z_n)}} \qquad (4)$$

where:

v_n = the total voltage at port n,

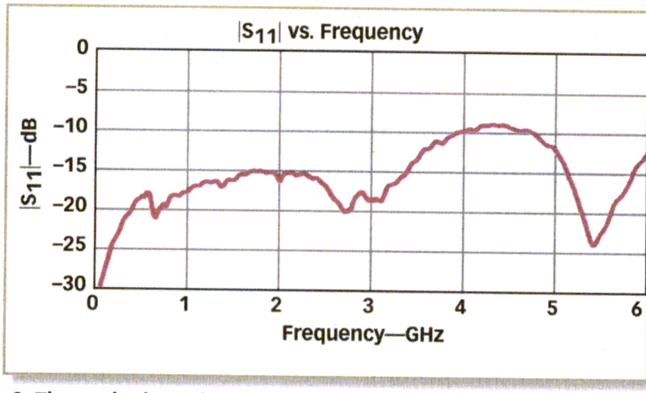
I_n = the total current at port n, and

Z_n = the characteristic impedance at port n.

S-parameters are used in many ways to characterize a device or transmission line. In the [S] matrix, the diagonal elements (S_{ij}) are the reflection coefficients if, and only if, all other ports are terminated with their characteristic impedance. From these measurements, the VSWR, return loss (in decibels), and other parameters can be calculated. The S_{ij} terms are the transmission coefficients. From this quantity, gain of an active device, loss in a passive device, insertion loss, group delay, and other related parameters can be found.

An analogy to optics and reflected light is helpful in explaining the concept of S-parameters. If one has a ray of light incident on a piece of clear glass (as shown in Fig. 2 of Part 1), then the incident light wave would be the equivalent of a_1 of **Fig. 1**. The reflected wave would be the equivalent of b_1, the transmitted wave would be the equivalent of b_2, and the characteristic impedance would be that of free space (approximately 377 Ω). As a result, the transmitted wave can be thought of as S_{21} and the reflected wave can be thought of as S_{11}.

To show single-ended S-parameter measurements, the return loss of a model MAX3950 deserializer was evaluated with a VNA.



2. These single-ended network-analyzer measurements of return loss (S_{11}) were performed on a model MAX3950 10-Gb/s deserializer.

To demonstrate single-ended S-parameter measurements, the return loss of a model MAX3950 10-Gb/s deserializer from Maxim Integrated Products (Sunnyvale, CA) was evaluated with a model 8753D vector network analyzer (VNA) from Agilent Technologies (Santa Rosa, CA). Since the network analyzer has a maximum frequency of 6 GHz, data are not shown above this point, even though the deserializer works well beyond that test frequency.

The measurement setup is the same as that shown in Fig. 6 of Part 1.

To obtain the measured data, a standard short-open-load-through (SOLT) calibration was performed using a model 85033D 3.5-mm calibration kit from Agilent Technologies. Once the calibration was performed, it moved the measurement reference plane from the analyzer's input and output connectors to the end of the test cables (Fig. 6 of Part 1). Since no calibration kit was built to measure the deserializer on its circuit board, the measured S-parameters presented include the effects of the transmission line and SMA connectors required to deliver the test signals from the network analyzer to the MAX3950. As a result, the actual return loss of the device will be better than that which is presented here. These measurement results are presented in **Fig. 2**.

Next month, Part 3 will shift to mixed-mode S-parameters. This variation on single-ended S-parameters makes it possible to analyze and test devices that use differential or balanced signal lines. The article will explore the mathematical background of mixed-mode S-parameters and compare measurements made on balanced devices. MRF

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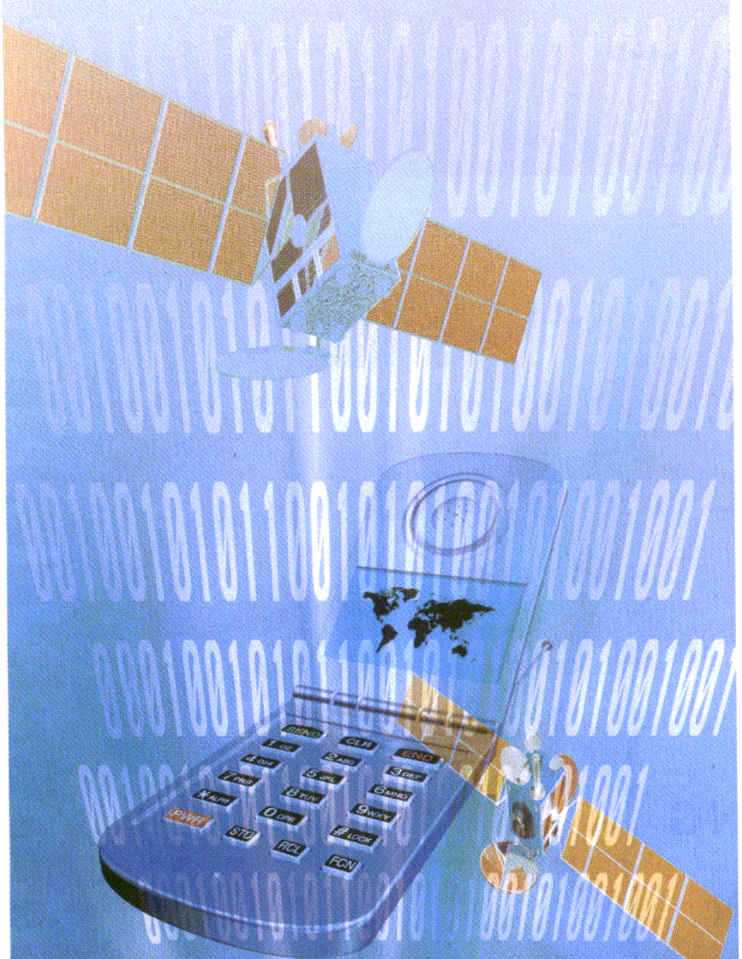

Avnet and Philips: PeRFect Partners

Completing its line-up of RF discrete semiconductors, Philips introduces for the first time a new range of PIN diodes developed for use as RF switches and attenuators. Targeted for a variety of RF wireless designs, including phone and satellite applications, the new devices feature high isolation between a phone's transmitter and receiver, low insertion loss and low distortion, enabling designers to create smaller, lighter and lower-cost mobile products.

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BAP50-04	SOT23	Series	50	50	25	3	0.45	0.3@5V
BAP50-05	SOT23	CC	50	50	25	3	0.45	0.3@5V
BAP64-02	SOD523	Single	200	100	20	2	0.52	0.23
BAP64-03	SOD323	Single	200	100	20	2	0.52	0.23
BAP64-04	SOT23	Series	200	100	20	2	0.52	0.23
BAP64-04W	SOT323	Series	200	100	20	2	0.52	0.23
BAP64-05	SOT23	CC	200	100	20	2	0.52	0.23
BAP64-05W	SOT323	CC	200	100	20	2	0.52	0.23
BAP64-06	SOT23	CA	200	100	20	2	0.52	0.23
BAP51-02	SOD523	Single	60	60	5.5	1.5	0.4	0.2@5V
BAP51-03	SOD323	Single	60	60	5.5	1.5	0.4	0.2@5V
BAP51-05W	SOT323	CC	60	60	5.5	1.5	0.4	0.2@5V
BAP65-02	SOD523	Single	30	100	-	0.56	0.65	0.375
BAP65-03	SOD323	Single	30	100	-	0.56	0.65	0.375

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Measuring IMD with a VNA

WIRELESS COMMUNICATIONS power-amplifier (PA) nonlinearity is most often determined by two-tone intermodulation-distortion (IMD) measurements and the third-order-intercept-point (IP3) extrapolation. The usual instrument for measuring IMD is the spectrum analyzer, but vector network analyzers (VNAs) now being marketed by a few test-equipment manufacturers can offer designers more flexibility and faster performance. To aid them in this effort, the Microwave Measurements Division of Anritsu (Morgan Hill, CA) published the "Intermodulation Distortion (IMD)" application note, which pertains primarily to its MS462xx Vector Network Measurement System, but which provides sufficient generality about IMD and IP3 to be helpful in other VNA applications.

As the seven-page note points out, one of the problems in IP3 extrapolation is that it does not always follow a 3:1 Pout/Pin slope ratio as theory would predict. The natural reaction is to perform measurements at a few different power levels to get a more accurate extrapolation, but the note offers several reasons why it would be unwise to do so. Therefore, it recommends sticking with the most common measurements, which are the raw IMD product and the standard IP3 extrapolation.

The focus of the note is that a user has a number of choices that must be considered carefully whatever instrument is used for the measurements. These include details of the test setup [source type, frequencies, swept or continuous-wave (CW) measurements, proper filtering at the input and output to the device under test (DUT), etc.], the type of measurement (IMD product or IP3), the references relative to tones and input/outputs (I/Os), and calibrations. Having the flexibility to perform measurements suitable to manufacturing and customer specifications is the ultimate goal. This note is available as a free download from the company's website.

Anritsu Microwave Measurements Division, Morgan Hill, CA 95037; Internet: http://www.us.anritsu.com/downloads/files.

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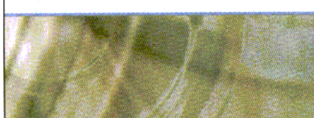

For those new to fiber-optic networks, the tutorial on a typical photonic network should be a good starting point.

Fiber-optic networks hit the limelight

MANY SEGMENTS of the communications industry have fallen on hard economic times during the past year, but fiber optics is not one of them. In fact, the need for ever-faster high-speed optical networks to carry the heavy data, video, and Internet loads of the future is escalating rapidly. Chances are that in the next few years, many engineers in the communications business will need a good understanding of how these networks operate. To shed some light on the subject, Tektronix (Beaverton, OR) released a nine-page backgrounder called "Photonics in Complex Networks," which explains the architecture of an optical network and the technology that makes it so fast, known as wavelength-division multiplexing (WDM) and the higher-speed version known as dense WDM or DWDM.

Tektronix's interest in optical networks is a natural one. Their complexity and speed will require very special test equipment to design, test, and maintain them. One type of test equipment is known as a cornerstone product, which is an instrument that can make so-called mission-critical measurements, or one that must meet the highest standards because it makes measurements on equipment that must conform to the network's standards.

For those new to fiber-optic networks, the tutorial on a typical photonic network should be a good starting point. It goes through the basic substructures of a network and explains where the WDM and DWDM elements come in. Then it proceeds down a level to the structure of a typical DWDM link where the network operates at its highest speed. Of course, there is a section on network testing and the two different types (performance assessment and conformance) required for network management.

The final section of the backgrounder turns to the test-and-measurement needs of manufacturers who build equipment for optical networks. Their requirements are varied and demanding, since they need instruments for various phases of a project: design, integration of elements, manufacturing test, installation, and maintenance. The backgrounder is available as a free download from the company's website.

Tektronix, Beaverton, OR 97077; Internet: http://www.tek.com/measurement/commtest/photonics.

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cover story

SAWs Stabilize Low-Phase-Noise Voltage-Tuned Sources

These SAW oscillators provide high fundamental-frequency outputs at 622 and 2488 MHz with low phase noise and high immunity to vibration.

ENGINEERING DEPT.
Synergy Microwave Corp,
201 McLean Blvd., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, Internet: http://www.synergymwave.com.

Phase noise is critical in many communications applications, especially those employing high-data-rate digital modulation schemes. In a digital radio employing quadrature-amplitude modulation (QAM), for example, different phase states represent digital bits. Excessive phase noise in the system can obscure these bits, resulting in an excessively high bit-error rate (BER) and possible lost data. Fortunately, a line of voltage-controlled surface-acoustic-wave oscillators (VCSOs) developed by Synergy Microwave Corp. (Paterson, NJ) provides extremely low phase noise at high fundamental output frequencies, making them suitable for digital microwave radios, optical communications, and other phase-critical systems. The first several models are available at fixed frequencies of 622 MHz and 2.488 GHz.

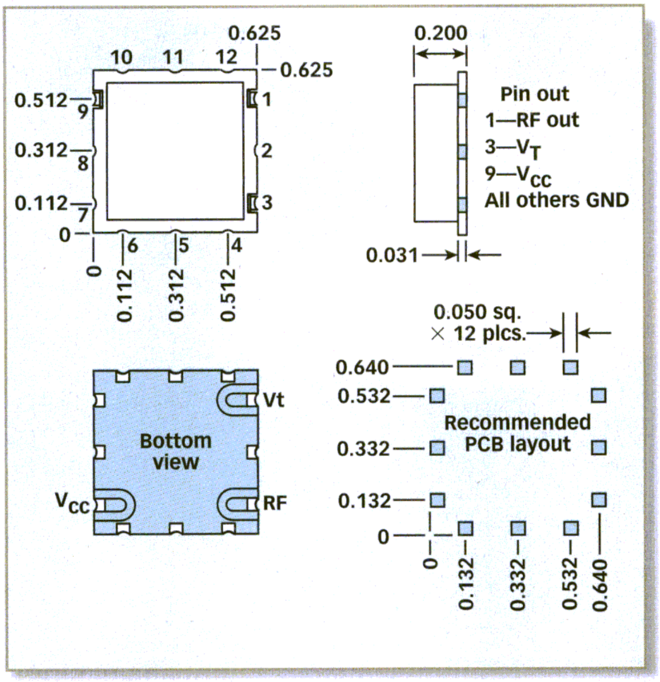
Oscillators based on surface-acoustic-wave (SAW) technology offer several advantages compared to other source types, including high fundamental-frequency operation without subharmonic content, very-low noise floor, and excellent immunity to vibration and microphonics. The use of high fundamental frequencies helps to minimize the number of multiplication stages required to achieve a particular output frequency. Since phase noise will degrade with multiplication by a factor of 20logN, where N = the multiplication factor (for example, N = 2 for doubling), a simple doubling of a signal source will result in a degradation of 6 dB in phase noise. Quadrupling the output

Continued from page 115

frequency will result in a penalty of 12 dB in phase noise, and so on. Thus, ideally, a low-phase-noise oscillator should be specified at the highest-possible fundamental frequencies to minimize the number of multiplication steps required.

The first series of Synergy SAW oscillators **(Fig. 1)** is at optical-carrier (OC) frequencies of OC-12 (622.08 MHz) and OC-48 (2.488 GHz), models VCSO-OC12 and VCSO-OC48, respectively. (Phased-locked versions are also available as models PLL-OC12 and PLL-OC48, respectively.) The sources are based on the use of a fundamental-tone SAW resonator in a feedback-loop circuit **(Fig. 2)**. The phase-shift circuitry, which is realized with inductive-capacitive (LC) lumped or distributed circuit elements, provides the tuning mechanism using varactor diodes through applied voltage, typically from +0.5 to +4.5 VDC. It essentially pulls the resonator across its frequency range of adjustment, typically ±100 PPM of the center frequency. Energy is coupled out of the oscillator through the small-signal amplifier, which is maintained in its linear region to minimize harmonic contributions. The amplifier delivers output signals at +10 dBm typical.

Compared to a coaxial or ceramic resonator (CR), the SAW resonators make it possible to create extremely small



1. The new VCSOs include models at center frequencies of 622 MHz and 2.488 GHz for fixed-frequency and phase-locked applications.

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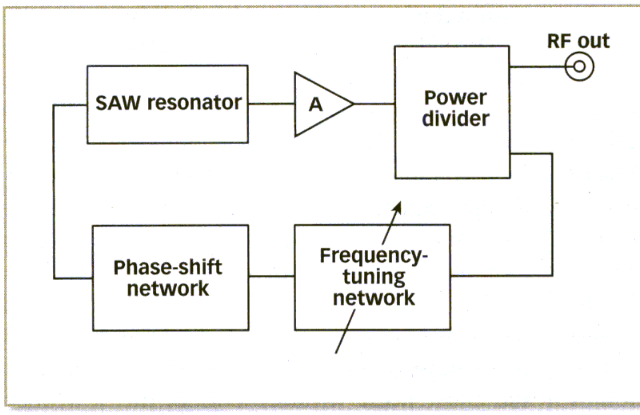
fundamental-frequency oscillators that can fit within standard surface-mount packages. The 2.488-GHz model, for example, uses a resonator measuring only 3.8 × 3.8 mm. Of course, at higher OC frequencies, such as OC-192 (10 GHz), the small size of the SAW resonator required becomes a practical limit to achieving OC-192 sources using this technology, although some work is being performed on practical 5-GHz resonators which can be doubled in frequency to achieve the desired OC-192 frequencies. Presently, higher OC rates are typically achieved by multiplying high-fundamental-frequency sources. For example, an OC-48 source at 2.488 GHz can be multiplied by four to achieve the 10-GHz OC-192 frequency, although with a phase-noise penalty of 20log4 = 12 dB.



2. The basic architecture of the SAW sources consists of active circuitry, a resonator, an LC phase shifter, and a buffer amplifier.

The SAW oscillators are designed for phase-locked-loop (PLL) synthesizer applications, providing enough of a tuning range (±100 PPM) to accommodate oscillator-frequency variations due to temperature, load pull, and voltage pushing. High-quality-factor (Q) resonators are used in these sources, typically 700 to 800 for the 2.488-GHz OC-48 oscillators and greater than 1200 for the OC-12 (622-MHz) oscillators. The temperature coefficient for the higher-frequency resonator is typically less than 150 PPM from −40 to +85°C.

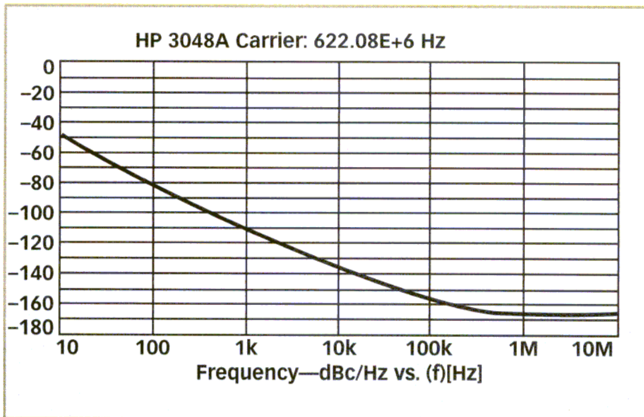
Phase-locked oscillators (PLOs) basically consist of a phase detector, a voltage-controlled oscillator (VCO), an integrator (in the form of a loop filter), and frequency divider(s) connected in a feedback loop. The phase-noise performance of the new VCSOs is good enough to forgive a degradation of 12 dB in phase noise due to a quadrupling of the carrier frequency. Since it is the phase noise of the oscillator

Continued from page 119

that essentially dominates the noise in the loop, especially at wider loop bandwidths, the noise floor of a VCSO will basically set the BER for an optical- or digital-communications system. Designers working with PLLs should keep in mind that the loop bandwidth should be kept as narrow as possible to take advantage of the low phase noise of the VCSOs, although some consideration should also be given to the fact that the design may become susceptible to microphonics when using a narrow loop filter. This can be explained by the fact that the VCSO phase noise dominates the noise performance outside the loop bandwidth.

The VCSOs are suitable for use in phase-locked converters or multipliers for optical-communications networks. These devices have an integer relationship with the system reference frequency. For example, the most common reference frequency, 155.52 MHz or OC-3, is four times the frequency of OC-12 (622.08 MHz) and 16 times the frequency of OC-48 (2488.32 MHz). Ideally, a multiplication factor of 4 is used, so that the phase-noise degradation with multiplication is held to 20log4 = 12 dB. Unfortunately, the phase-noise limitation comes from the usable frequency of the phase detector. The noise floor of the detector degrades with increasing frequency. Without overly degrading the noise performance, the practical high end of the phase-detector frequency band is 20 to 30 MHz. In the case of an OC-3/OC-12 converter, the reference signal is divided by 6 (for a frequency of 25.92 MHz), while the OC-12 VCSO is divided by 24 to achieve the same 25.92-MHz frequency at the phase detector. The multiplication factor with respect to the phase-detector frequency will be 24, with degradation due to multiplication of 20log24 = 27.6 dB. Assuming phase noise of −140 dBc/Hz for the phase detector, the phase noise within the loop will be −112 dBc/Hz.

Depending upon system specifications, a PLL loop filter can be adjusted for optimum performance. For wider loop bandwidths, the phase noise within the loop is limited by −112 dBc/Hz. If a design requires better phase noise at some desired offset frequency, then the loop bandwidth must be kept narrow so that the VCSO becomes the dominant source of phase noise. Even if the phase noise of the VCSO is better than the phase noise within the loop, the noise of the loop will dominate. The choice of loop bandwidth is then dictated by the system switching-speed and phase-noise requirements. Better immunity to vibration and microphonics is achieved through the use of wider loop bandwidths. The integrated phase noise over a particular bandwidth depends on the levels of spurious products and the phase noise at different offset frequencies within the band.



3. The single-sideband (SSB) phase noise of a 622-MHz VCSO reaches a noise floor of −165 dBc/Hz after dropping from a close-in level of −80 dBc/Hz.

Since specifications for Synchronous Optical Network (SONET) systems call out for low phase noise close to the carrier (1 kHz), these SAW sources are well-suited for SONET and synchronous-digital-hierarchy (SDH) applications. The 622-MHz oscillators, for example, exhibit close-in phase noise of −80 dBc/Hz offset 100 Hz from the carrier **(Fig. 3)**. The phase noise drops to −110 dBc/Hz offset 1 kHz from the carrier, −135 dBc/Hz offset 10 kHz from the carrier, and −155 dBc/Hz offset 100 kHz from the carrier. At 300 kHz from the carrier, the phase noise rolls down toward the noise floor of −165 dBc/Hz. It should be noted that these phase-noise specifications translate into very-low-phase jitter performance (on the order of picoseconds) in terms of time-domain system performance.

The voltage-tuned SAW oscillators are inherently resistant to microphonics, which are essentially frequency-modulated (FM) signals that result as a function of vibration. When an oscillator is subjected to single-tone-type vibration, it will produce sideband energy at a carrier frequency offset equal to the vibration frequency. When the oscillator is subjected to vibration of a more random nature, the resulting noise is similar to phase noise, due to the mechanical stressing of the SAW resonator. The immunity of a SAW oscillator to vibration can be expressed in terms of gravitational-force (G) sensitivity or acceleration sensitivity, which is the ratio of the power in the vibration sidebands to the carrier power per G unit of vibration. The typical immunity to vibration sidebands and microphonics for the 622-MHz oscillator is 5×10^{-10}/G, with similar performance for the 2.488-GHz unit.

The voltage-tuned SAW oscillators are suitable for local-multipoint-distribution-system (LMDS) applications, for clock cleanup/recovery applications in digital- and optical-communications systems, and for digital microwave radios employing higher-order modulation schemes, such as 16QAM and 64QAM. The first series of these stable sources operates at OC-12 (622 MHz) and OC-48 (2.488 GHz) frequencies and are well-suited for surface-mount assembly. **Synergy Microwave Corp., 201 McLean Blvd., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, Internet: http://www.synergymwave.com.** MRF

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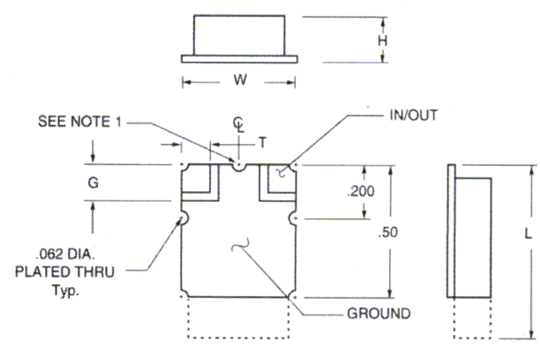

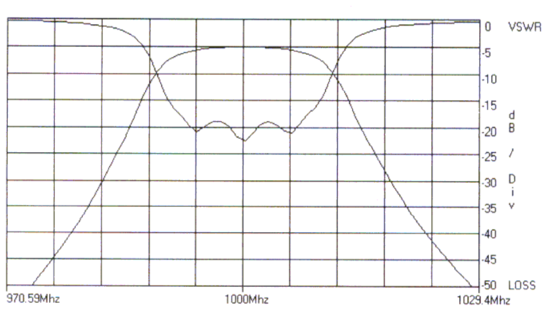

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PRODUCT technology

Device Measures Gain And Phase From 0.1 To 2.7 GHz

This versatile IC, which can measure gain/loss and phase on a pair of input signals from 0.1 to 2.7 GHz, is suitable for power-control and amplifier linearization applications.

JACK BROWNE
Publisher/Editor

Measurements of gain and phase are synonymous with a vector network analyzer (VNA). And the new AD8302 from Analog Devices (Norwood, MA) shares some of the functionality of an expensive VNA, except that this is a tiny, low-cost integrated circuit (IC) that can be readily employed in receivers (Rxs), transmitters (Txs), spectrum analyzers, as well as in other systems operating from 0.1 to 2.7 GHz.

The innovative model AD8302 gain and phase detector **(see figure)** combines a closely matched pair of demodulating logarithmic amplifiers, each with a measurement range of 60 dB. By taking the difference of the two logamps' outputs, a measurement of the difference in magnitude of two input signals is possible. The two input signals need not be at the same frequency, enabling the measurement of conversion loss or gain in mixers and Rxs. When a calibrated AC reference signal is applied to one of the AD8302's input ports, the IC can be used to determine the absolute signal level of an unknown signal. The AD8302 is capable of measuring gain or loss over a full 60-dB range from −62 to −2 dBm in a 50-Ω system, or from −75 to −15 dBV. The gain/loss measurement accuracy is typically better than 0.5 dB.

The AD8302 can make phase measurements over a total range of 180 deg. It provides accurate phase-measurement scaling of 10 mV/deg. from 0 to +1.8 VDC, with typical accuracy of better than 1 deg. **Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; (800) 262-5643, (781) 329-4700, FAX: (781) 326-8703, Internet: http://www.analog.com.** MRF

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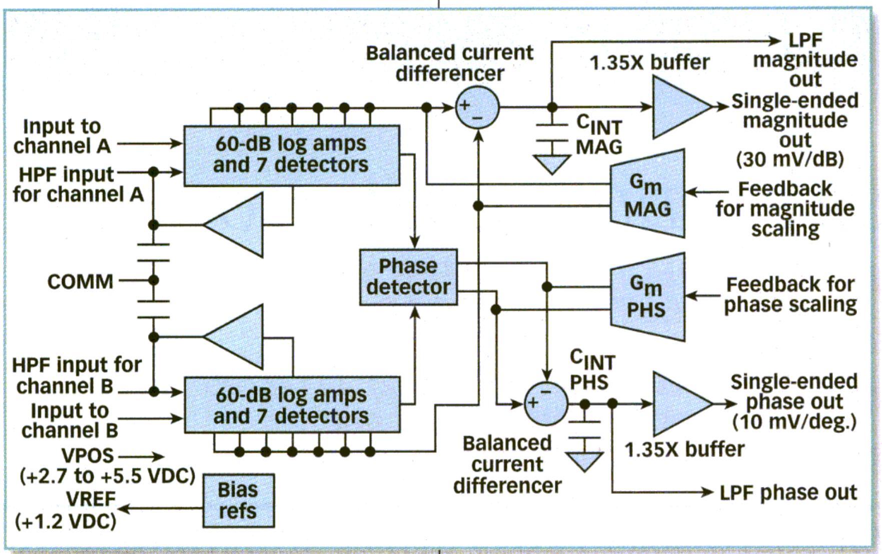
The AD8302 RF/IF gain and phase detector is based on a pair of tightly matched demodulating logamps and a phase detector.



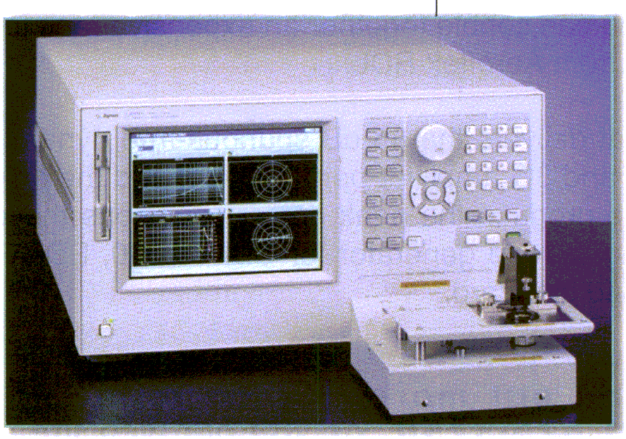
Analyzer Provides Repeatable Impedance Measurements To 3 GHz

This versatile analyzer extends the frequency range for direct impedance measurements of passive components through 3 GHz.

Impedance measurements have never been easy at high frequencies. Inductance-capacitance-resistance (LCR) meters with a four-terminal-pair configuration are often used at higher frequencies, while accepting inaccuracies. Fortunately, the new model E4991A RF impedance/material analyzer from Agilent Technologies (Santa Rosa, CA) provides direct readings of impedance measurements to 3 GHz.

MITSU TSUJI
Agilent Technologies
1400 Fountaingrove Pkwy., Santa Rosa, CA 94501; (707) 577-3770, FAX: (707) 577-5666, Internet: http://www.agilent.com.

The E4991A makes measurements at frequencies from 1 MHz to 3 GHz and impedances from mΩ to kΩ ranges, making it ideal for characterization of devices for wireless applications, such as Bluetooth, wireless local-area networks (WLANs), and wideband code-division-multiple-access (WCDMA) systems. The E4991A RF impedance/material analyzer also performs a wide range of highly accurate measurements on material characteristics, including permittivity (ϵ_r*) and permeability (μ_R*).



The E4991A RF impedance/material analyzer provides direct readings of impedance at frequencies through 3 GHz. Other key material parameters, including permittivity (ϵ_r*) and permeability (μ_r*), can be measured up to 1 GHz.

The E4991A RF impedance/material analyzer **(see figure)** enables characterization of components such as capacitors, inductors, diodes, resonators, and antennas, as well as evaluation of dielectric and other materials when using the proper test fixture. It improves upon its predecessor, the 1.8-GHz model 4291B, with increased frequency range, better measurement repeatability, and a more flexible (Windows-based) user interface.

The impedance/material analyzer employs an RF current-voltage (RF-IV) measurement technique to achieve basic measurement accuracy of 0.8 percent. The RF-IV method measures impedance directly from a ratio of voltage and current, without having to convert the measured data. In contrast, a vector network analyzer (VNA), which usually has characteristic system impedance of 50 Ω (for RF and microwave testing) or 75 Ω [for cable-television (CATV) testing], relies on a transmission/reflection technique to derive impedance.

A VNA first measures the reflection coefficients of a device under test (DUT), then calculates the impedance values. For a VNA, small changes in the measured reflection coefficient can produce large changes in impedance. For example, for an impedance measurement of 2 kΩ, a 1-percent error in reflection coefficient results in a 24-percent error in impedance.

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The E4991A can be set with 1-MHz resolution across its frequency range. The built-in DC bias function supplies DC voltage (±40 VDC) and current bias (±50 mV) across the device. The E4991A provides an equivalent-circuit analysis function that automatically calculates and displays the equivalent-circuit element values for five built-in equivalent-circuit models.

The E4991A is well-suited for one particularly troublesome component, the chip or surface-mount inductor. Quality factor (Q) is a key parameter for inductors. This sensitive measurement and measured results are easily influenced by the instrument's accuracy. To date, a network analyzer has been used to measure the Q beyond 1.8 GHz. However, when the typical network analyzer measures an inductor with Q = 100, the measurement error will be more than 300 percent. On the other hand, the E4991A achieved 30 percent or less Q-measurement error with the same device measurement. Since the accuracy of Q depends upon phase accuracy, the E4991A is calibrated with a unique four-step technique. Conventional one-port calibrations use open, short, and 50-Ω load standards. The E4991A has an additional phase-calibration step involving a low-loss air capacitor as a phase standard, using a calibration technique known as the short/ open/load/air-capacitor (SOLA) method. This approach improves the phase accuracy and helps to achieve highly accurate high-Q inductor measurements up to 3 GHz. In addition, the E4991A includes short/open and electrical-length compensation to offset the effects of connecting fixtures and cables.

To simplify connections between the E4991A and DUTs, a number of fully characterized test fixtures have been developed for use through 3 GHz. A new universal test fixture can accommodate various-sized devices with bottom electrodes. Another family of test fixtures is available for surface-mount components with parallel electrodes. A recently added option for the E4991A allows it to be connected to a microwave probe system from Cascade Microtech (Hillsdale, OR) for making on-wafer impedance measurements.

The E4991A provides direct readings of impedance on an 8.4-in. (21.3-cm) color liquid-crystal-display (LCD) screen. P&A: $44,530 US list price; supplier response time is 4 weeks[T.S1]. **Agilent Technologies, Test and Measurement Organization, 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; (800) 452-4844 ext. 7021, Internet: http://www.agilent.com.** MRF

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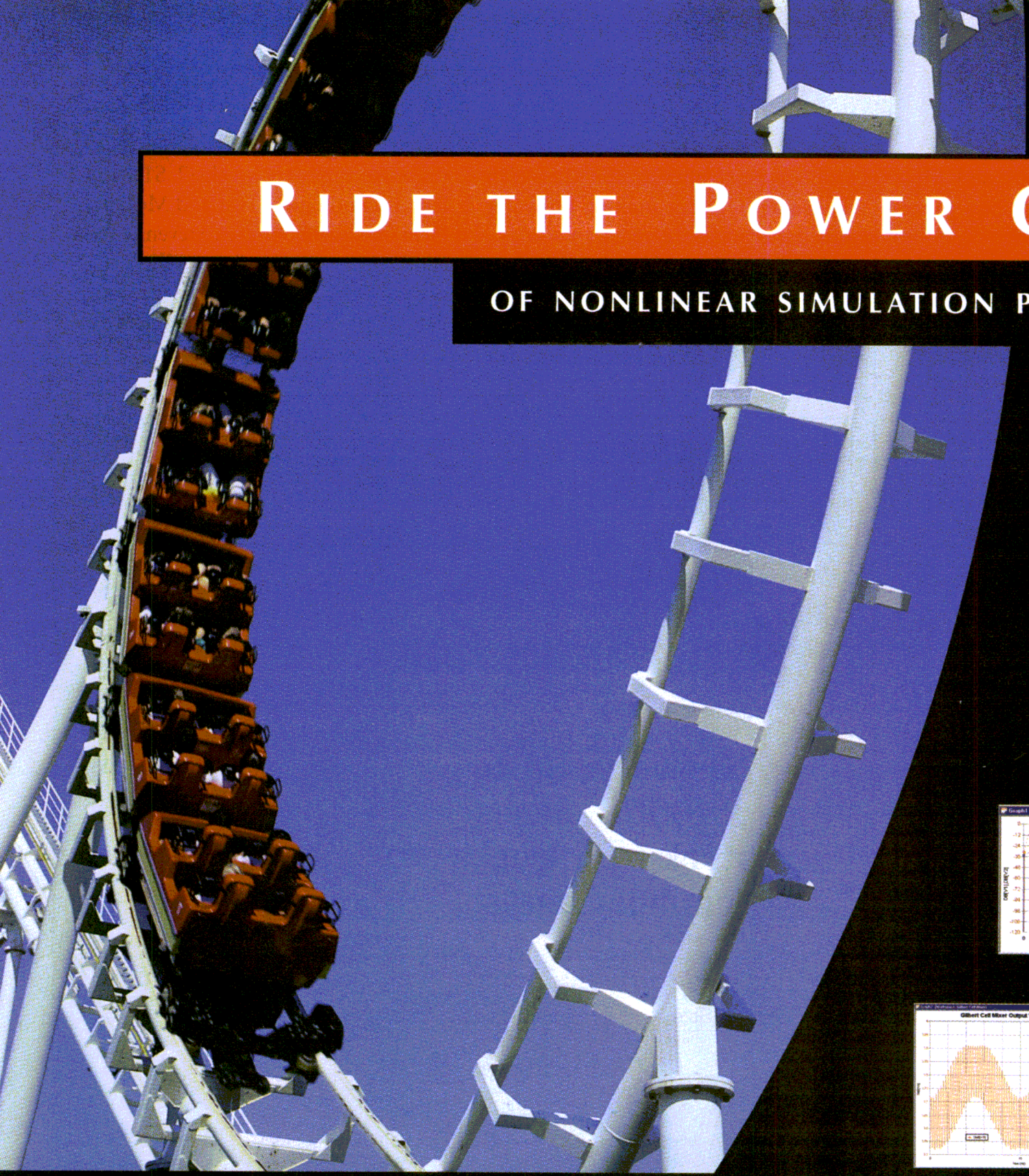


Wideband Analyzer Checks Multichannel Propagation

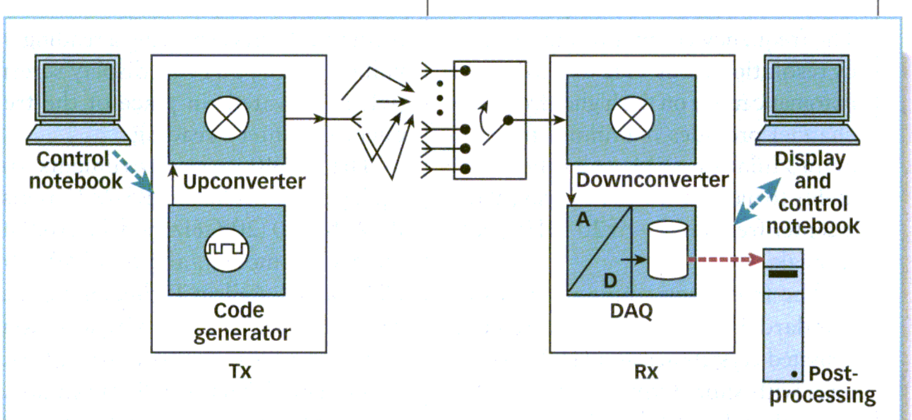
This test system employs a dedicated transmitter and multi-antenna receiver to evaluate the radio-channel characteristics of wireless communications systems.

JACK BROWNE
Publisher/Editor

Propagation of radio waves in a communications system is complex, and requires powerful analysis tools for testing and characterization. The PropSOUND Radio Channel Sounder from Elektrobit AG (Bubikon, Switzerland) provides the measurement power that is needed for multichannel analysis in the time and frequency domains. The system provides channels that are as wide as 200 MHz from 1.8 to 2.5 GHz and 5.1 to 5.9 GHz. The PropSOUND system is based on the spread-spectrum sounding method. In this particular approach, a carrier signal is spread over a large bandwidth by mixing it with a pseudo-noise (PN) sequence. Multiple antennas that are used with the receiver enable the capture of spatial channel information, while Global Positioning System (GPS) time tagging generates location information.

The PropSOUND test system can generate variable code lengths from 31 to 4096 chips. It can link with large antenna arrays to form as many as 256 receive channels.

The modular PropSOUND Radio Channel Sounder provides a variety of post-processing functions, including analysis of complex impulse responses per each antenna, while also computing polarization and frequency information for each channel. The system can resolve time delays that are as fine as 10 ns, with an option for time-delay resolution of 5 ns. The system offers a standard dynamic range of 30 dB, with options for dynamic-range performance levels of 35 or 40 dB. The Tx section provides output-power levels of 0.5 W standard.



The PropSOUND Radio Channel Sounder test system consists of a dedicated transmitter, control computer, and receiver with user-specified number of analysis channels.

The PropSOUND system **(see figure)** is controlled by a notebook computer. Elektrobit AG, Rosswiesstrasse 29, CH-8608 Bubikon, Switzerland; (41) (0) 55-2532060, FAX: (41)(0) 55-2532070, e-mail: info@elektrobit.ch, Internet: http://www.elektrobit.ch. MRF

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Instrument Combines Counter, Power Meter, And Digital Voltmeter

Three of the most commonly used test functions for telecommunications systems can be found in a single, portable instrument.

JACK BROWNE
Publisher/Editor

Multiple measurement functions are needed for a wide range of communications systems. For the first time, three of the most commonly used functions—measurements of frequency, power, and voltage—can be found in a single instrument, the 53140 series of portable test tools from Agilent Technologies (Santa Rosa, CA). The instruments measure only 330 × 156 × 376 mm and weigh 4.5 kg. The 53140 series offers a choice of three different frequency-counter bandwidths—10 Hz to 20 GHz (model 53147A), 10 Hz to 26.5 GHz (model 53148A), and 10 Hz to 46 GHz (model 53149A). The frequency counters measure low-frequency signals from 10 Hz to 125 MHz with channel 1 while higher-frequency signals are handled over a second channel. The counter sensitivity is typically better than −33 dBm through 12.4 GHz and typically better than −30 dBm through 18 GHz. The frequency counter offers frequency resolution from 1 Hz to 1 MHz. An automatic mode on the higher-frequency channel provides maximum frequency-modulation (FM) tolerance—the ability to measure a signal varying about a center frequency—of 20 MHz peak-to-peak.

The frequency counter employs a standard 10-MHz temperature-compensated-crystal-oscillator (TCXO) timebase with short-term (1-s) stability of better than 1×10^{-9} and an aging rate of better than 1×10^{-7}/month. For those requiring higher accuracy, an optional 10-MHz oven-controlled crystal oscillator (OCXO) timebase offers short-term stability of better than 2×10^{-10} and an aging rate of better than 1.5×10^{-8}/month.

The power-meter section works with the company's 8480 power sensors to offer a total measurement range of −70 to +44 dBm at frequencies to 50 GHz. The power meter features 0.01-dB resolution and 0.02-dB basic instrument accuracy.

The digital-voltmeter (DVM) section provides a ±50-VDC measurement range with 2-mV resolution. It is accurate within ±0.25 percent of a reading ±10 mV, showing a reading of voltage on the 53140's display screen (when activated) in place of the frequency counter's reading.

The 53140 series instruments are equipped with GPIB and RS-232C ports. P&A: $9950 (20-GHz model), $10,950 (26.5-GHz model), and $15,750 (40-GHz model). **Agilent Technologies, Inc., Test and Measurement Organization, 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; (800) 452-4844 ext. 7176, Internet: http://www.agilent.com.**

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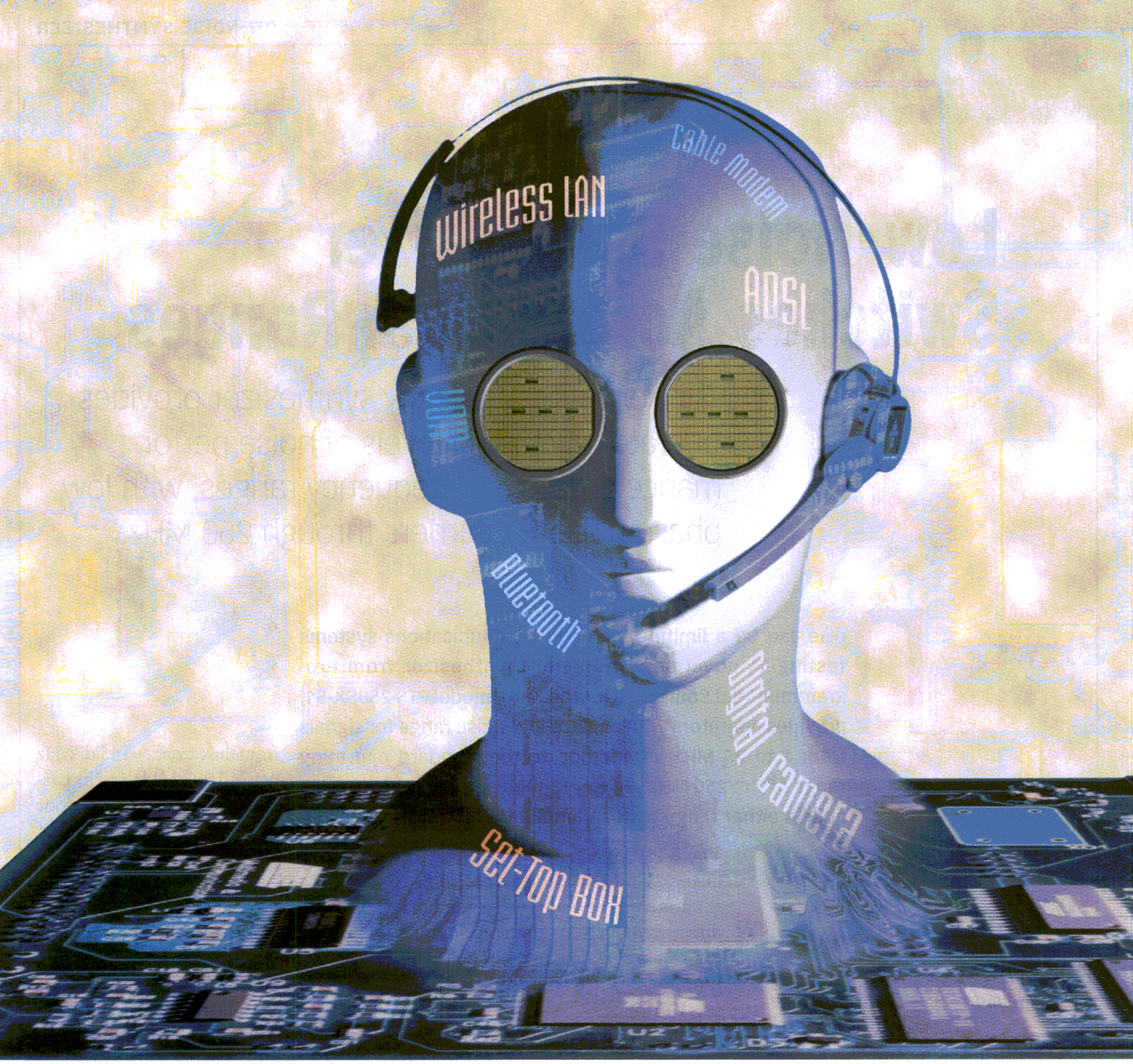
Wireless LAN
Cable Modem
ADSL
VoIP
Bluetooth
Digital Camera
Set-Top Box

Low-Noise Synthesizer Switches Across Dual Ranges

This versatile frequency synthesizer provides operators with two levels of noise performance across two frequency ranges, with low phase noise for carriers through 250 MHz.

JACK BROWNE
Publisher/Editor

Noise can be a limiting factor in communications systems testing. A novel new frequency synthesizer from Programmed Test Sources (Littleton, MA), model PTS 250SX-51, provides operators with an ultra-low-noise range for signals from 1 to 25 MHz, in addition to the standard operating range of 1 to 250 MHz. Up to +13-dBm output power is available in either range with an amplitude flatness of ±0.5 dB.

The PTS 250SX-51 dual-range frequency synthesizer makes use of Programmed Test Sources' trademark direct-frequency-synthesis techniques for fast frequency-switching speeds, fine frequency resolution, and good spectral purity. The rack-mountable instrument **(see figure)** achieves impressive performance in its standard frequency range of 1.000000 to 249.999999 MHz, with frequency resolution as good as 1 Hz, harmonic levels of −30 dBc, and spurious levels of −70 dBc. The phase noise is −105 dBc/Hz offset 100 Hz from the carrier, dropping to −123 dBc/Hz offset 10 kHz from the carrier, −127 dBc/Hz offset 100 kHz from the carrier, and hitting a noise floor of −135 dBc/Hz.

When better noise performance is required, the PTS 250SX-51 can deliver from 1.000000 to 24.999999 MHz. Over that range, it has harmonics of −35 dBc and spurious levels of −75 dBc. The phase noise improves to −135 dBc/Hz offset 100 Hz from the carrier, dropping to −142 dBc/Hz offset 10 kHz from the carrier, −145 dBc/Hz offset 100 kHz from the carrier, and hitting a noise floor of −147 dBc/Hz.

In either frequency range, the PTS 250SX-51 requires only 5 to 20 μs to switch between any two frequencies. The fast switching speed is achieved, of course, under remote control, although the PTS 250SX-51 also allows operators to set output frequencies and levels manually from the front panel. A parallel binary-coded-decimal (BCD) interface is provided as the standard remote control bus, although a general-purpose-interface-bus (GPIB) connection is available as an option. The output-signal-level programming uses an analog DC control voltage.

The PTS 250SX-51 can be supplied with or without front-panel controls (for those applications requiring only remote control). It measures 19.00 × 5.25 × 18.00 in. (48.26 × 13.34 × 45.72 cm) and weighs 35 lbs. **Programmed Test Sources, Inc., 9 Beaver Brook Rd., P.O. Box 517, Littleton, MA 01460; (978) 486-3008, FAX: (978) 486-4495, e-mail: sales@programmedtest.com, Internet: http://www.programmedtest.com.** MRF

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EM Software Receives Major Enhancements

The latest version of a powerful three-dimensional electromagnetic (EM)-analysis and optimization tool adds more than 400 new features and improvements.

JACK BROWNE
Publisher/Editor

Sofware developers are sometimes accused of releasing new versions of a product with only limited improvements. But in the case of Version 3.0 of the CST MICROWAVE STUDIO from CST of America, Inc. (Wellesley, MA), more than 480 features and improvements have been added from Version 2.0 in less than one year, making this a significant upgrade to this powerful Windows-based software suite.

The CST MICROWAVE STUDIO software is designed to solve three-dimensional (3D) high-frequency electromagnetic (EM) problems. It is based on a number of different solvers, including a transient solver and an Eigenmode solver, to provide the most efficient solutions for a large number of engineering problems. Version 3 also adds a frequency-domain solver for low-frequency applications.

The new version can also perform specific-absorption-rate (SAR) calculations when modeling, for example, the performance of a cellular-handset antenna in the presence of a human head. The SAR capability is augmented by the inclusion of extensive human data.

Version 3.0 benefits from refined adaptive-mesh capability, supporting more efficient mesh coverage of two-dimensional (2D) and 3D structures. The software includes a built-in optimizer, which will search out the values for a set of circuit elements in order to approach a user-defined set of operating/performance conditions.

Version 3.0 employs new PBA techniques, new capability that considers surface impedance for metallic losses, the ability to operate solvers in parallel on a multiprocessor computer, and the ability to perform complex radar-cross-section (RCS) calculations.

Since Version 3.0 will be used with other design/analysis tools, it is equipped with extended dynamic SPICE extraction capabilities for working with SPICE files. It can also readily import planar structures from Gerber, DXF, and GDSII files, and export Touchstone files. Version 3.0 uses a sophisticated import filter in order to fix defects in imported data.

The new version includes new diode and lumped-element models, the ability to perform excitation with port modes, discrete elements (inner ports), and plane waves. The software is available for use on computers running Windows 98, 2000, and NT operating systems. **CST of America, Inc., 8 Grove St., Suite 203, Wellesley, MA 02482; (781) 416-2782, FAX: (781) 416-4001, e-mail: info@cst-america.com, Internet: http://www.cst-america.com.** MRF

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E-PHEMT Promises High Linearity From A Single Supply

This enhancement-mode transistor can operate from a single positive voltage supply while delivering high efficiency and output third-order-intercept performance.

JACK BROWNE
Publisher/Editor

When something works well, why change it? Despite the high performance possible with conventional pseudomorphic-high-electron-mobility-transistor (pHEMT) devices, the semiconductor architects at Agilent Technologies (Santa Clara, CA) came up with a better design, the model ATF-54143, an enhancement-mode pHEMT with improved efficiency. The ATF-54143 operates from a single positive voltage supply. It is well-suited for a wide range of base-station applications from 450 to 6000 MHz.

Depletion-mode pHEMTs conduct at zero gate bias, or when the drain current, I_d, reaches a saturated level (I_{dss}) at a gate-source voltage (V_{gs}) of 0 VDC. But an enhancement-mode pHEMT (E-pHEMT) shows no conduction at zero gate bias, so that $I_d = 0$ at $V_{gs} = 0$ VDC. Thus, it can operate without the negative voltage (required for switch on) common to depletion-mode pHEMTs.

The ATF-54143 is a 0.5-µm-gate-length, 800-µm-gate-width device fabricated with a process capable of transition frequncies up to 35 GHz. The transistor exhibits drain-source current (I_{DSS}) of 1 mA and a maximum current density (I_{max}) of better than 2 A/mm.

The ATF-54143 E-pHEMT is housed in the company's tiny four-lead SC-70 package **(see figure)**. The measured output third-order intercept point (OIP3) is +36 dBm at 2 GHz, with an input third-order intercept point (IIP3) of +16.5 dBm at 2 GHz. The output power at 1-dB compression is +20.4 dBm at 2 GHz. The noise figure at 2 GHz is 0.55 dB, with an associated gain of 17.4 dB. The device typically draws 60-mA current from a single +3-VDC supply.

In addition to its better-than-average third-order-intercept performance, which supports designs requiring high linearity, the ATF-54143 should provide significant advantages in power-added efficiency (PAE). This is in comparison to conventional gallium-arsenide (GaAs) pHEMTs as well as aluminum (Al) GaAs and indium-gallium-phosphide (InGaP) heterojunction-bipolar transistors (HBTs), resulting in power savings.

The high-efficiency E-pHEMT transistor can be supplied in bulk (with 100 units shipped per antistatic bag), or in tape-and-reel format [with 3000 devices supplied per 7.00-in. (30.48-cm) reel or 10,000 devices supplied per 12.00-in. (17.78-cm) reel]. P&A: $1.97 (25,000 to 49,000 qty.); stock. **Agilent Technologies, Inc., Technical Response Center, 3175 Bowers Ave., Santa Clara, CA 95054; Internet: http://www.semiconductor.agilent.com.** MRF

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Chip Contains Full Bluetooth Solution

All of the functions needed to assemble a Bluetooth-compliant node can be found in this single chip, including the transceiver, link controller, and baseband processor.

Debate may continue for some time as to whether multiple integrated circuits (ICs) or a single-chip solution make more sense for Bluetooth 2.4-GHz wireless personal connectivity applications. But with the introduction of the TC2000 complete Bluetooth radio from Zeevo, Inc. (Santa Clara, CA), designers can now have transceivers and baseband controllers united on a single surface-mount device.

JACK BROWNE
Publisher/Editor

The TC2000 integrates all RF circuitry, analog circuitry, and digital circuitry, including the link controller, the baseband processor, power-management circuitry, a microcontroller, and even Flash memory **(see figure)**. The chip does require some external components, including a crystal resonator, an antenna, reference resistors, and four decoupling capacitors. The process to bring these different functions together is 0.18-mm complementary-metal-oxide-semiconductor (CMOS) technology.

The TC2000 achieves radio sensitivity of −80 dBm when measured at the antenna port. The IC, which is mounted within a low-temperature-cofired-ceramic (LTCC) package, is designed to operate from a single +3.3-VDC power supply. The TC2000 has a 12-MHz ARM7TDMI central processing unit (CPU) embedded within the chip to provide the "intelligence" needed for Bluetooth operations. The chip also incorporates 64 kB of static random-access memory (SRAM) and 8 kb of boot read-only memory (ROM).

Zeevo is now offering the Sierra development board to speed implementation of the TC2000 into Bluetooth designs. The firm has two versions of the TC2000. The TC2000P-4 is supplied in a 65-pin package measuring 9.85 × 11.85 mm with 4 MB of internal Flash memory. The TC2000M-E version is the same size, but without internal Flash memory. **Zeevo, Inc., 2500 Condensa, Santa Clara, CA 95051; (408) 982-8000, FAX: (408) 982-8008, Internet: http://www.zeevo.com.** MRF

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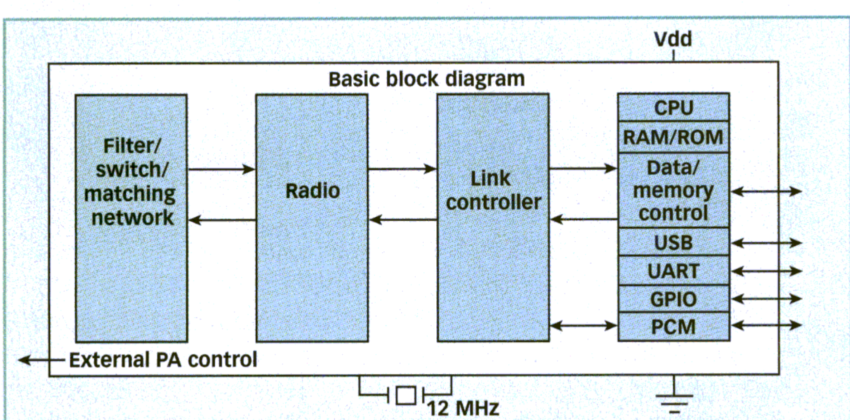

The TC2000 IC is a single-chip solution for Bluetooth applications, complete with transceiver, embedded microcontroller, memory, and link controller.


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Synthesizers Stop Degradation From Phase Hits

Careful design practices in this 1-to-23-GHz synthesizer eliminate the cause of phase hits that can degrade high-speed telecommunication system performance.

JACK BROWNE
Publisher/Editor

Phase hits are infrequent but damaging causes of signal degradation in telecommunications systems, and the severity of their effect increases with increasing data rates. In order to improve performance in these systems, the DFS series of frequency synthesizers from Elcom Technologies (Rockleigh, NJ) has been designed for reducing phase hits while reducing susceptibility to microphonics. The DFS syn-thesizers are designed to meet the needs of high-capacity digital radios, multichannel-multipoint-distribution-systems (MMDS) and local-multipoint-distribution-services (LMDS) systems, Synchronous Optical Network (SONET), and synchronous-digital-hierarchy (SDH) optical networks, and satellite-communications applications.

Phase hits can be defined as sudden, uncontrolled changes in the phase of a transmitted signal that occurs randomly, and generally last fractions of a second. They may be caused by temperature changes from dissimilar metals expanding and contracting at different rates, as well as from vibration or impact. In addition, detecting and measuring phase hits generally requires specialized test equipment that is capable of characterizing transitory events that last a few tens of microseconds at most.

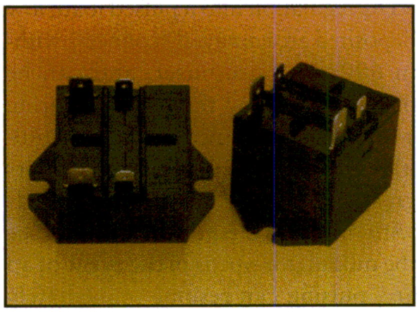
In addition, there has been no standardized measurement protocol on which to rely when evaluating a product. While phase hits (along with gain hits and other degrading phenomena) have plagued communications equipment for years, today's higher transmission speeds accentuate the problem due to the greater amounts of data affected in a given time. Elcom created a proprietary phase-hit test system in order to evaluate the performance of its own synthesizers.

The DFS series is available in frequency bands from 500 MHz to 23 GHz, with a tuning bandwidth of 1 GHz. Standard step sizes are 25, 125, and 500 kHz, as well as 1 and 10 MHz. Switching speed is less than 25 ms. Phase noise is well-controlled with typical performance of −120 dBc at a 100-kHz offset from the carrier at X-band. The synthesizers were designed to provide significant resistance to microphonics, which can be a problem for equipment mounted in locations where wide temperature variations are experienced. Elcom offers the DFS series in various configurations based on customer requirements, including various frequency bands, step sizes, and output powers. **Elcom Technologies, 11 Volvo Dr., Rockleigh, NJ 07647; (201) 767-8030, FAX: (201) 767-6266, e-mail: sales@ elcom-tech.com, Internet: www.elcom-tech.com.** MRF

Enter No. 60 at www.mwrf.com

Relay Is Rated At 15 A

THE GREENWICH CHP electromechanical (EM) relay is rated at 15-A current and boasts 115-VAC- or 220-to-240-VAC-



rated coils and plug-in solder or quick-connect terminals. The relay provides a maximum 250-VAC, +30-VDC switching voltage, as well as 20-A switching current. The relay offers a mechanical life expectancy that consists of 5×10^6 operations and 1×10^5 operations electrical at rated load. The relays operate from the −25 to +70°C temperature range at 45-to-85-percent RH.

Greenwich Electronics, Inc., 5 Division St., East Greenwich, RI 02818; (888) 554-5561, (401) 884-4584, e-mail: gerelays@ids.net, Internet: http://www.geirelays.com.

● **Enter No. 66 at www.mwrf.com**

Termination Provides 250-W Peak Power

THE 462-1F3 IS an SMA-male coaxial termination that is suitable for low-power applications, dissipating 1-W average power (250 W peak) with a typical VSWR of 1.05:1 to 3 GHz. The 401-1F3 is an N-male coaxial termination providing high value, while dissipating 2-W average power (1 kW peak) with a typical VSWR of 1.05:1 to 3 GHz. Both terminations feature brass housings and connectors, gold (Au)-plated contact pins, and virgin electrical-grade Teflon insulation within the connectors. The 401 series termination family also includes N-female plus BNC and TNC connector styles. A low-profile, N-male version (model 415-1) is offered for space-restricted applications. Other terminations are available up to 18 GHz with power ratings spanning 1 to 50 W.

MECA Electronics, Inc., 459 East Main St., Denville, NJ 07834; (973) 625-0661, FAX: (973) 625-1258, e-mail: sales@e-meca.com.

● **Enter No. 67 at www.mwrf.com**

PLL Generates Up To 928 MHz

THE MODEL PLL400-915 phase-locked loop (PLL) generates frequencies ranging from 902 to 928 MHz with a 200-kHz step size. The unit typically requires 18.5 mA of current from a +5.0-VDC supply voltage. Typical phase noise at 100-kHz offset is −131 dBc/Hz. Phase-detector spurious suppression is typically −82 dBc. Typical output power is +3.7 dBm, while second-harmonic suppression is typically −13.3 dBc and third-harmonic suppression is typically −27 dBc.

Vari-L Co., Inc., 4895 Peoria St., Denver, CO 80239, (303) 371-1560, FAX: (303) 371-0845, Internet: http://www.vari-l.com.

● **Enter No. 68 at www.mwrf.com**

Resonator Operates From2.0 To 3.8 GHz

BY USING THIN-FILM diamond as a medium for very-high-velocity surface-acoustic waves (SAWs), a resonator reaches a frequency range spanning 2.0 to 3.8 GHz. The resonator boasts an insertion loss that is less than 10 dB, with temperature characteristics that are less than 150 PPM over the temperature range of −45 to +85°C. Applications include intermediate-frequency (IF) filters, clock and data recovery, as well as wideband-code-division-multiple-access (WCDMA) pilot-signal processing.

Sumitomo Electric USA, Inc., 65 E. 55th St., 16th Fl., New York, NY 10022; (212) 317-7201, FAX: (212) 308-6575, Internet: http://www.sawdevice.com, http://www.sumitomoelectricusa.com.

● **Enter No. 69 at www.mwrf.com**

Epoxy Boasts 200 To 600 PPM

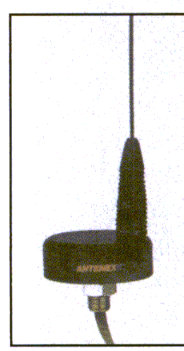
UNI-FORMS EPOXY PREFORMS are designed to provide a method for sealing or potting electromechanical components. The preforms are one-part epoxy resins that are solid at room temperature. When heated, they melt and cure, forming a consistent seal that protects components from dust, moisture, oil, flux, industrial cleaning solvents, conformal coatings, as well as other contaminants. The epoxy is available in a range of shapes, sizes, and materials to accommodate diverse applications, and can be dispensed at rates from 200 to 600 PPM.

Multi-Seals, Inc., 540 North Main St., Manchester, CT 06040; (860) 643-7188, FAX: (860) 643-5669, e-mail: sales@multi-seals.com, Internet: http://www.multi-seals.com.

● **Enter No. 70 at www.mwrf.com**

Antenna Offers 26-dB Gain

THE MODEL GPSDVHF is a dual-band 26-dB gain-active ceramic-patch Global Positioning System (GPS) receive antenna that features a black-chrome-plated, shock-spring-protected, very-high-frequency (VHF) quarter-wave antenna in one package. The antenna is constructed with a fully potted heavy-wall resin housing, a one-piece solid-brass mounting stud, a tapered shock spring, and a tunable 17-7 ph stainless-steel radiator for the VHF band. Applications include heavy-equipment asset tracking as well as monitoring.



Antenex, 2000-205 Bloomingdale Rd., Glendale Heights, IL 60139; (800) 323-3757, (630) 351-9007, FAX: (630) 351-9009, e-mail: sales@antenex.com.

● **Enter No. 71 at www.mwrf.com**

Switch Targets IC Failure Analysis

THE MTS700 IS a high-channel switch subsystem that is designed for integrated-circuit (IC) failure analysis. The systems place high pin-count ICs into known states by switching VDD and VSS supplies, as well as AC vector sources. They can also provide capabilities for multipoint I_{DDQ} testing along with analog-circuit debug. The unit uses shielded switching modules, allowing 512- or 1024-pin subsystems to be housed in footprints that can be used in lab environments that are without production testers.

VXI Technology, Inc., 17912 Mitchell St., Irvine, CA 92614; (949) 955-1894, FAX: (949) 955-3041, Internet: http://www.vxitech.com.

● **Enter No. 72 at www.mwrf.com**

MOSFET Handles 7.5 A Of Current

THE MODELS SI4830DY, Si4808DY, and Si4834DY combine a low-side synchronous metal-oxide-semiconductor field-effect transistor (MOSFET), a high-side control MOSFET, and a Schottky diode that is in a single SO8 package, which reduces space requirements for 2-to-5-A logic-voltage DC-to-DC converters. Optimized for synchronous buck converters with a switching frequency of up to 300 kHz, the devices combine a +30-VDC breakdown voltage with a power MOSFET on-resistance of 22 mΩ per channel at a +10-VDC gate drive. Each MOSFET can handle up to 7.5 A of current. Maximum forward voltage for the Schottky-diode component is +0.5 VDC at 1 A, while the source and gate pins reduce control-loop inductance for improved gate drive. P&A: $0.59 (100,000 qty.).

Vishay Intertechnology, Inc., 63 Lincoln Highway, Malvern, PA 19355; (610) 644-1300, FAX: (610) 296-0657, e-mail: info@vishay.com, Internet: http://www.vishay.com.

● **Enter No. 73 at www.mwrf.com**

Power Supply Provides 20-kHz Switching Speeds

THE POWERMOD(TM) HVPS-40 transmitter (Tx) power supply targets radar applications. The supply provides ±10-VDC regulation into a pulsed load, low deposited arc energy, disconnects within 600 ns of arc onset, and can be instantly reset by the user. Featuring +1-VDC peak-to-peak ripple, the 40-kW DC solid-state power supply offers greater than 20-kHz switching speeds with full overvoltage protection. Since the modulator opens in the event of an arc, pulsing can resume immediately after the arc clears. P&A: $100,000.

Diversified Technologies, Inc., 35 Wiggins Ave., Bedford, MA 01730; (781) 275-9444, FAX: (781) 275-6081, e-mail: info@divtecs.com, Internet: http://www.divtecs.com.

● **Enter No. 74 at www.mwrf.com**

Modem Operates To 9600 Baud

THE RF9600 IS a multiuse-radio-service (MURS) radio modem with five very-high-frequency (VHF) channels. The

modem is capable of 9600 baud and provides error correction with robust reliability. It comes preprogrammed with all five frequencies and each station has its own ID code to ensure that it responds to commands. Units are compatible with weather stations.

RF Neulink, 7610 Miramar Rd., San Diego, CA 92126; (800) 233-1728, (858) 549-6340, FAX: (858) 549-6345, e-mail: rfneulink@rfindustries.com, Internet: http://www.rfneulink.com.

● **Enter No. 75 at www.mwrf.com**

Filter Tolerates 200-W Power Handling

THE 16DBCVSP-2317/2348/C4.5-N is a cross-coupled double bandpass filter that uses Super Q Perovskite dielectric resonators. This low-loss configuration yields a passband loss of 1 dB typical with a bandwidth of 0.19 percent, along with a 30-dB shape factor of 1.33. The unit can withstand 200-W power handling.

ComNav Engineering, Inc., 987 Riverside St., Portland, ME 04103; (207) 797-4588, FAX: (207) 797-8155, e-mail: info@comnav-eng.com, Internet: http://www.comnav-eng.com.

● **Enter No. 76 at www.mwrf.com**

OCXO Targets Optical-Switching Systems

THE MODEL N45HP subminiature oven-controlled crystal oscillators (OCXOs) are suitable for optical-switching systems and other Stratum 3 applications. The OCXO features +3.3-VDC positive-emitter-coupled-logic (PECL) output at standard frequencies of 51.84, 77.76, and 100 MHz.

Bliley Technologies, Inc., 2545 West Grandview Blvd., Erie, PA 16506; (814) 838-3571, e-mail: info@bliley.com.

● **Enter No. 77 at www.mwrf.com**

Oscillators Offer Signals From 1.5 To 125 MHz

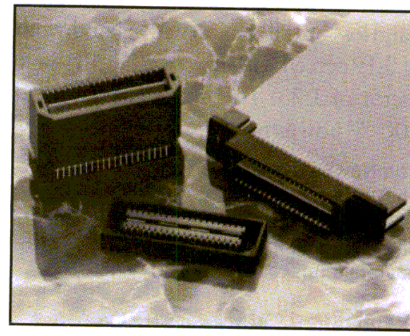
THE R3312 SURFACE-MOUNT clock oscillators provide time- and frequency-reference signals from 1.5 to 125 MHz. The units maintain ±50-PPM frequency stability over the −40 to +85°C extended industrial temperature range. Maximum jitter is 5-ps RMS, waveform rise-and-fall times are 2.5 ns typical, and waveform symmetry is better than 45/55. P&A: $3.00; stock to 6 wks.

MF Electronics, 10 Commerce Dr., New Rochelle, NY 10801; (914) 576-6570, FAX: (914) 576-6204, e-mail: sales@mfelectronics, Internet: http://www.mfelectronics.com.

● **Enter No. 78 at www.mwrf.com**

Interfaces Terminate On 0.8-mm Pitch

THE QTE SERIES are surface-mount, micro-pitch interfaces for matched-impedance and high-speed applications.



The interfaces terminate on 0.8-mm pitch and feature an integral ground plane. They are fully tested for 50- and 70-Ω systems for impedance, VSWR, attenuation, crosstalk, propagation delay, and rise time at frequencies from 10 MHz to 1 GHz. P&A: $0.09 to $0.12 (per mated pair).

Samtec, Inc., P.O. Box 1147, 520 Park East Blvd., New Albany, IN 47151; (800) SAMTEC-9, (812) 944-6733, FAX: (812) 948-5047, e-mail: info@samtec.com, Internet: http://www.samtec.com.

● **Enter No. 79 at www.mwrf.com**

ICs Feature +48-dBm IP3 Typical

THE SPA series of power-amplifier (PA) RF integrated circuits (RF ICs)is suitable for wireless network system requirements. These GaAs heterojunction-bipolar-transistor (HBT) devices cover the 850-, 1950-, and 2150-MHz frequency bands and serve as driver amplifiers for base-station and repeater applications. Housed in standard surface-mount SOIC-8 plastic packages with backside metallization, the amplifiers provide the linearity demanded by advanced network-modulation standards. P&A: $10.95 (50,000 qty.).

Stanford Microdevices, 522 Almanor Ave., Sunnyvale, CA 94086; (800) 764-6642, (408) 616-5400, FAX: (408) 739-0970, e-mail: info@stanfordmicro.com, Internet: http://www.stanfordmicro.com.

● **Enter No. 80 at www.mwrf.com**

Crystal Spans 10 To 160 MHz

THE LFN1000 SERIES crystal is manufactured in the TO-5 (HC-35) package and is suitable for data transmission and microwave applications. The crystal offers a frequency range from 10 to 160 MHz and is specified at series resonance and optional temperatures of 258 or 758°C. Manufactured to meet shock and vibration-performance requirements, the crystal is designed for high-stability, low-phase-noise applications that are multiplied up to the gigahertz range. The crystals can be manufactured to meet other values.

International Crystal Manufacturing, P.O. Box 26330, 10 North Lee, Oklahoma City, OK 73126; (800) 725-1426, (405) 236-3741, FAX: (800) 322-9426, (405) 235-1904, e-mail: freeland@icmfg.com, Internet: http://www.icmfg.com.

● **Enter No. 81 at www.mwrf.com**

Meter Measures Cable Length

THE CLM200 IS a handheld meter that measures the length of telecommunications, data communications, RF, small-signal and power cables on drums, on cut lengths, or in installed sections. The meter is ergonomically designed, measures up to 6000 ft., and detects and provides distance to fault for opens and shorts. The unit is preprogrammed with the characteristics of 26 different standard cables. Cable impedance and velocity factor are user selectable to ensure that any cable construction and type can be measured.

Jensen Tools, Inc., 7815 S. 46th St., Phoenix, AZ 85044; (800) 426-1194, (602) 453-3169, FAX: (800) 366-9662, (602) 438-1690, Internet: http://www.jensentools.com.

● **Enter No. 82 at www.mwrf.com**

Attachment Supports Repeated Flexing

THE SR SERIES strain relief-clamp attachment screws onto the back of RF coaxial connectors to provide support where cables are subjected to repeated flexing. The unit features a rolling clamp nut that prevents distortion of the cable, which can be caused by overtightening. The clamp will not alter the cable's electrical characteristics and is specified for use with virtually any size cable that is equipped with RG214, RG393, or RG217 connectors. P&A: $24.95 (list).

Tru-Connector Corp., 245 Lynnfield St., Peabody, MA 01960; (800) COAXTRU, (978) 532-0775, e-mail: trusales@tru-con.com, Internet: http://www.tru-con.com.

● **Enter No. 83 at www.mwrf.com**

Resistors Offer 25-To-225-W Power Rating

A SERIES OF resistors can be used in DC and low-frequency AC circuits where appreciable power needs to be dissipated. The resistors are designed to meet mechanical and electrical requirements rated at 350°C when suspended horizontally in free air. The resistors are cured at low temperatures and are, therefore, able to use heavier wire, increasing the transfer of heat from the interior of the resistor to the terminal. P&A: stock to 3 wks.

E.A.P., 313 Evans Ave., Etobicoke, Ontario, Canada, M8Z IK2; (416) 259-6635, FAX: (416) 503-1546.

● **Enter No. 84 at www.mwrf.com**

Coupler Ranges 0.5 To 50 GHz

MODEL 202050010 OPERATES over 1 to 40 GHz. Nominal coupling is 13 ±1.0 dB with a frequency sensitivity of ±1.2 dB. Minimum directivity is 14 dB from 1 to 20 GHz and 10 dB from 20 to 40 GHz. VSWR is 1.5:1 maximum from 1 to 20 GHz and 1.7:1 maximum from 20 to 40 GHz. Insertion loss is less than 1.1 dB from 1 to 20 GHz and less than 1.8 dB from 20 to 40 GHz. P&A: stock to 3 wks.

Krytar, 1292 Anvilwood Ct., Sunnyvale, CA 94089; (408) 734-5999, FAX: (408) 734-3017, Internet: http://www.krytar.com.

● **Enter No. 85 at www.mwrf.com**

Amplifiers Operate From DC To 8 GHz

FOUR BROADBAND HETEROJUCTION-BIPOLAR-TRANSISTOR (HBT) amplifiers are designed as cascadable 50-Ω gain blocks. The GBH112 provides 13 dB of small-signal gain with 8 GHz of bandwidth. It has a P1dB of +12.5 dBm at 2 GHz and third-order intercept point (IP3) of +25 dBm. The GBH114 operates from DC to 8 GHz with 15 dB of gain and a 3-dB bandwidth of 6 GHz. It provides P1dB of 16 dBm at 2 GHz and IP3 of 31 dBm. The GBH120 is designed for DC-to-4-GHz operation with 18-dB small-signal gain, while the GBH121 is designed for DC-to-4-GHz operation with 22-dB small-signal gain. P&A: GBH112-214: $0.95; GBH114-214: $2.35; GBH120-214: $2.40; GBH121-214: $1.10 (10,000 qty.).

Alpha Industries, 25 Computer Drive, Haverhill, MA 01832; (978) 247-7700, FAX: (978) 247-7905, e-mail: sales@alphaind.com.

● **Enter No. 86 at www.mwrf.com**

Antenna Spans 2.40 To 2.49 GHz

MBEAM IS A six-beam antenna using smart-antenna technology, which manages frequency congestion and interference. The unobtrusive panel antenna operates in the unlicensed spread-spectrum/industrial-scientific-medical (ISM) band of 2.40 to 2.49 GHz and features a 90-deg. beam coverage while using six sector beams. The MBeam is available with optional field-removable beam combiners. The combination of the multibeam performance and panel design allows system operators to reduce site clutter.

Gabriel Electronics, Inc., P.O. Box 70, 16 Manson Libby Rd., Scarborough, ME 04074; (207) 883-5161, FAX: (207) 883-4469, Internet: http://www.gabrielnet.com.

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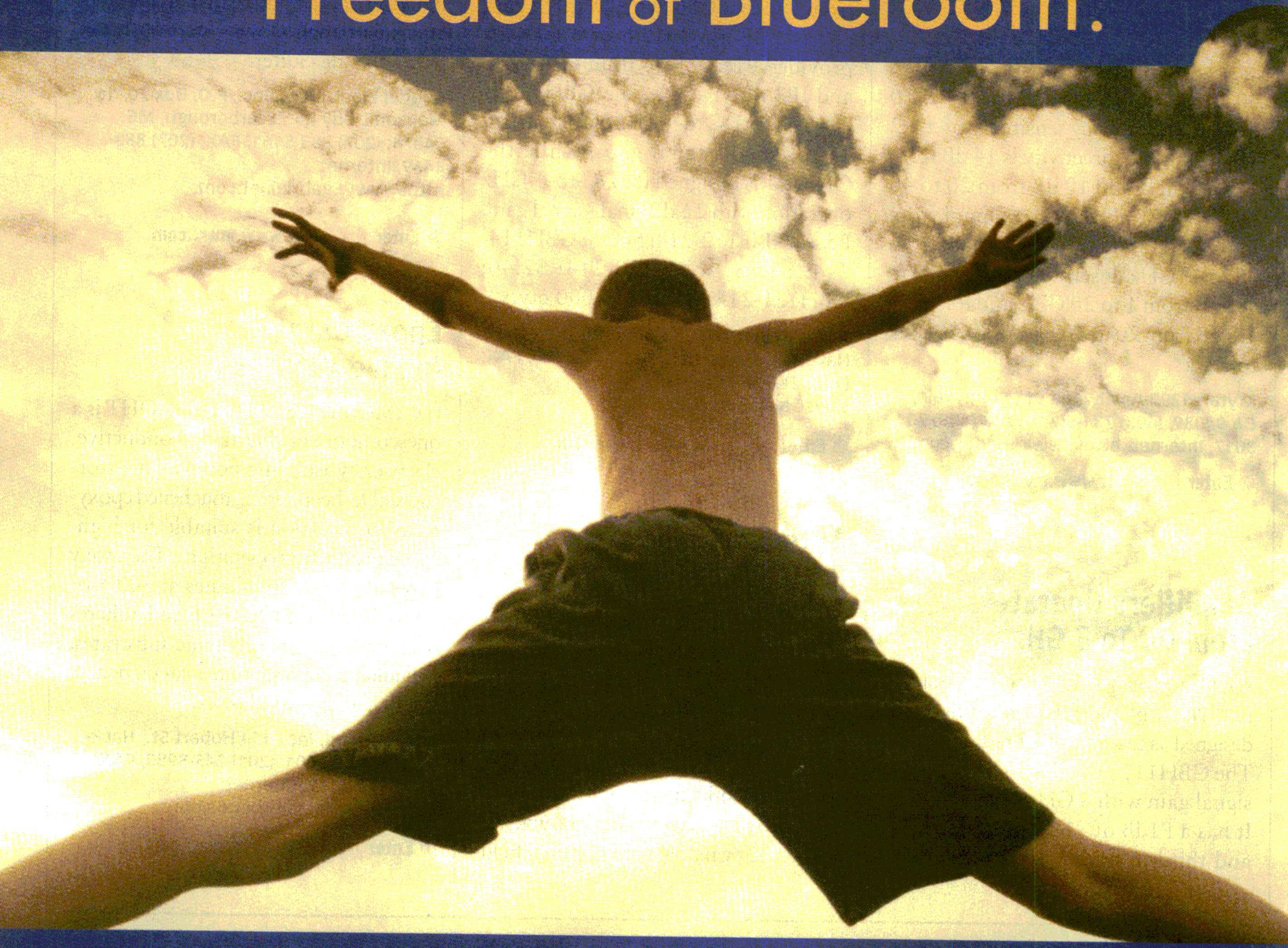
Epoxy Cures In Five Minutes

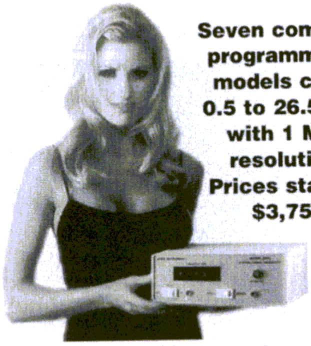
POLYMER SYSTEM SUPREME 3AOHT is a one-component thermally conductive, electrically isolating epoxy. This storage-stable, heat-curing, toughened epoxy-resin formulation is suitable for high-speed production operations. The epoxy cures at five to 10 minutes at 300°F or 20 to 30 minutes at 250°F and adheres to metallic and nonmetallic substrates, including ceramics, printed-circuit boards (PCBs), and most plastics.

Master Bond, Inc., 154 Hobart St., Hackensack, NJ 07601; (201) 343-8983, FAX: (201) 343-2132, Internet: http://www.masterbond.com.

● **Enter No. 88 at www.mwrf.com**



0.5 TO 26.5 GHz SIGNAL GENERATORS



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Dwight Streit Elected to National Academy of Engineering

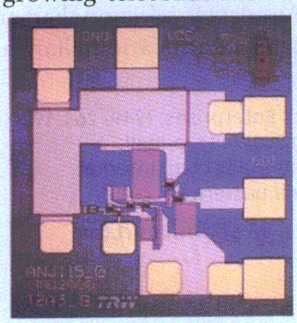
Millimeter-wave technology has long been of interest to military electronic system designers, and one of the leading developers of the technology is a company known as TRW (Redondo Beach, CA). It is largely due to the contributions of innovators like Dwight Streit that TRW has maintained its leadership in millimeter-wave technology.

1. Dwight Streit, a presenter at the first Military Electronics Show and TRW's vice-president of Advanced Semiconductors, was recently elected to the National Academy of Engineering.

Streit (**Fig. 1**) was recently elected to the prestigious National Academy of Engineering, due in part to his pioneering work in advanced semiconductor materials such as gallium arsenide (GaAs) and indium phosphide (InP). Streit, TRW's vice-president of Advanced Semiconductors, is scheduled to speak at the first Military Electronics Show (MES) in Baltimore, MD.

Over the past 15 years, Streit led work at TRW that greatly extended the performance, reliability, and high-volume production of high-electron-mobility transistors (HEMTs) and heterojunction-bipolar transistors (HBTs). Streit has published more than 300 scientific and engineering papers on advanced semiconductors and holds 20 patents.

Late last year, TRW announced the completion of a high-volume InP production facility, which will produce TRW's advanced InP for rapidly growing telecommunications-market applications, including fiber-optic transmission systems, mobile wireless communications, and broadband wireless services. Fabrication equipment is currently being installed, with low-volume pilot production scheduled for early 2001.



2. This InP chip is a 40-Gb/s photoreceiver with integrated photodetector and transimpedance amplifier.

Recent developments include an InP power amplifier (PA) capable of 400-mW output power at 23 GHz. The InP chip, with output-power density of 360 mW/mm^2 at 23 GHz, was developed by TRW under contract to the Air Force Research Laboratory (AFRL), Sensors Directorate, Wright-Patterson Air Force Base, Ohio, as part of the government's Dual Use Science and Technology program.

Streit has routinely created radically new designs and reliable production techniques. Most recently, Streit led TRW's development of millimeter-wave InP HEMT and HBT circuits for applications such as radio-astronomy and high-data-rate fiber-optic communications systems, including an InP chip with integrated photodetector and transimpedance amplifier capable of supporting optical carrier (OC) rates of OC-192 [40 Gb/s] (**Fig. 2**). For more information about TRW, visit the company's website at www.trw.com. And for more information about Dwight Streit and his work at TRW, don't miss his presentation at the Military Electronics Show. MRF

Continued from page 32

Corp. (Shelton, WA) examines the use of welded stainless-steel coaxial cables in high-reliability military systems compared to conventional soldered semirigid cables.

Additional technical sessions will feature a talk by Paul Bennett of Virtual Prototypes (Montreal, Quebec, Canada) on the development of avionics displays according to DO-178B safety standards, and the implication of the standard in terms of software development for military avionics systems. Jim Johnson of LPKF Laser & Electronics (Wilsonville, OR) will discuss the security that can be achieved by maintaining printed-circuit-board (PCB) prototyping capability in-house through the use of a compact and automated PCB prototyping system. Mike Busse of Micro Networks/Anderson Labs (Worcester, MA) will review a new surface-acoustic-wave (SAW) packaging technology that makes higher-density circuits and more reliable operation in severe shock environments possible. Oscillators using these encased SAW resonators exhibit very little change in output signal characteristics during repeated mechanical g loading in excess of 100,000 g's in any axis. This technology can be applied to other SAW devices to achieve circuit size reduction as well as shock hardening, and may be combined with selected crystal substrates to realize oscillators with an improved temperature coefficient.

Mohamed K. Nezami of Mnemonics, Inc. (Melbourne, FL) will discuss direct-conversion Rxs for military and commercial software-defined radio systems. Some of the design shortcomings of these zero-intermediate-frequency (zero-IF) Rxs will be highlighted, along with several methods to overcome these difficulties. Finally, Frank Gutleber of Airlinx Communications (Greenville, NH) will review multiplexed-noise (MN) codes for spread-spectrum communications and how they can be applied. **For more information on the Military Electronics Show, please visit the website at http://www.militaryelectronicsshow.com.** MRF

Spectrum Analyzers

Instruments and accessories for electronic production, test, measurement, and repair are the subject of a 68-page catalog. Soldering and desoldering products, hot-air assemblies, oscilloscopes, spectrum analyzers, meters, power supplies, counters, function and signal generators, as well as programmers and erasers are offered. Specifications are provided.

Products International; (800) 638-2020, FAX: (800) 545-0058, e-mail: sales@prodintl.com, Internet: http://www.prodintl.com.

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Specialty Tools

A 132-page catalog offers telecommunications products. Tool kits, hand and specialty tools, cable, as well as telephone and electrical test equipment are presented. Custom tool kits and cases are offered.

Jensen Tools, Inc.; (800) 426-1194, (602) 453-3169, FAX: (800) 366-9662, (602) 438-1690, e-mail: jensen@stanleyworks.com, Interent: http://www.jensentel.com.

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Coatings/Substrates

A six-page brochure describes a firm's capabilities for the production of a variety of industrial and aerospace coatings and substrates in prototype as well as in production quantities. Electron-beam evaporation, RF and DC magnetron sputtering, ion-beam-assisted deposition, reactive sputtering, photolithographic patterning, gold (Au) and copper (Cu) electroplating, substrate dicing, and custom tooling are featured.

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Coaxial Cables

A catalog focuses on microwave coaxial connectors. Specifications for electrical, mechanical, and environmental parameters, along with material and finish information for the connector body, spring, center contact, insulator, and O-ring are included. Schematics are provided for connectors, jacks, plugs, adapters, interconnects, and accessories. An index is included.

Dynawave, Inc.; (978) 469-0555, e-mail: connect@dynawave.com, Internet: http://www.dynawave.com.

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PFC Advantages

A 104-page brochure contains information on a range of power-factor-correction (PFC) information. The fundamentals of PFC, applications, power capacitors, AC capacitors, PFC key components, PFC controllers, fuse elements, capacitor contractors, the anti-resonance three-phase filter reactor, pulse-repetition-frequency (PRF) capacitors, and the discharge reactor are discussed. Tables and formulas for PFC calculation, installation and maintenance suggestions, and a component-selection table for detuned systems are -provided.

EPCOS, Inc.; (800) 888-7729, (800) 689-3717, Internet: http://www.epcos.com.

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A 760-page data book provides product information, specifications, and application notes for electronic components. Trimming and precision potentiometers, position sensors, turns-counting dials, passive networks, discrete components, magnetic components, microcircuits and modules, and screened substrates are offered. Inductors, transformers, isolated circuits, bussed circuits, and termination circuits are also presented.

BI Technologies; (714) 447-2345, FAX: (714) 447-2400, Internet: http://www.bitechnologies.com.

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Electrical Materials

A 96-page catalog offers books and journals. Subject matter includes electrical materials, environmental studies, metals, electronics, packaging, nondestructive testing, chemicals, as well as analytic techniques and measurements. Electrical insulation, nuclear materials, polymers, and sensory evaluation are also presented. Subject indexes are provided.

ASTM; (610) 832-9585, FAX: (610) 832-9555, e-mail: service@astm.org, Internet: http://www.astm.org.

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DC Blocks

Coaxial and fiber-optic products are featured in a 186-page catalog. Adapters, amplifiers, attenuators, bias tees, caps, circulators, coaxial cable assemblies, coaxial connectors, DC blocks, detectors, directional couplers, distributors and fuse holders, isolators, limiters, matching pads, and patch cords are listed. Phase trimmers, power dividers, shorts, switches, and terminations are offered. An adapter-selection chart and a connector-identification chart are included.

Pasternack Enterprises; (949) 261-1920, FAX: (949) 261-7451, e-mail: sales@pasternack.com, Internet: http://www.pasternack.com.

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Production Tools

A 356-page catalog focuses on laboratory equipment and accessories. Production tools, rules and gauges, soldering and desoldering equipment, adapters, inspection systems, electrical meters, cleanroom supplies, and test instruments are offered. Product specifications are included.

Techni-Tool; (800) 832-4866, (610) 941-2400, FAX: (800) 854-8665, (610) 828-5623, e-mail: sales@techni-tool.com, Internet: http://www.techni-tool.com.

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Digital I/O

Peripheral-component-interface (PCI)-based digital input/output (I/O) is the subject of a 20-page brochure. PCI-bus-compatible digital I/O boards, industry-standard-architecture (ISA)-bus compatible digital I/O boards, counter/timer boards, PC-card-bus-compatible digital I/O and counter/timer cards, PC/104-bus compatible digital I/O and counter/timer boards, relay and solid-state I/O module racks are presented.

Measurement Computing; (508) 946-5100, FAX: (508) 946-9500, Internet: http://www.measurementcomputing.com

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Receiver Measurements

A 72-page handbook covers commonly used RF data. Modulation, methods of measuring phase noise, intermodulation (IM), receiver (Rx) measurements, signal to noise plus distortion (SINAD), and RF mixers are presented. Splitters and combiners and RF-level conversion are discussed.

IFR; (800) 835-2352, (316) 522-4981, e-mail: info@ifrsys.com, Internet: http://www.ifrsys.com.

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Gain Compression

An application note focuses on measuring the gain compression of power amplifiers (PAs). The note describes how the fast and accurate frequency sweep of the company's microwave synthesizer, combined with the power-meter accuracy of the company's scalar network analyzer, can be used to tune amplifiers for optimum performance, while reducing test time. An alternative measurement approach for faster measurement of gain compression is included.

Giga-tronics, Inc.; (925) 328-4650, FAX: (925) 328-4700, e-mail: info@gigatronics.com, Internet: http://www.gigatronics.com/pdf/gain-comp_appnote.pdf.

● **Enter No. 100 at www.mwrf.com**

ESDF1

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Table Of Contents

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- Communications/Networking
- Computing & Information Appliances
- Test & Measurement

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- PlanetEE's customized comprehensive, searchable components directory
- Microwaves & RF's "Product Data Directory"
- Used Equipment Network's "Surplus Corner"

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- Embedded University
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Stay tuned to this page for new innovations and special announcements that are now in-process. Visit PlanetEE at **www.PlanetEE.com**.

PlanetEE Kicks Off E-Newsletter Campaign With "Bluetooth Bulletin"

Responding to strong demand from site visitors and Penton Electronics Group publication readers, *PlanetEE* now offers the first of what will be a series of free bi-weekly e-newsletters. The "Bluetooth Bulletin," a natural progression off of *PlanetEE*'s successful Bluetooth page, will provide on-the-edge commentary from leaders in the Bluetooth movement, including *Electronic Design*'s Louis Frenzel, along with news, major product announcements, events, etc. Go to *PlanetEE*'s home page *(www.PlanetEE.com)* to sign up for the free newsletter, and keep checking back for upcoming newsletters in other technology areas scheduled for release in May and June.

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SALES STAFF

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MARKETING AND ADVERTISING STAFF

GROUP PUBLISHER
Craig Roth
(201) 393-6293
e-mail:croth@penton.com

DIRECT CONNECTION ADS
Joanne Reppas
(201) 666-6698
e-mail: jrepfran@aol.com

EXHIBIT SALES REP, ELECTRONICS
Todd Cusumano
(212) 547-1841,
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Regional Sales Manager
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San Jose Gateway
2025 Gateway Place, Suite 354
San Jose, CA 95110
(408) 441-0550
e-mail: groberts@penton.com

NEW YORK, NEW ENGLAND, MID-WEST, MID-ATLANTIC, CANADA
Paul Barkman
Regional Sales Manager
Penton Media, Inc.
611 Route #46 West
Hasbrouck Heights, NJ 07604
(908) 704-2460
FAX: (908) 704-2496
e-mail: pbarkman@penton.com

SOUTHWEST, SOUTHEAST, SOUTHERN CA
Mary Bandfield
Regional Sales Manager
Penton Media, Inc.
501 N. Orlando Avenue
Winter Park, FL 32789
(407) 629-8745
FAX: (407) 629-8715
e-mail: mbandfield@penton.com

MIDWEST, MID-ATLANTIC
Paul Barkman
Regional Sales Manager
Penton Media, Inc.
611 Route #46 West
Hasbrouck Heights, NJ 07604
(908)391-8735
FAX: (201) 393-6297
e-mail: pbarkman@penton.com

PRODUCTION
Robert D. Scofield
(201) 393-6253
e-mail: rscofield@penton.com

ISRAEL
Igal Elan, General Manager
Elan Marketing Group
2 Habonim Street
Ramat Gan, Israel 52462
Phone: 011-972-3-6122466
011-972-3-6122467
011-972-3-6122468
FAX: 011-972-3-6122469

TAIWAN, R.O.C.
Charles C.Y. Liu, President
Two-Way Communications Co., Ltd.
11F/1, No. 421
Sung Shan Road
Taipei 110, Taiwan, R.O.C.
Phone: 886-2-727-7799
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ITALY
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Via Napo Torriani 19/c
1-22100 Como - Italy
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FRANCE
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Defense & Communication
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FAX: 33-4387-2729

SPAIN
Luis Andrade, Miguel Esteban
Espana
Publicidad Internacional
Sepulveda, 143-38
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Phone: 011-34-93-323-3031
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SCANDINAVIA
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Ramsden Heath
Billericay, Essex
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United Kingdom
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FAX: 44-1268-711-567

GERMANY, AUSTRIA, SWITZERLAND
Friedrich K. Anacker
Managing Director
InterMedia Partners GmbH (IMP)
Deutscher Ring 40
42327 Wuppertal
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HOLLAND, BELGIUM
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Rechtestraat 58
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JAPAN
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Japan Advertising Communications, Inc.
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3-10-3 Kanda Jimbocho
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Japan
Phone: 81-3-3261-4591
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PORTUGAL
Paulo Andrade
Ilimitada-Publicidade Internacional. LDA
Av. Eng. Duarte Pacheco
Empreedimento das Amoreiras-Torre 2
Piso 11-Sala 11
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EUROPEAN OPERATIONS
Paul Barrett, Mark Whiteacre, David Moore
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Hartswood, Maycock Media
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Czech Republic
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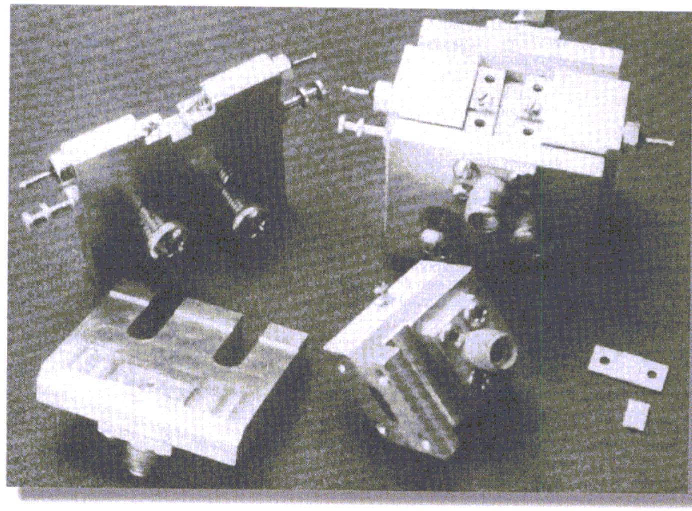

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next month

MICROWAVES & RF May Editorial Preview

Issue Theme: Radar & Antennas/ MTT-S Preview

News

The May issue of *Microwaves & RF* will feature an extensive preview of the 2001 IEEE International Microwave Theory & Techniques Symposium (MTT-S), scheduled for May 20-25, 2001 in the Phoenix Civic Plaza (Phoenix, AZ). The preview section will provide a summary of the more than 400 technical presentations to be made in Phoenix, along with highlights of the leading new hardware, software, and test-equipment products.

Design Features

The May issue offers a cross-section of the technologies featured at the 2001 IEEE MTT-S. An author from Spain's University of Madrid, for example, details low-cost manufacturing techniques for millimeter-wave components and systems, while an author from the British University of Warwick describes advances in modeling electronic cooling processes, critical for designing high-power amplifiers (PAs).

Product Technology

May's Product Technology section will highlight major announcements from the recent Optical Fiber Conference (OFC). In addition, product features will disclose a receive module that shrinks the size of code-division-multiple-access (CDMA) designs, a line of broadband synthesizers that set new standards for phase-noise performance, and transceiver modules for data links at 900 MHz.

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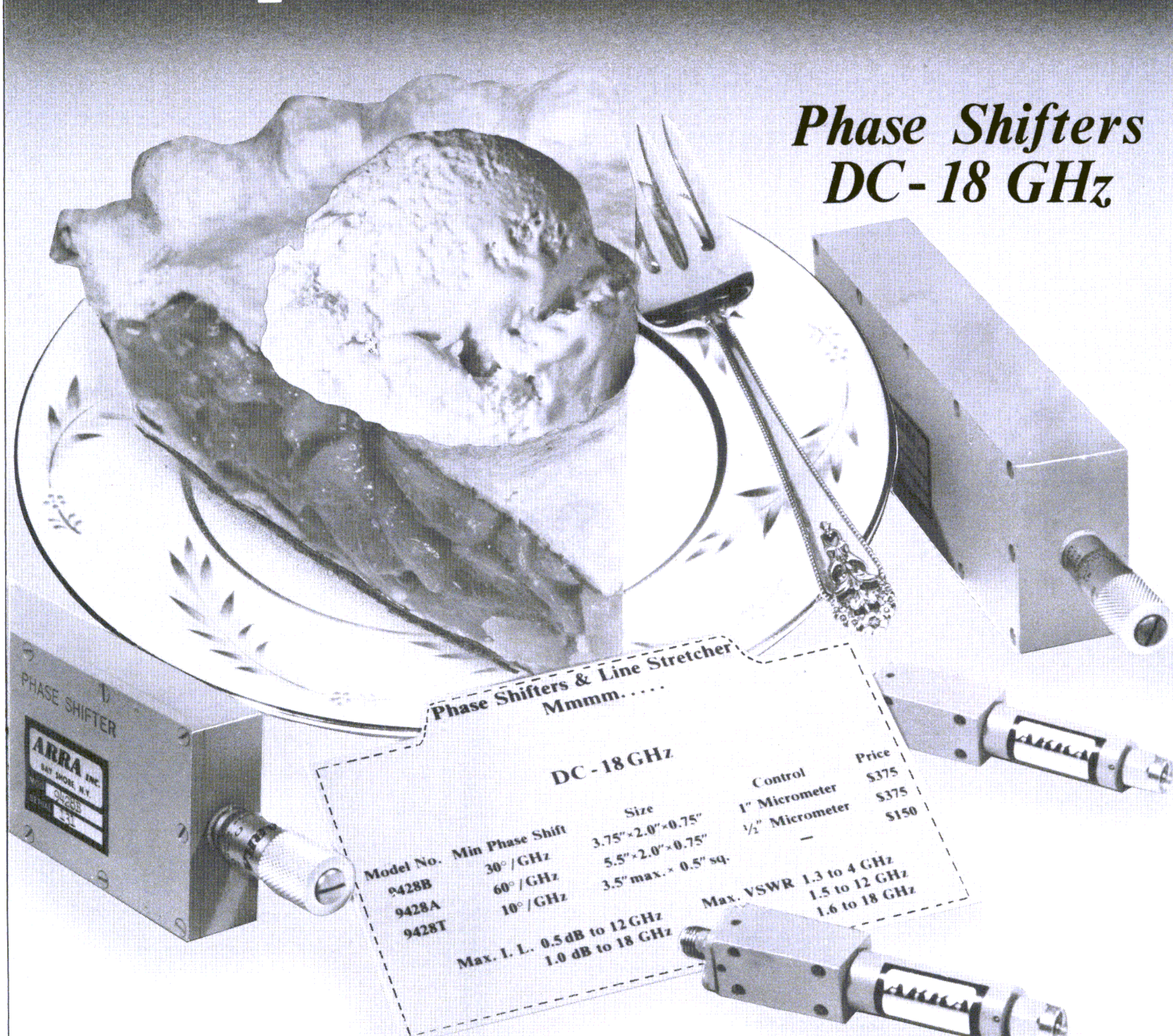

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