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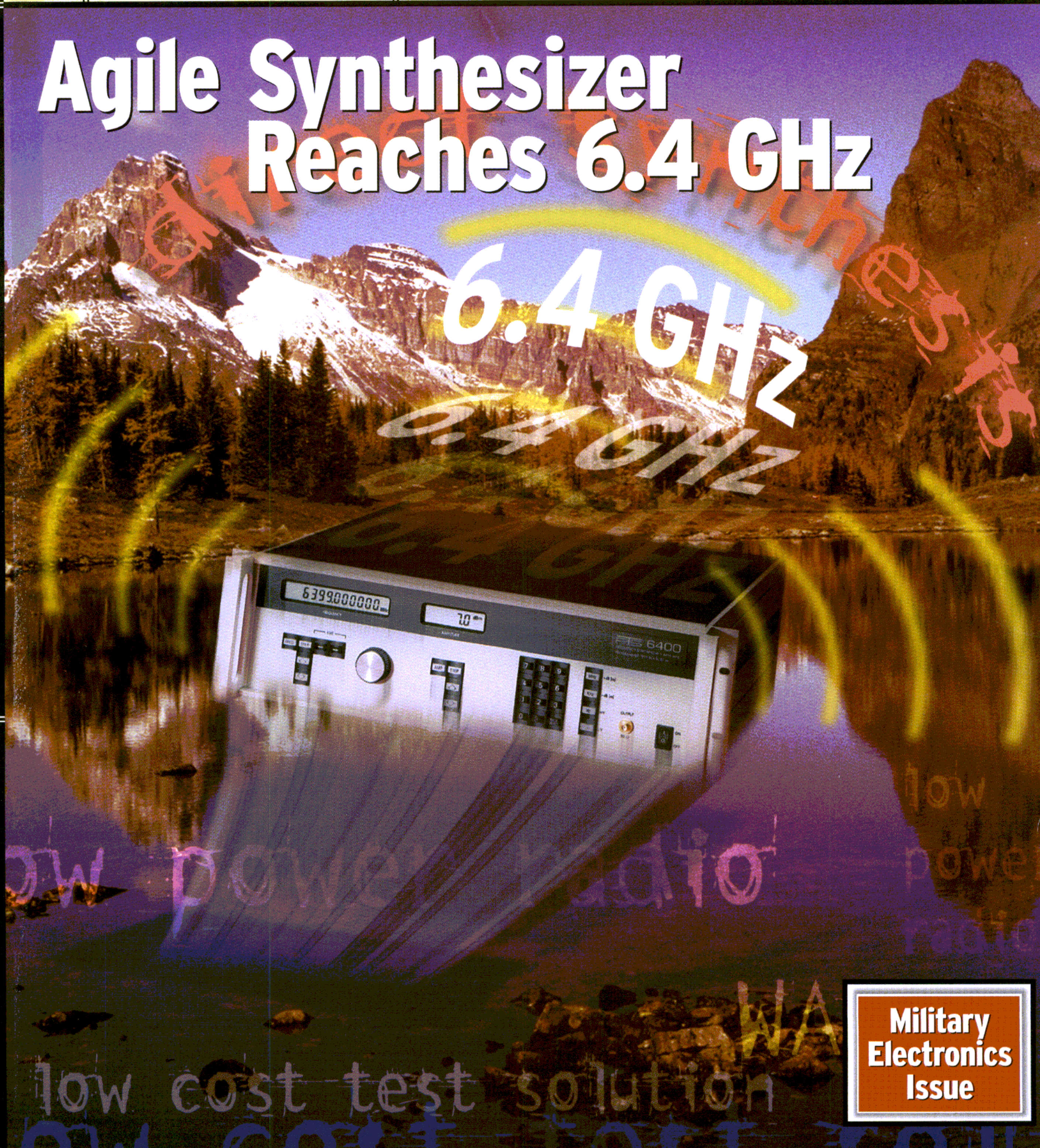
Microwaves & RF

News
Process enhancements spark semiconductor advances

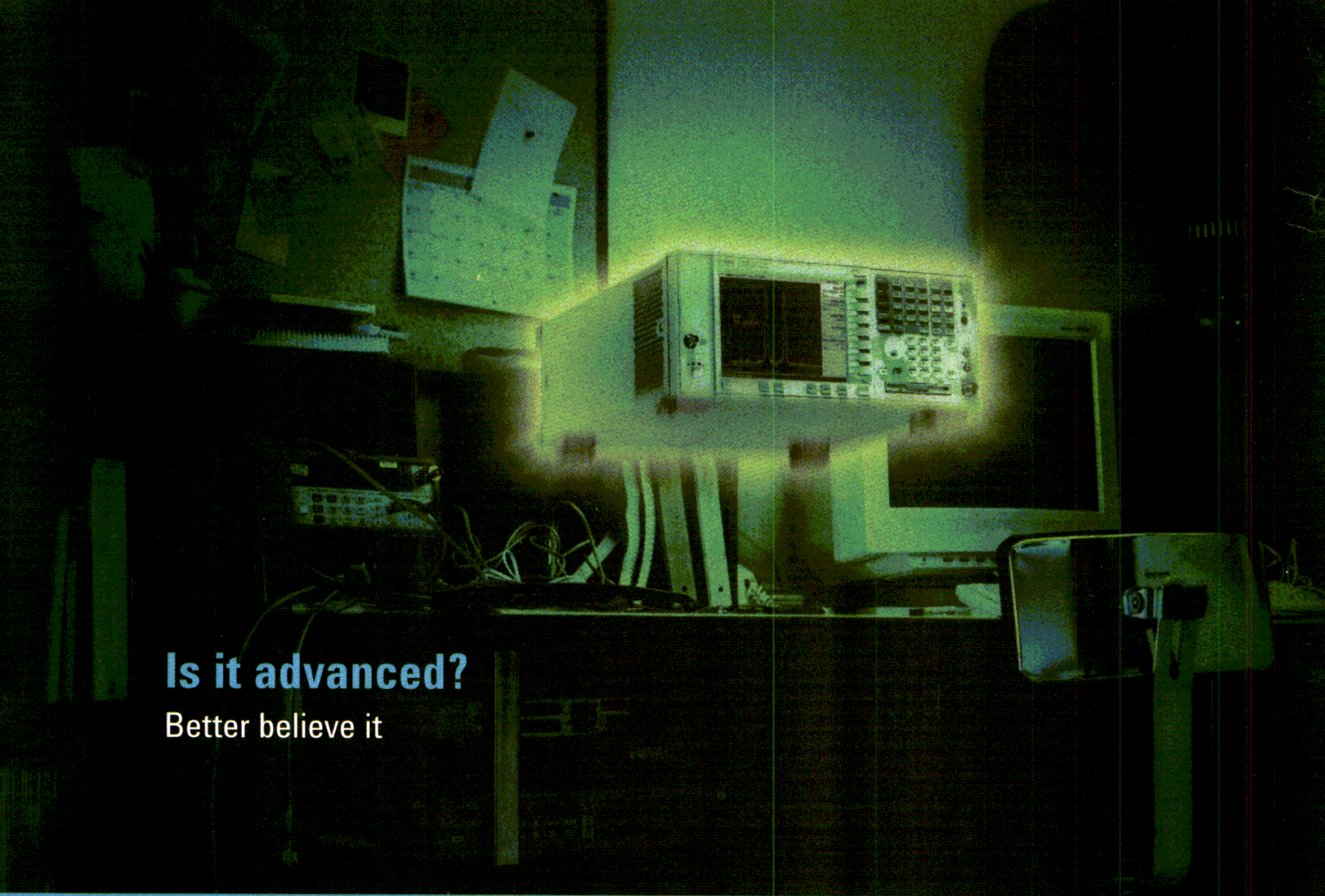
Design Feature
Noncoherent detection improves FQPSK system performance

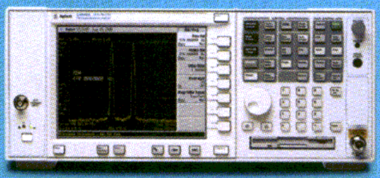
Product Technology
Vector signal generator keeps pace with 3G

Agile Synthesizer Reaches 6.4 GHz



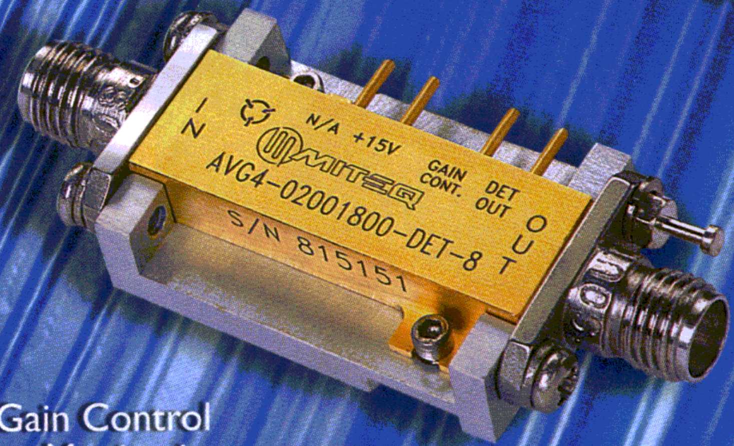
Military Electronics Issue


Is it advanced?
Better believe it



Broadband Amplifiers

With Gain Control & Power Monitoring



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- Continuous Power Monitoring
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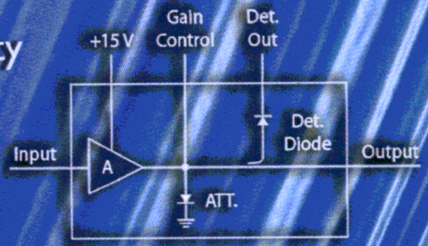
- Instrumentation Configuration Available
- Custom Designs



Model Number	Frequency (GHz)	Gain (dB)	Flatness (dB)	Noise Figure (dB)	VSWR Input	VSWR Output	Output Power @1 dB Comp. (dBm, min.)	DC Power +15 V (mA, Nom.)
AVG4-00100800-DET-8	0.1-8	26	±1.0	2.8	2.0:1	2.0:1	+10	175
AVG4-00101200-DET-8	0.1-12	26	±1.25	3.0	2.0:1	2.0:1	+10	185
AVG4-00101800-DET-8	0.1-18	26	±2.5	3.5	2.5:1	2.5:1	+10	180
AVG4-04000800-DET-8	4-8	32	±1.0	1.8	2.0:1	2.0:1	+10	125
AVG4-08001200-DET-8	8-12	28	±1.0	2.0	2.0:1	2.0:1	+10	125
AVG4-02000800-DET-8	2-8	28	±1.0	2.5	2.0:1	2.0:1	+10	175
AVG4-02001800-DET-8	2-18	26	±2.5	3.0	2.5:1	2.5:1	+10	180

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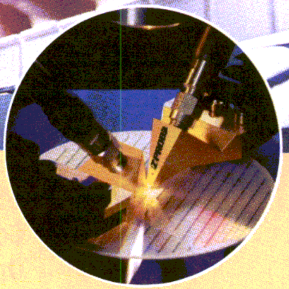

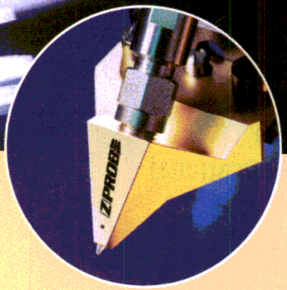

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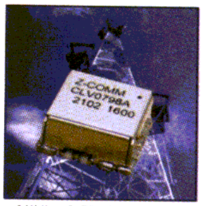
CLV0815E	806	824	0.5-4.5	11	-113	-35	5.0	11
CLV0950E	865	1035	1-10	27	-114	-11	5.0	24
CLV0915A	902	928	0-4	17	-108	-30	3.0	10
CLV1085E	1050	1086	0.5-4.5	21	-112	-20	5.0	20
CLV1385E	1370	1400	0.5-4.5	18	-110	-20	5.0	20
CLV1550E	1500	1600	0.5-5.0	44	-106	-35	5.0	22
CLV2465E	2436	2496	1-4	26	-107	-20	5.0	25



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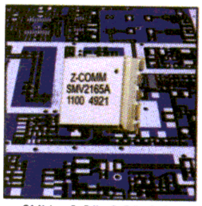
SMV0162A	125	200	0.7-8.3	12	-100	-6	5.0	36
SMV1570L	1540	1600	0.5-2.5	128	-90	-15	2.7	9
SMV2165A	2118	2218	0-3	148	-91	-10	3.3	16
SMV2390L	2290	2485	0-4	116	-90	-11	5.0	16
SMV2660L	2620	2700	0.5-4.5	90	-91	-17	5.0	21



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USSP2330	2300	2360	0.5-2.5	0±3	-83	-15	2.7	8

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PLL0210A	200	230	100	0.50	-105	3.5±2.5	+5	25
PLL0930A	900	960	100	0.75	-101	3±2	+5	40
PLL1260A	1230	1290	1000	0.75	-102	1±2	+5	40
PLL1456A	1420	1490	1000	0.75	-103	1±2	+5	40
PLL2710A	2670	2740	1000	1.25	-98	1±4	+5	30

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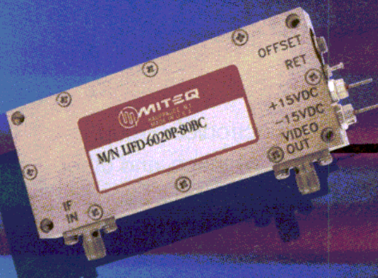
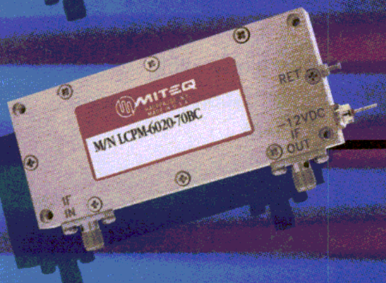


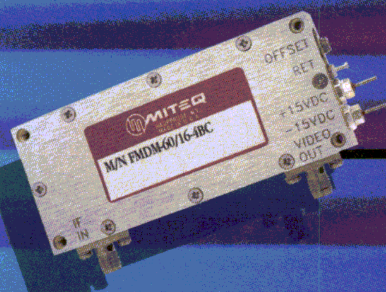
MODEL NUMBER	CENTER FREQUENCY (MHz)	DYNAMIC RANGE (dBm, Min.)	LINEARITY (dB, Max.)	RISE TIME (ns, Max.)	LOGGING SLOPE INTO 93 OHMS (mV/dB, Typ.)
LIFD-3010P-80BC	30	-80 to 0	±0.5	100	25
LIFD-6020P-80BC	60	-80 to 0	±0.5	50	25
LIFD-7030P-80BC	70	-80 to 0	±0.5	30	25
LIFD-16040-80BC	160	-80 to 0	±1.0	30	25
LIFD-300100-70BC	300	-70 to 0	±1.0	20	15

CONSTANT PHASE LIMITING AMPLIFIERS



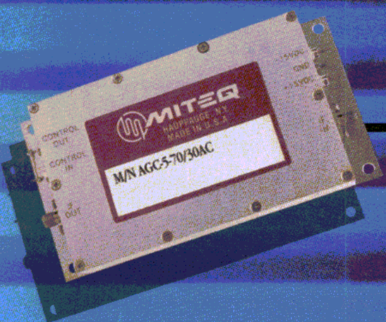
MODEL NUMBER	CENTER FREQUENCY (MHz)	DYNAMIC RANGE (dB, Min.)	OUTPUT POWER (dBm, Min.)	POWER VARIATION (dB, Max.)	PHASE VARIATION (Max.)
LCPM-3010-70BC	30	-70 to 0	10	±0.5	±3°
LCPM-6020-70BC	60	-70 to 0	10	±0.5	±3°
LCPM-7030-70AC	70	-65 to 5	10	±0.5	±5°
LCPM-16040-70BC	160	-65 to 5	10	±1.0	±3°

FREQUENCY DISCRIMINATORS

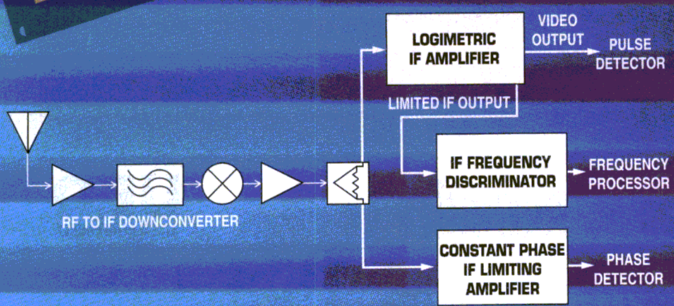


MODEL NUMBER	CENTER FREQUENCY (MHz)	LINEAR BANDWIDTH (MHz, Min.)	SENSITIVITY (mV/MHz, Typ.)	LINEARITY (%, Max.)	RISE TIME (ns, Max.)
FMDM-30/6-3BC	30	6	1000	±3	120
FMDM-60/16-4BC	60	16	250	±3	90
FMDM-70/36-10AC	70	36	50	±2	50
FMDM-160/35-15BC	160	35	100	±2	30
FMDM-160/50-15AC	160	50	40	±2	25
FMDM-750/150-20BC	750	150	20	±3	20
FMDM-1000/300-50AC	1000	300	10	±5	7

AUTOMATIC GAIN CONTROL LINEAR AMPLIFIERS



MODEL NUMBER	CENTER FREQUENCY (MHz)	BANDWIDTH (-3 dB) (MHz, Min.)	DYNAMIC RANGE (dBm, Min.)	OUTPUT POWER (dBm, Min.)	POWER VARIATION (dB, Max.)
AGC-7-10.7/4AC	10.7	4	-70 to 0	10	±0.5
AGC-7-21.4/10AC	21.4	10	-70 to 0	10	±0.5
AGC-5-70/30AC	70	30	-50 to 0	-4	±0.5
AGC-7-160/30AC	160	30	-70 to 0	8	±1.5
AGC-7-300/400AC	300	400	-65 to 0	3	±1.0



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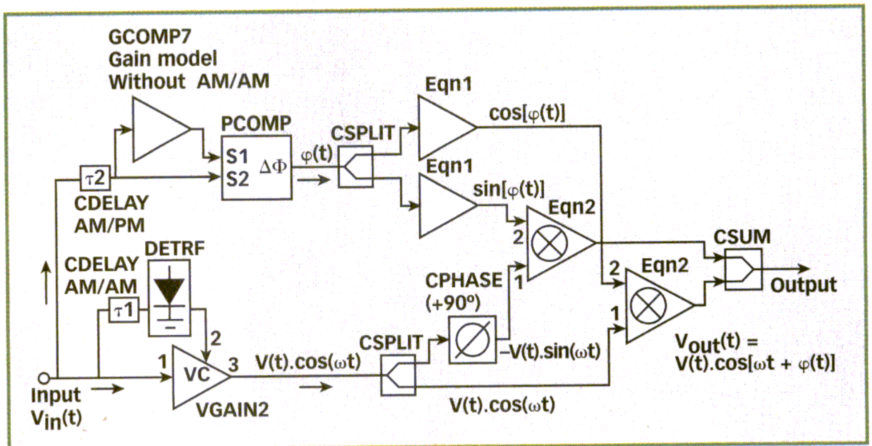
Editor's Note

Part 3 of the Design Feature article series "Understanding Regulations For Short-Range Radios" by author Farron Dacus does not appear in this month's issue. It will, however, appear next month in one of our bigger (if not the biggest) issues of the year. We apologize to our readers for this inconvenience. As a result of this change, Part 4 of this article series will appear in our January 2002 issue.

Incorrect Figure

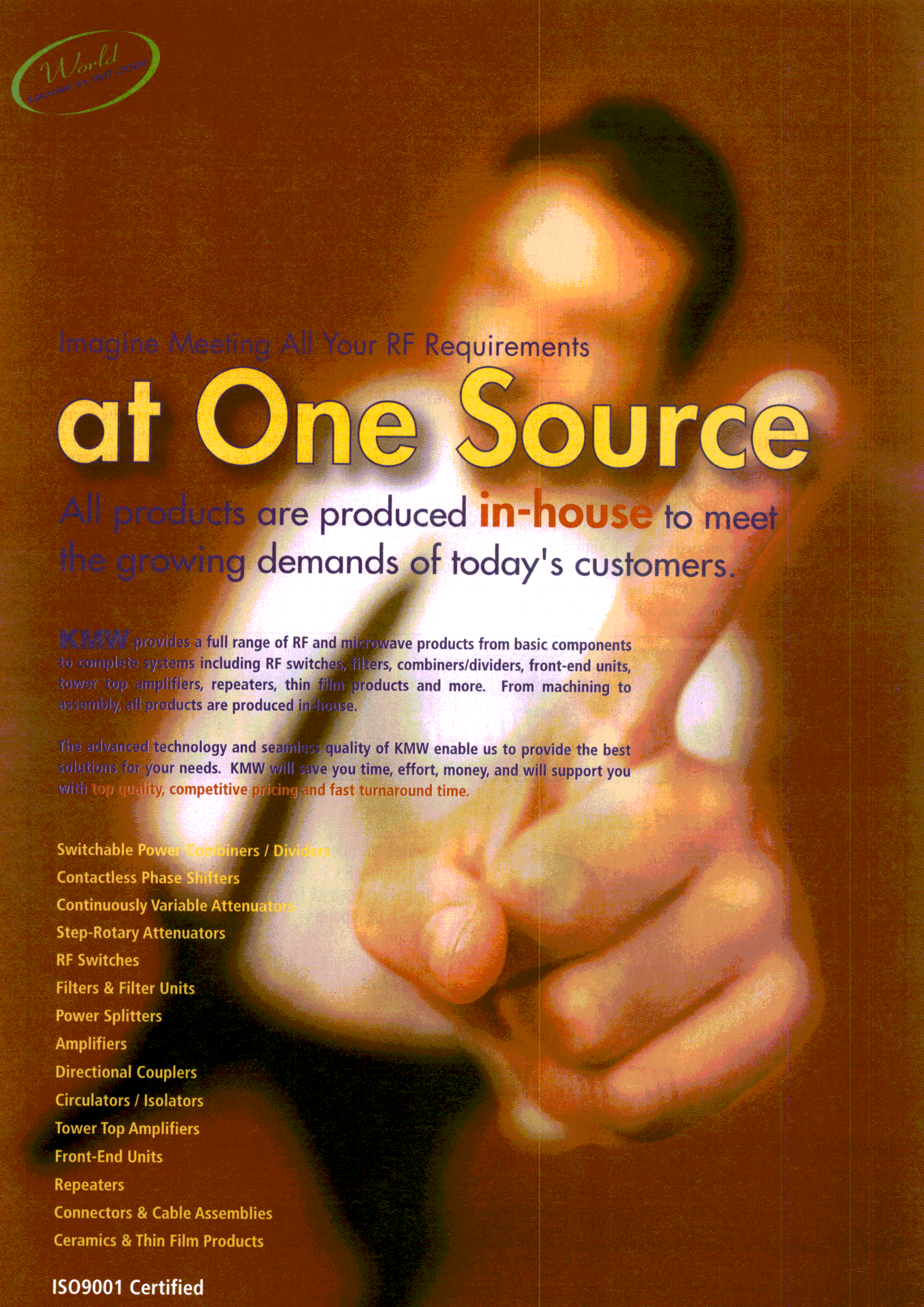
In the August 2001 issue of *Microwaves & RF*, I noticed a strong editing error on page 85. Figure 1 was inadvertently replaced by a duplicated Figure 1 from another article in the same issue. The wrong Figure 1 on page 85 came from the article "LDMOS Delivers 500 W For IFF Systems" by Ron Olson, Mike Mallinger, and Lee Max, which began on page 185.



Several people who saw the article were surprised by this and have questioned me about the confusion. I have no idea what happened to the original figure.

Due to the significance of this figure and for reader comprehension, my co-authors and I would appreciate it if you could show the correct figure (shown above) that corresponds to the caption on page 85, "A block diagram of the OMNISYS-based Memory Effects simulation is shown here." This is the original figure that should have appeared on page 85. It is the only figure that shows the OMNISYS-based system architecture used for our IMD simulations.

Pascal Delemotte
France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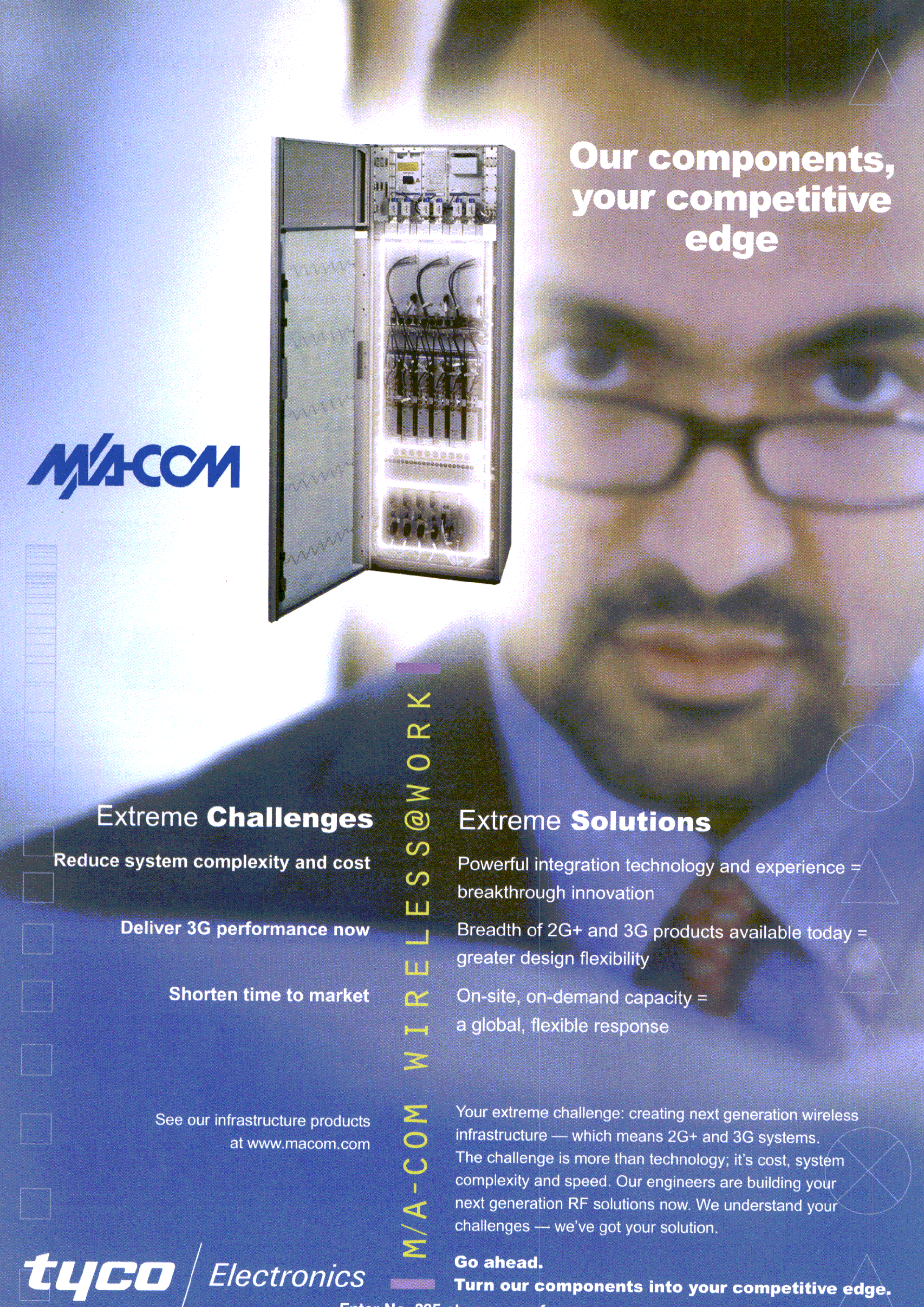
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WILL WE EVER GO HOME AGAIN?

Change is often received with mixed feelings. Some embrace change for the escape that it represents from a current situation, while others recoil from it due to a fear of the unknown. It is safe to say that, for most of us, the world changed dramatically on September 11, 2001, when terrorists hijacked four commercial airliners and used them as weapons of mass destruction. A sense of security for many democratic peoples around the world dissipated that day, as it was replaced with an uneasy sense of foreboding for what might come.

The American novelist Thomas Wolfe once wrote that "you can't go home again." The world changes, and we change with it or are left behind. The safety and security of an America untouched by foreign threats are behind us now, but we cannot cower in the shadows of the past. For those who embrace change, this is a time not to think about going home again, but to consider how to make "home" a better place. Otherwise, we will hand our descendants a legacy of fear and distrust, with little hope for the future.

Microwave engineers enjoy the enviable position of commanding a group of technologies that can be used for military defense and human health. In the past, microwave signals have been used as the basis for sophisticated radar systems as well as for missile guidance and remote triggering of weapon systems. But the same microwave signals can also be used in treatments for various forms of cancer, for dielectric probing of tumors, and for medical telemetry. And, as most people are familiar, microwave signals are now probably most closely associated with the cellular telephone.

Yet, the uses for microwave energy are almost unlimited, and some of these uses may have benefits for a world that is facing the changes of terrorism. Microwave energy has long been used for dielectric measurements of materials, and it is conceivable that these same types of (calibrated) measurements could form the basis of a nonmagnetic airport-security detection system to differentiate such materials as plastic explosives from luggage carriers. In addition, the approach might also be used to screen the contents of envelopes and other mailed packages for the presence of biological threats.

The lure of commercial ventures was strong during the 1990s, and many microwave firms abandoned their once traditional military businesses. Hopefully, government funding will return during the next several administrations to encourage companies to perform basic research on the capabilities of microwave energy for wartime and peacetime uses. This is an industry with tremendous technical talent. If properly encouraged, this talent could certainly find ways for us to at least make home safer once again.

Jack Browne

Publisher/Editor

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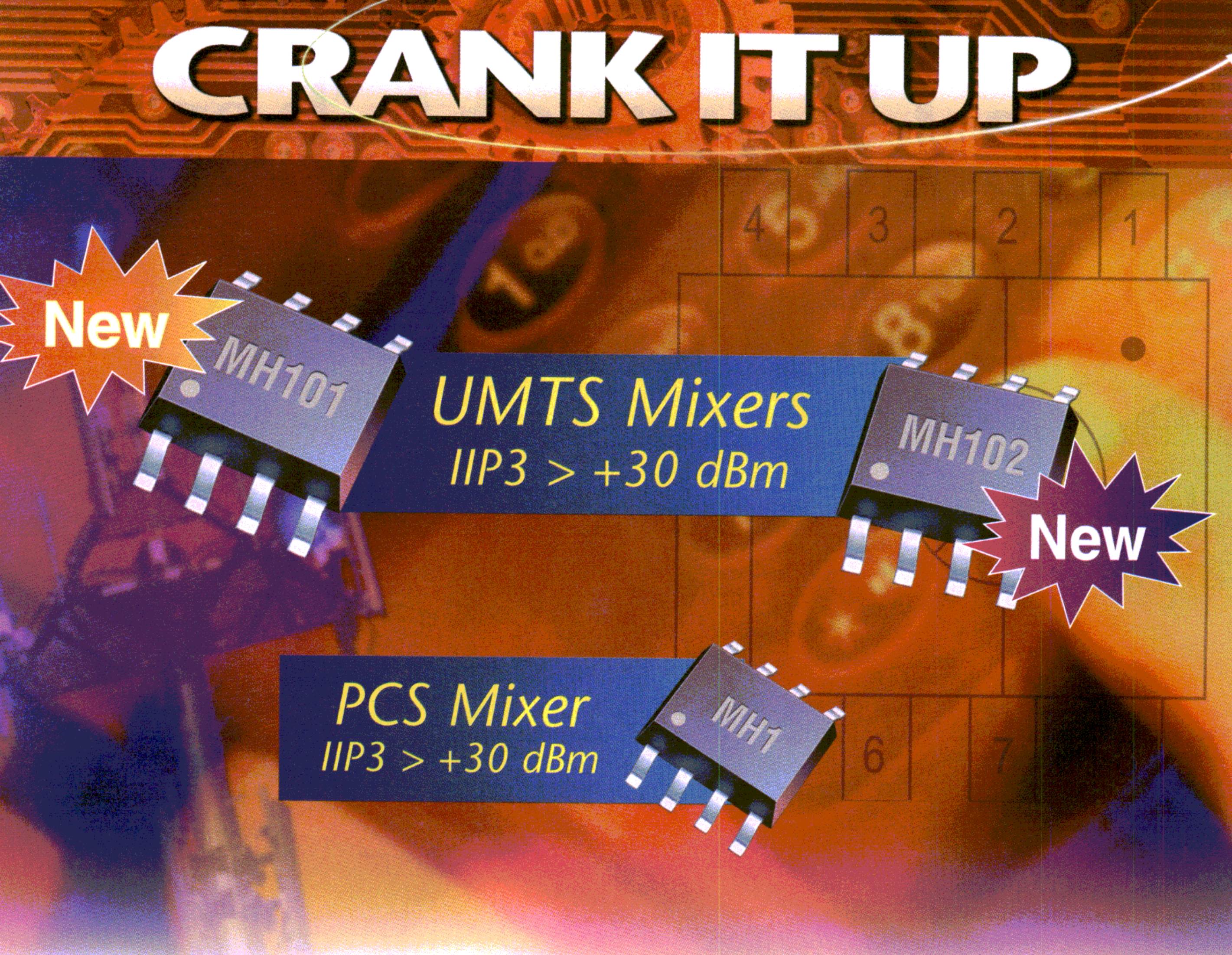

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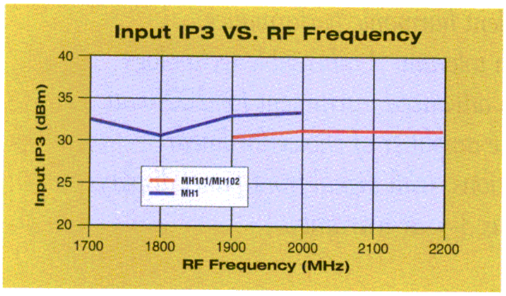

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MH102	1900-2200	150-300	+17	+30	26

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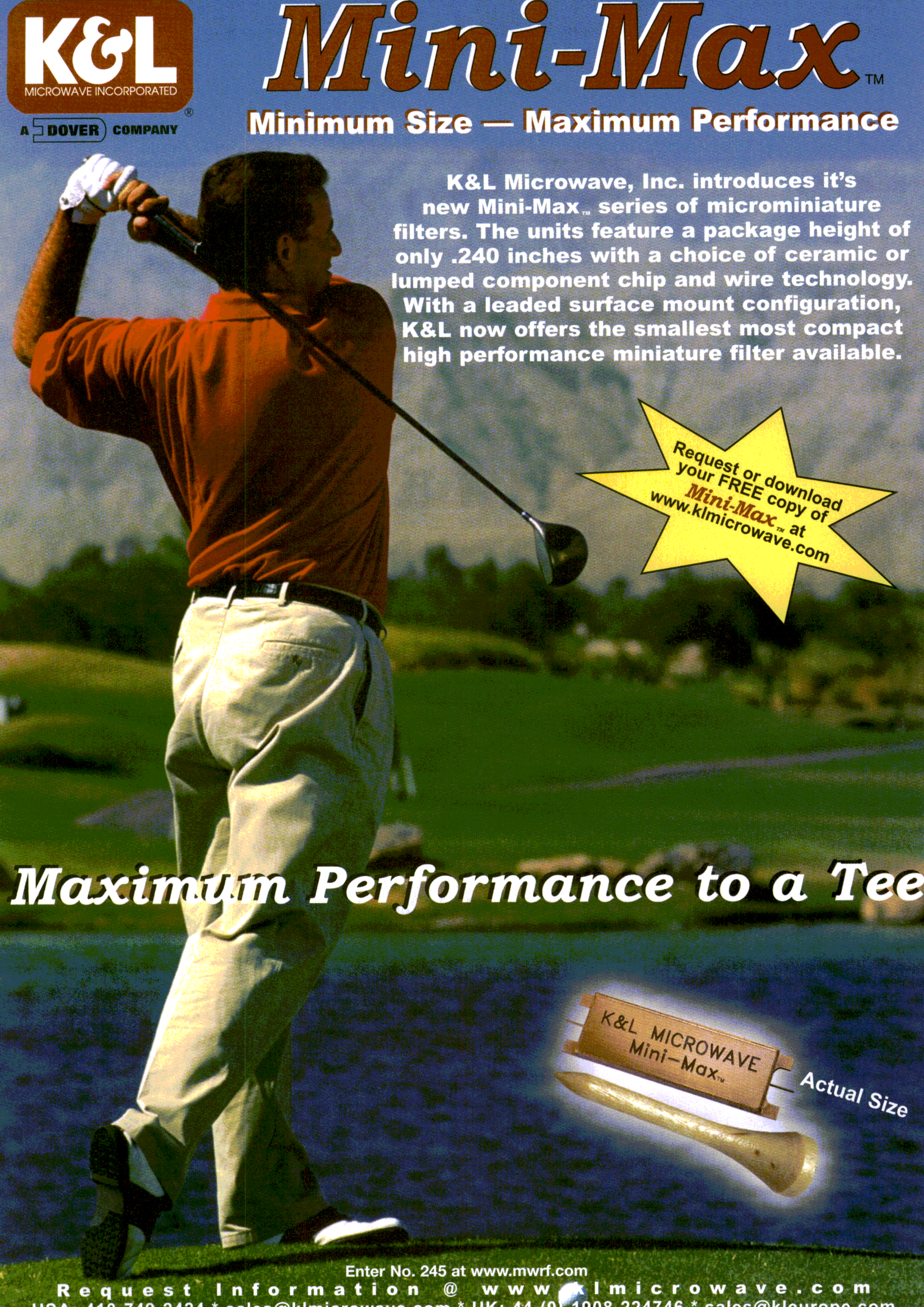

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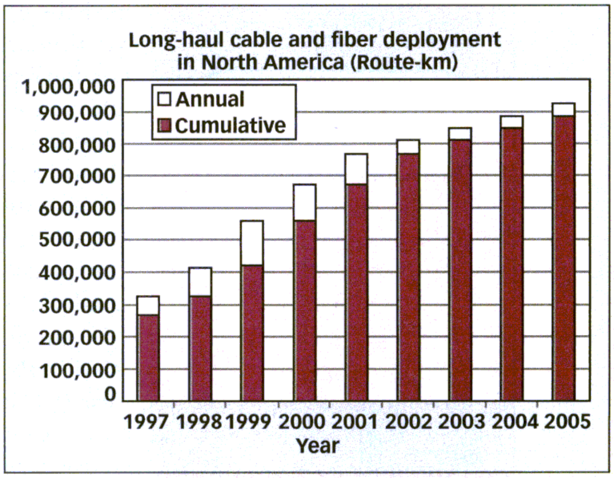
North American Fiber Demand Is Forecast To Begin Slow Rise In 2004

PROVIDENCE, RI—According to a KMI report, *Fiberoptic Networks of Long-Distance Carriers in North America: Market Developments and Forecast,* fiber deployment will slow significantly over the next two to three years. The report is an update of a November 1999 report that accurately forecasts a downturn in the US long-distance fiber and cable market starting in 2001.

As a result of the slowdown, industry consolidation is likely for the next two years. Carriers that survive the downturn in relatively good health will be in a strong position to prosper from the coming broadband boom as more end users shift away from dial-up modems and put more traffic on the Internet backbone.

At the end of 2000, North American carriers had deployed some 672,000 route-km of fiber-optic cable in long-haul networks **(see figure)**. At an average count of 52 fibers per cable, nearly 35 million km of fiber have been deployed, five times the amount only four years earlier.



After reaching a peak of some 140,000 route-km in 1999, annual deployment of cable is expected to fall back to just under 35,000 route-km by 2003. With increasingly higher fiber counts cushioning the decline in terms of fiber-km, annual deployment of fiber drops from a peak of just over 10.8 million fiber-km in 2000 to approximately 7 million fiber-km in 2003.

Beyond 2003, improved business conditions and friendlier capital markets, combined with a resurgence in bandwidth demand (caused by new broadband applications), will lead to positive growth in annual long-haul fiber deployment, though still at levels below those of the peak years of 1999 and 2000.

Aerospace Industry Assesses Impact Of Airline Crisis

WASHINGTON, DC—The Aerospace Industries Association (AIA) has revised its estimate for aerospace industry sales based on revised delivery projections of its manufacturers in the wake of the terrorist attacks that occurred on September 11. Commercial aircraft and parts sales are expected to decline by approximately $2 billion from the previous estimate. Total industry sales will decline only by $400 million, to $143 billion—from the $143.4 billion in sales in 2000. Prior to the events of September 11, the Aerospace Industries Association had predicted industry sales of $145 billion, a $1.6 billion sales increase this year from 2000.

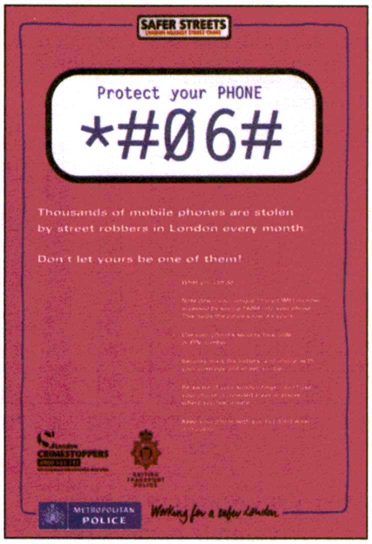
John Douglass, AIA president and CEO, said that industry sales could decline up to $5.6 billion in 2002 and by $6.7 billion in 2003. Increased sales in space and defense markets may offset to some extent the decline in commercial sales, he said, depending on the way that the Bush administration responds to the crisis.

"An air campaign would have a different impact than a campaign involving the movement of large-to-moderate ground and naval forces," says Douglass. He adds, "Space sales will probably increase in any event." Douglass also says that the final balance in sales will depend in large degree on how quickly the Defense Department adds funds to its procurement and spares budget. "A lot will depend on the immediate stress on the operations and maintenance budget," Douglass states.

AIA will continue to refine its sales estimates as actions in the war against terrorism unfold.

London's Metropolitan Police Launch Mobile-Phone Theft-Prevention Campaign

LONDON, ENGLAND—The theft of mobile phones has become an increasingly serious problem in the United Kingdom. Each month, approximately 15,000 mobile phones are stolen nationwide. The monthly average for mobile-phone thefts in London is 1600. In London's Westminster borough, approximately 50 percent of all street robberies concern the theft of mobile phones. The Metropolitan Police of London reported a fourfold increase in personal robberies involving mobile phones between 1998-99 and 2000-01. Last year, there were 19,032 thefts of mobile phones on London streets.



London's Metropolitan Police have undertaken a mobile-phone theft-prevention initiative. This poster is featured in the campaign.

In an effort to combat this disturbing trend, the Metropolitan Police introduced a campaign to help prevent mobile-phone theft earlier this year **(see figure)**. Advertisements were placed in several London newspapers and a 30-second spot concerning the initiative aired on local radio stations.

The aim of the campaign was to encourage owners to record their phone's identification number, which can be accessed by dialing *#06#. Then, if the phone is stolen, the identification number can be given to the local police, and this would be filed on a data base as part of the crime report. If the police then come across a phone, they can check its identification number against those listed on the data base to determine whether or not the phone has been stolen.

Posters featuring information about the mobile-phone anti-theft initiative were distributed to schools, mobile-phone retailers, community groups, and in train stations. Material supporting the campaign advises owners to keep their mobile phones safe by: locking the keypad when not in use; security marking the phone and battery; not wearing the phone (i.e., hanging from the belt); and wherever possible, not using their phone in crowded places, among large, boisterous crowds, or wherever one feels uncomfortable.

Chief inspector Nick Wood of London's West End Central Police Station, says, "Mobile-phone thefts are a particular problem at the moment in the West End.

"The busy streets of central London make mobile-phone users easy prey to criminals. People often walk out of a tube station onto a busy street, start talking on their phone, and before they know it, the phone has been ripped from their ear and someone has made off with it.

"If the users were to lock their phones using the personalized code then they would be of little use if they were stolen.

"And a quick note of the IMEI (or serial) number would also hamper the thief because, with this number, the service provider can discontinue the service, again making the phone useless. But we cannot emphasize the point enough: when using your mobile phone, be aware of what and who is around you."

Several of the UK's mobile-phone firms, including Virgin Mobile and Vodafone, have cooperated with law-enforcement officials in the campaign. The mobile-phone firms in the UK are devising ways to ensure that stolen mobile phones are unusable once the theft has been reported to the authorities and the theft victim's mobile-phone provider. Vodafone, for example, bars the Subscriber Identity Module (SIM) from the network as soon as the theft is reported.

Florida Startup Firm Begins Operations

TEMPLE TERRACE, FL—Modelithics, Inc., a company focusing on precision RF and microwave characterization and measurement-based computer-aided-engineering (CAE) models, began operations on August 1. More than 1200 substrate-dependent models for passive surface-mount components are available for licensing, and contracts are underway for custom active and passive-device characterization and modeling services.

Modelithics was founded by University of South Florida professors Tom Weller and Larry Dunleavy. The firm is one of the first companies in a new, high-technology startup company incubator near USF's Tampa campus. More information can be found at www.modelithics.com.

Wireless Chip Sets Are Leading Home-Network Silicon Market Growth

OYSTER BAY, NY—In the midst of an industry-wide semiconductor downturn, the home-networking silicon (Si) market will represent one of the fastest-growing integrated-circuit (IC) markets over the next few years. Allied Business Intelligence (ABI) forecasts that worldwide revenues from wireless, power-line, and phone-line home-networking chips, driven by embedded implementations, are poised to grow from $49 million in 2000 to $887 million by 2006, an average annual growth rate of 62 percent. Leading the charge will be wireless ICs which, by 2006, will account for 48 percent of all home-networking chip sets shipped, and 66 percent of all revenue.

"Innovation and fierce competition is expected to drive down chip-set prices, which in turn will spur greater market penetration."

ABI's report, "Home Networking Chipsets: Wireless, Powerline and Phoneline IC Markets," points out that wireless local-area-network (WLAN) ICs are seeing dramatic price declines due to increasing chip integration and a ramp up in shipments. IEEE 802.11b, and to a lesser extent HomeRF chip sets, will show promising market penetration over the next few years with 5-GHz WLAN technologies, such as 802.11a and HiperLAN2, enabling multimedia home-networking applications in the longer term.

"The prospect of strong growth in the home-networking IC market has attracted a number of silicon suppliers, especially in the wireless and power-line segments," says Navin Sabharwal, the report's author and ABI's vice president of Residential and Networking Technologies. "Innovation and fierce competition is expected to drive down chip-set prices which, in turn, will spur greater market penetration."

Product Makes GPS Antennas Lighter, Cheaper, And Smaller

SALT LAKE CITY, UT—The Titan Corp. and its subsidiary, e-tenna Corp., a developer of RF technologies for commercial wireless applications, have unveiled e-tenna's AccuWave G100 product, designed to make Global Positioning Systems (GPS) antennas significantly lighter, cheaper, and smaller than today's devices.

The first commercial product to emerge from e-tenna's AccuWave product line, the AccuWave G100, is a groundplane designed to minimize GPS position errors caused by multipath. This common phenomenon in wireless systems occurs when RF signals bounce from the earth or other surfaces and interfere with the original RF transmission. The AccuWave G100 uses e-tenna's RF Mirror artificial magnetic conductor technology to greatly reduce these bounced signals, thus minimizing interference.

By reducing interference for GPS antennas, the AccuWave 100 groundplane performs similarly to a traditional choke-ring groundplane. However, today's choke-rings are significantly larger, heavier, and more costly than the AccuWave 100 groundplane. In fact, choke-ring treatments are on average 3 in. (7.62 cm) thick and 15 in. (38.1 cm) in diameter, weigh 10 to 15 lbs., and cost thousands of dollars. In contrast, the AccuWave G100 groundplane which, like choke-ring groundplanes, mechanically attaches to GPS antennas, is less than 0.5 in. (1.27 cm) thick while maintaining the 15-in. (38.1-cm) diameter, weighs less than 2 lbs., and costs from 50 to 75 percent less than today's choke-ring solution.

Kudos

Qualcomm, Inc. announced shipment of the company's 500 millionth chip, which represents Qualcomm CDMA Technologies' (QCT) cumulative CDMA chips shipped across all product lines. From less than one million chips shipped prior to 1996, QCT has become the world's largest provider of chip sets and system software for code-division-multiple-access (CDMA) wireless systems...Analog Devices, Inc. announced that its Othello™ and SoftFone™ Global System for Mobile Communications (GSM)/general-packet-radio-service (GPRS) solutions have achieved full type approval (FTA) in the S600 mobile handset from Guangzhou Southern High-tech Co. Ltd. (Soutec), a Chinese mobile-phone manufacturer...In response to the September 11th terrorist attack on the US, Gabriel of Scarborough, ME announced that it is dedicating its resources to accommodate relief efforts during this time of national disaster. The coordination will include the combined efforts of all sales and distribution channels and offer priority production and shipment of wireless infrastructure equipment during the reconstruction effort. MRF

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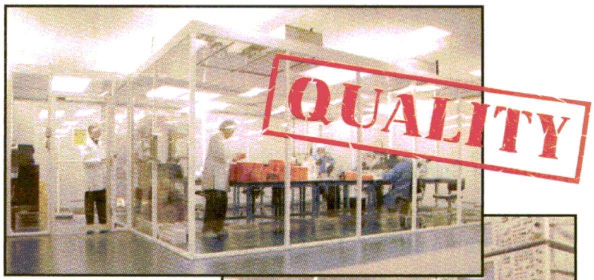

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NEWS

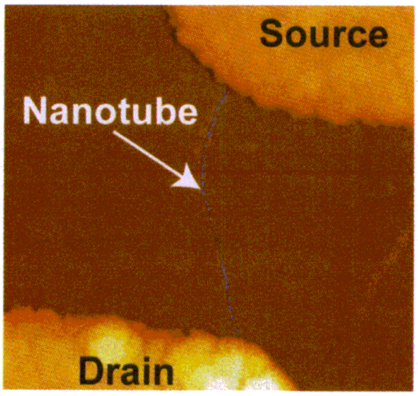
Process Enhancements Spark Semiconductor Advances

Motivated by increasing demands for analog bandwidths and digital data rates, researchers shared their thoughts on the next generation of device technologies.

JACK BROWNE
Publisher/Editor

Continuing improvements in semiconductor technology generally require advances in processing equipment and methods. The 47th Annual IEEE International Electron Devices Meeting (IEDM) offers evidence that there is still room for growth in many semiconductor technologies and, even with mature technologies such as silicon (Si) complementary-metal-oxide-semiconductor (CMOS), breakthroughs are still possible. The IEDM, the world's largest semiconductor device conference, is scheduled for December 3-5, 2001 at the Washington Hilton and Towers (Washington, DC).

The 47th Annual IEDM features more than 200 invited and contributed technical papers, selected from over 600 submitted abstracts by leading researchers and industry professionals. According to Paul Packan, Program Manager of Compact Device Modeling at Intel Corp. (Santa Clara, CA), who also serves as IEDM 2001 Publicity Chairman, "Other meetings can't compare to the IEDM's breadth of information on leading achievements in so many areas of microelectronics. Two trends that are clearly evident this year are the advancements in data storage and processing and further breakthroughs in the development of practical, high-speed components for high-bandwidth communications systems, such as 40-Gb/s fiber-optic systems."



C nanotubes are essentially wires for nanoelectric circuits. There is potential for making transistors that are as much as 10 times smaller than existing Si transistors.

Single-electron transistors (SETs) have been among the more exciting semiconductor developments in recent years. These device architectures employ Coulomb blockade effects to control the transfer of individual electrons without statistical fluctuations. SETs offer great potential for gigabit-scale integrated circuits (ICs) and extremely low-power memory devices. An invited paper by Junji Koga and associates from the Advanced LSI Technology Laboratory of Toshiba Corp. (Yokohama, Japan) reported on advances in SETs for floating dot-type memory devices as well as in programmable SET logic devices, with significant advances in functionality at room temperature compared to conventional CMOS logic. Hiroshi Inokawa and associates from the NTT Basic Research Laboratories of NTT Corp. (Kanagawa, Japan) also reported on SETs, verifying the operation of a merged SETs and metal-oxide-semiconductor field-effect transistors (MOSFETs) that were fabricated by pattern-dependent oxidation (PADOX). The combination of a SET and MOSFET was used as a basic component in a multi-valued logic system, showing that a flash analog-to-digital converter (ADC) and full adder for redundant number representation could be made with half the number of elements in conventional implementations.

Richard Martel and co-workers from the IBM Thomas J. Watson Research Center (Yorktown Heights, NY) presented a new technology for manufacturing carbon-nanotube FETs (CNFETs) with metal single-wall nanotube contacts. Carbon (C) nanotubes are essentially metallic or semiconducting wires with extremely small diameters **(see figure)** that provide conductive regions for nanoelectric circuitry. The researchers note that C nanotubes may make it possible to form transistors that are as much as 10 times smaller than existing Si transistors.

Minoru Ida and fellow researchers from the NTT Photonics Laboratory of NTT Corp. (Kanagawa, Japan) announced results on the world's fastest bipolar transistor, featuring a cutoff frequency of 341 GHz and high current density of more than 800 kA/cm^2. The indium-phosphate/indium-gallium-arsenide (InP/InGaAs) double-heterojunction bipolar transistor (HBT) features a 150-nm-thick collector region for high current density at a practical breakdown voltage. The collector charging time is estimated to be as low as 0.13 ps, while the carrier-transit delay time is only 0.26 ps.

Researchers at HRL Laboratories (Malibu, CA) detailed a family of transistors that strike a balance between the needs for high speed and low power in dense logic circuits for 40-Gb/s OC-768 optical-communications systems. The InP-based HBTs are used in static dividers for applications at 20 and 60 GHz. The dividers employ identical In-aluminum-arsenic (InAlAs)/InGaAs HBTs with a cutoff frequency of 180 GHz, but use different current bias for the different operating frequencies. The high-speed 64-GHz toggle rate compares in speed with the 67 GHz reported for a laboratory Si-germanium (SiGe) device, but with one-fifth the power per flip-flop reported for the smaller SiGe device.

T. Matsumoto and co-workers from Mitsubishi Electric Corp. (Hyogo,

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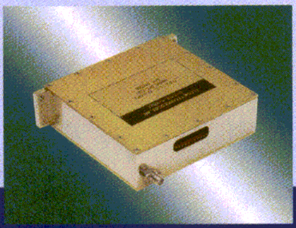

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DC Power consumption below 4 watts is maintained by utilizing low power components resulting in low junction temperatures and overall high reliability.

SPECIFICATIONS

- **Frequency Range: 0.5-23 GHz**
- **Tuning Bandwidths up to 1000 MHz**
- **Switching Speed: <25 ms**
- **Phase noise meets 16, 32, 128 & 256 QAM requirements**
- **Output Power Range: 12-18 dBm**
- **Load VSWR 1.5:1**
- **Step Sizes: 0.125-10.0 MHz**

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This line of compact frequency synthesizers employs a single module design implemented with CMOS, ASIC, advanced RF MMIC and a dedicated microcomputer. A Ku-band synthesizer with 1 KHz step, 2.2 GHz bandwidth and integrated L-band LFLO consumes only 8 watts–a 65% savings compared to competing units.

Very low phase noise makes the MFS Series ideal for applications in Satcom converters (L, X, C, Ku and Ka Bands), Instrumentation and Wireless Communications.

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- **Frequency Bandwidth: 1-2.25 GHz**
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- **Step Size: 1 KHz or 125 KHz**
- **Switching Speed: 50 ms**
- **Power Output: 12-16 dBm**
- **Load VSWR: 2.0:1**
- **In-Band Spurious: -70 dBc**
- **Out-of-Band Spurious: -82 dBc**
- **Fixed L-Band Output:**
  Freq. Range: 0.5-3.0 GHz
  Pwr. Out.: 12 dBm ±2 dBm
  Spurious: -95 dBc
- **Low Profile: 0.73" high**
- **Meets IESS, Eutelsat and MIL-STD-188/146**

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The PDRO series of oscillators employ a unique technique to phase-lock DROs to a crystal reference of 5 to 100 MHz. Several models in the series require only a single loop for reliable phase-lock performance. By utilizing just one loop, size and power consumption are minimized and multiple frequencies can be realized from the same reference. The low profile and small size (2.5" x 3.5" x 0.65") features ultra low phase noise and low DC power consumption with a ruggedized design and wide operating temperature range.

SPECIFICATIONS

- **Frequency Range: 0.5-18 GHz**
- **Fractional Reference Multiplicator**
- **-100 dBc Spurious**
- **Meets MIL-STD-188 & IESS 308**
- **Integrated Reference Optional (Same Package)**

MINIATURE PHASE LOCKED OSCILLATORS

The miniature MPDRO sources employ a unique technology to phase-lock DRO to a crystal reference of 5 to 100 MHz. The technique requires only a single loop for reliable phase-lock performance. By using just one loop, size, power consumption and cost are minimized.

SPECIFICATIONS FOR THE MPDRO SERIES

- **0.5 to 26 GHz Operation**
- **Single Loop, locks to 5 to 100 MHz Reference**
- **Ultra Low Phase Noise**
- **Integrated Buffer Amplifier**
- **-100 dBc Spurious**
- **Ruggedized**
- **Low DC Power Consumption**
- **Small 2.25" x 1.4" x 0.8" Size**
- **Meets MIL-STD-188 and IESS 308**

Both the PDRO and MPDRO series of Phase Locked Oscillators are ideal for applications in Satcom Converters, Digital Radios and Instrumentation. In addition, the MPDRO series has applications as a fiber optic clock generator.

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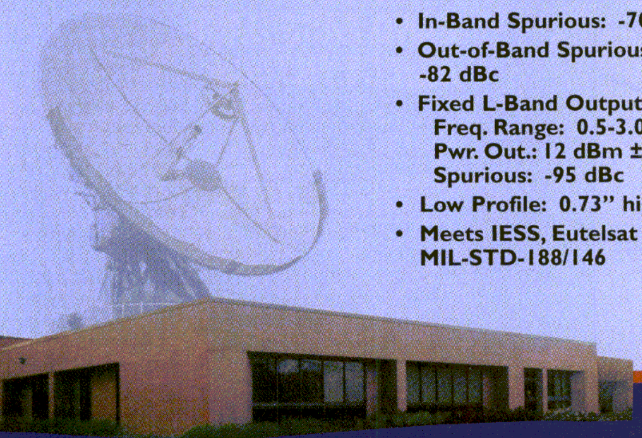

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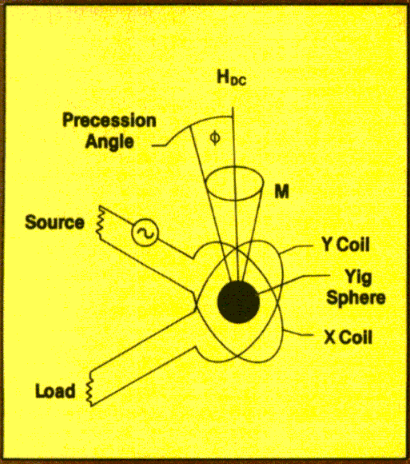

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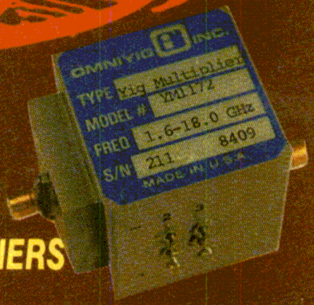

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YM 1001	1-2 GHz	2-13	6 dBm
YM 1002	100 MHz	1-12	−33 dBm
YM 1003	200 MHz	1-12	−28 dBm
YM 1004	500 MHz	1-12	−10 dBm
YM 1026	1-2 GHz	2-18	4 dBm
YM 1027	100 MHz	1-18	−40 dBm
YM 1028	200 MHz	1-18	−34 dBm
YM 1029	500 MHz	1-18	−22 dBm
YM 1087	1-.2 GHz	1-12	−30 dBm

*RF input power on all models 0.6 to 1.0 watts.

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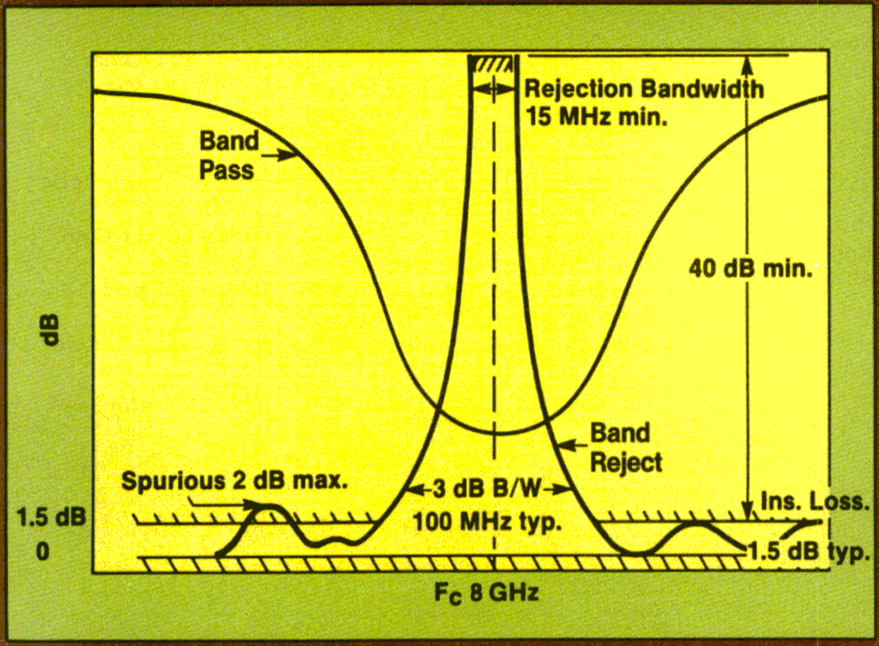

DUAL 10-STAGE BAND PASS/BAND REJECT FILTERS

Model No.	M138	M139
Frequency Range	2-8 GHz Band Pass	8-18 GHz Band Pass
Insertion Loss	4.5 dB	4.5 dB
3 dB Bandwidth	25-50 MHz	25-50 MHz
No. Stages	4	4
Off Resonance Isolation	70 dB	70 dB
	Band Reject	Band Reject
30 dB Rejection Bandwidth	15 MHz Min.	75 MHz
3 dB Bandwidth	125 MHz Max.	150 MHz
VSWR	2:1	2.5:1
No. Stages	6	6
Model #	M138	M139

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Technical Data:

Omniyig Model No.	Frequency Range (GHz)	Filter IL (dB)	Oscillator RF Power (dBm)	Frequency Tracking Between Os./Filter (MHz)	Filter 3 dB BW (MHz)
M129YTO	0.5-2.0	5.5	+17	±5	15-30
M120YTO	2-8	5.0	+17	±7	23-40
M121YTO	8-18	5.0	+17	±8	25-45

Additional RF Performance Specifications:

a) Oscillator frequency range is typically 160 MHz above the filter bandwidth. The oscillator frequency can also be factory adjusted to any other frequency requirements.
b) Pulling Figure (1.25:1 VSWR) is less than 3 MHz.
c) The Second Harmonic is typically 17 dBc and 14 dBc minimum below fundamental frequency.
For final specification data sheet, call Omniyig's Sales Department at:

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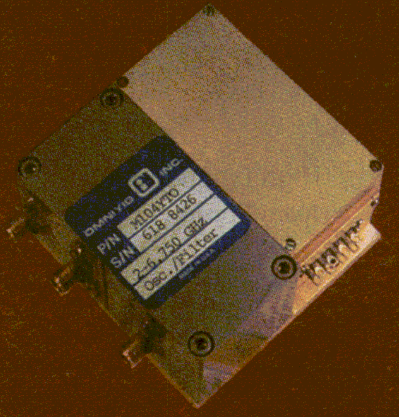

STANDARD COMB GENERATORS

Omniyig Model No.	Input Freq. (MHz)	Output Freq. Range (GHz)	Output Power (dBm)
OHG 10118	100	0.1 to 18.0	−40
OHG 20218	200	0.2 to 18.0	−35
OHG 51026	500	0.5 to 18.0	−28
OHG 61026	1000	1.0 to 18.0	−18

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YIG FILTERS

Omniyig Model No.	Frequency Range (GHz)	Ins. Loss (dB)	Bandwidth at 3 dB (MHz)
2-STAGE			
P102	0.5-1.0	4	17-30
L102	1.0-2.0	3	24-35
S102	2.0-4.0	2.5	25-40
C102	4.0-8.0	2.5	25-40
X102	8.0-12.4	2.5	25-40
Ku102	12.4-18.0	2.5	30-45
3-STAGE			
P103	0.5-1.0	5	14-25
L103	1.0-2.0	3.5	20-35
S103	2.0-4.0	3	20-35
C103	4.0-8.0	3	25-40
X103	8.0-12.4	3	25-40
Ku103	12.4-18.0	3.5	30-45
4-STAGE			
P104	0.5-1.0	6	12-23
L104	1.0-2.0	4.5	20-35
S104	2.0-4.0	4	20-35
C104	4.0-8.0	4	25-40
X104	8.0-12.4	4	25-40
Ku104	12.4-18.0	4	28-45
DUAL 2-STAGE			
P1022	0.5-1.0	3.5	17-30
L1022	1.0-2.0	3	24-35
S1022	2.0-4.0	2.5	25-40
C1022	4.0-8.0	2.5	25-40
X1022	8.0-12.4	2.5	25-40
Ku1022	12.4-18.0	2.5	30-45

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YIG BAND REJECT FILTERS

6-Stages & 8-Stages

Omniyig Model No.	Freq. Range GHz	40 dB (min.) MHz	Loss (max.) dB
P106RX	0.5-1.0	10	1.5
L106RX	1.0-2.0	10	1.5
S106RX	2.0-4.0	15	1.5
C106RX	4.0-8.0	20	1.5
X106RX	8.0-12.0	20	1.5
KU106RX	12.0-18.0	20	1.8
M102RX	4.0-12.0	8	1.5
M103RX	4.0-12.0	10	1.5
M104RX	4.0-18.0	8	2.0
M105RX	2.0-8.0	10	1.5
M107RX	8.0-18.0	20	1.5

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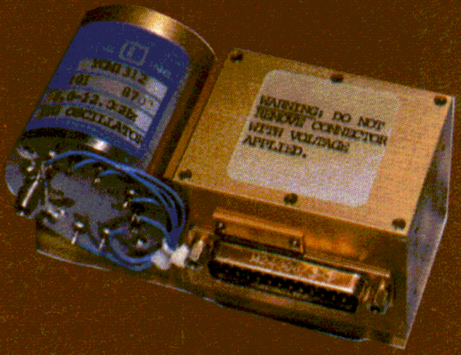
YIG OSCILLATOR ULTRA LOW NOISE BIPOLARS & GAS FETS



Omniyig Model No.	Frequency Range MHz	*Note RF Power Output dBm
YOM1517	0.5-2.0	10
YOM1518	1-4	10
YOM1317	9-8	13
YOM1515	4.0-18.0	10
YOM1587	4.0-18.0	15
YOM1679	2.0-12.0	13
YOM1516	6.0-18.0	10
YOM818-30B	8.0-18.0	15

*Notes: 1) Available at higher RF power output levels +13, +15 and +17 dBm Minimum.
2) We have an additional 200 designs for various frequency ranges and RF power outputs.

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Contact Omniyig's sales department for comprehensive specifications, price and delivery information.

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Santa Clara, California 95054-3125
(408) 988-0843 TWX 910/338-7356
FAX: (408) 727-1373

OMNIYIG INC

Japan) focused on improving the maximum frequency of oscillation of CMOS devices when they are scaled down for higher transition frequencies. The researchers, using a Si-on-insulator (SOI) CMOS technology, were able to achieve a maximum frequency of oscillation of 135 GHz and 10.98 maximum saturated gain at 40 GHz.

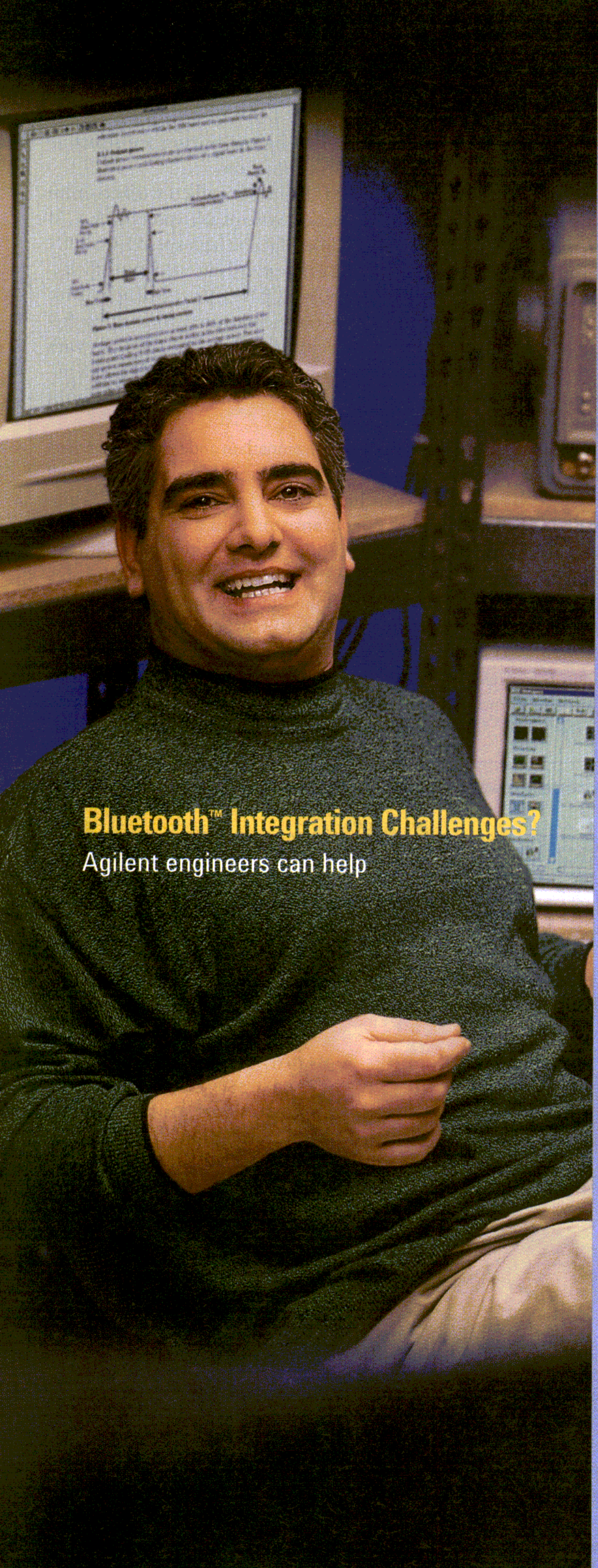
An even higher maximum frequency of oscillation for CMOS devices was achieved by L.F. Tiemeijer and associates from the Philips Research Laboratories (Eindhoven, The Netherlands) as they reported a frequency of 150 GHz for a 0.18-µm gate-length device. The researchers employed careful layout optimization which targeted the reduction of effective gate resistance. Side benefits included a minimum noise figure below 1 dB for frequencies to 8 GHz and a maximum cutoff frequency of 70 GHz.

In response to the CMOS researchers, a session on high-speed SiGe bipolar technology featured several performance advances that targeted optical- and wireless-communications systems. In an invited presentation, Y.K. Chen and associates from Lucent Technologies' Bell Laboratories (Murray Hill, NJ) used a 40-Gb/s optoelectronics transceiver as an example to illustrate the advantages and disadvantages of various compound semiconductor IC technologies. They also made projections on which technologies would be suitable for 100-Gb/s optical-communications systems.

Katsuya Oda and associates from the Central Research Laboratory of Hitachi Ltd. (Tokyo, Japan) reported on self-aligned selective-epitaxial-growth SiGeC HBTs with maximum frequency of oscillation of greater than 170 GHz, with a corresponding cutoff frequency of 124 GHz. Good uniformity and excellent crystallinity of the SiGeC layer were achieved by optimizing the selective growth conditions.

M. Racanelli and co-workers from Conexant Systems (Newport Beach, CA) disclosed data on high-speed SiGe NPN devices integrated into a 0.8-µm bipolar-CMOS (BiCMOS) process. The scalable NPN transistors feature a maximum frequency of oscillation of 148 GHz with a cutoff frequency of 163 GHz at a relatively low current density consisting of 6 mA/µm.[2]

B. Jagannathan and fellow researchers from IBM Microelectronics (Hopewell Junction, NY) reported on a SiGe bipolar transistor with a cutoff frequency exceeding 200 GHz and maximum frequency of oscillation of 150 GHz for optical-communications systems operating beyond 40 Gb/s. The device is implemented in a 0.18-µm technology without the use of SOI technology or high-resistivity substrates. The devices exhibit 200-GHz operation at a collector cur-



Bluetooth™ Integration Challenges?

Agilent engineers can help

It probably started with a conversation over in marketing: "*Bluetooth* wireless technology is the next big thing! We have to put it in all our products! Details? Bah, all you do is add an antenna. The engineers will figure it out. Let's go see if they're finished yet."

And now you and a few thousand other engineers are figuring out that *Bluetooth* integration is not a trivial task. From baseband DSP to RF interference, you've got an integration challenge worthy of legendary King Harald himself.

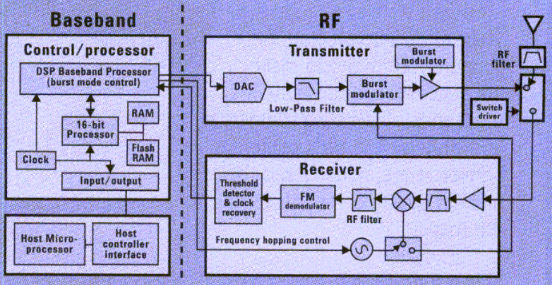
Welcome to the wild world of RF. New to RF? We've pooled the talents of our digital, DSP and RF experts to identify the most important signal checks you'll need to make when integrating *Bluetooth* designs. Our online resources include everything from an RF basics seminar to advanced measurement techniques.

Something for the RF experts, too. If you have the luxury of approaching *Bluetooth* from an RF background, we can offer advice on the most-efficient test procedures and toolsets to tackle a wide range of *Bluetooth* measurements.

The *Bluetooth* big picture. Most of the *Bluetooth* work we're seeing today involves the integration of a *Bluetooth* module into a new product design:

- Evaluating module performance and characterizing interoperability
- Understanding host-module integration issues
- Designing and debugging the host-module interface
- Conducting pre-qualification RF testing
- Getting *Bluetooth* Qualification
- Manufacturing quality products

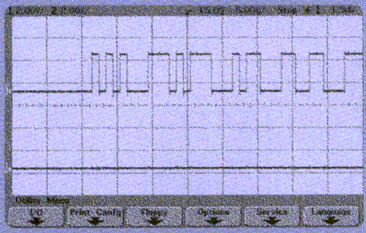
Some of the more interesting problems show up in the second stage, as you bring the RF transceiver into your host products.



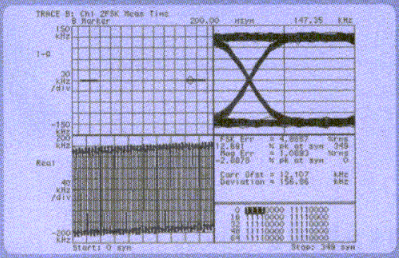
Watch out for some interesting interoperability problems when you integrate a Bluetooth module into your host device

Baseband signal integration. Challenges here include verifying transmission and receipt of data packets, viewing the actual data values transmitted, quantifying system bottlenecks, identifying logic errors, and resolving DSP and mixed-signal issues.

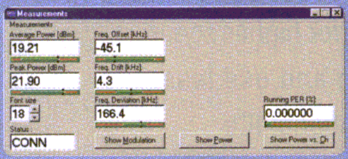
For instance, once you've found the preamble, you can identify the entire bit stream, including the access code, header and payload. Learn more in our free *Bluetooth* baseband application note.



The first two pulses in this idealized transmit signal correspond to the 0101 pattern of the preamble; the access code follows immediately after



Bluetooth measurement tools range from powerful design analysis to fast, automated tests for the production line. Above, a modulation characteristics test verifies proper performance of the modulation circuitry to ensure reliable data transfer over the Bluetooth communication link.



At left, an automated test combines pass/fail indications with numerical readouts

RF receiver tests. RF receiver performance is key to both *Bluetooth* qualification and overall product performance. For example, a sensitive radio that is immune to interference will reduce file transfer times and therefore increase battery life. You need to make sure the RF receiver will not be adversely impacted by the harmonics of high-frequency digital signals or other noise sources likely to be present in your system.

Receiver performance is tested in a number of ways for qualification, including carrier/interference and blocking tests. You probably won't need to run all the tests if you're integrating someone else's module, but they can be complicated so clear information and simplified procedures are important.

RF transmitter tests. The *Bluetooth* specification covers a wide range of transmitter tests, some to insure interoperability between *Bluetooth* devices (e.g., modulation characteristics) and others to meet regulatory limits (e.g., spurious emissions). Given the concerns about interference with other wireless systems, output spectrum tests are also important.

Integrating a module can create problems that affect transmitter performance, sometimes in unexpected ways. For example, power supply ripple coupled through your system can degrade the modulation characteristics.

You must be able to show that your device stays within both *Bluetooth* and regulatory limits, and the more of this work you can do on your design bench, the better. Some of the tests are complex and potentially time-consuming to understand and perform. Our free online application resources can help you look for and fix problems quickly.

Get the complete *Bluetooth* test story—FREE. Talk to one of our *Bluetooth* measurement specialists to learn more or tap into our free technical resources at www.agilent.com/find/bt.

Among the features you'll find there:

- A comprehensive measurement guide: *Performing Bluetooth RF Measurements Today* featuring descriptions and examples of the many RF measurements you might need
- Interactive measurements that show some key *Bluetooth* measurements in action, starting with frequency drift and frequency settling—explore these real-life measurements before you need to make them on your own system

We can't do much about your enthusiastic friends in marketing, but we can definitely help you through the *Bluetooth* integration experience.

Visit www.agilent.com/find/bt for a FREE *Bluetooth* CD-ROM packed with application notes, measurement tips and solution guides.

Agilent Technologies

rent of 1 mA and operation at 78 GHz with only 100-μA collector current.

J. Bock of Infineon Technologies (Munich, Germany) disclosed the company's high-speed SiGeC bipolar technology for achieving gate delays of only 6.5 ps with cutoff frequency of 106 GHz and maximum frequency of oscillation of 145 GHz. The Ge content is linearly graded across the base to achieve an accelerating drift field for the electrons. A double-polysilicon self-aligned emitter-base configuration is used to achieve high stable gains of 29.9, 24.8, and 22.3 dB at 2, 6, and 10 GHz, respectively.

The final presentation in the SiGe session featured a report by B. Heinemann and associates from IHP (Frankfurt, Germany) on how to integrate SiGe HBTs by using reliable BiCMOS technology that does not require a buried epitaxial layer or deep trench isolation. The simple technology yields HBTs with a cutoff frequency of 100 GHz, maximum frequency of oscillation of 130 GHz, and high breakdown voltage of +2.5 VDC. In addition, the devices achieve ring-oscillator delays of only 8.3 ps at 0.61 mA current per stage.

In the area of high-power devices, L. Shen and associates from the University of California at Santa Barbara (Santa Barbara, CA) detailed work on a Ga-nitride (GaN)-based high-electron-mobility transistor (HEMT) that is suitable for high-power applications. A 0.7-μm gate-length device yielded current-gain and power-gain cutoff frequencies of 28 and 56 GHz, respectively. When tuned for maximum power in Class AB mode at +45 VDC, the device featured output-power density of 8.4 W/mm at 8 GHz, with associated power gain of 7.5 dB and power-added efficiency (PAE) of 28 percent.

Y. Ando and associates from the Photonic and Wireless Devices Research Laboratories of NEC Corp. (Tsukuba, Japan) reported on an AlGaN/GaN heterojunction FET on a thinned sapphire substrate. A 16-mm-wide device achieved 22.6-W CW power with 9.4-dB linear gain and 41.9 PAE at L-band and +26 VDC. A 32-mm-wide device achieved 113-W pulsed output power and 6.8-dB linear gain at L-band and +40 VDC.

Finally, a session on microelectromechanical systems (MEMS) included a report by H.A.C. Tilmans and associates from IMEC (Leuven, Belgium) on wafer-level-packaged RF MEMS switched fabricated in a CMOS fabrication facility. Since standard wafer sawing will destroy a MEMS device, packaging must be carried out on the wafer during wafer processing. The researchers detailed their wafer-level packaging process which relies on wafer or chip-stacking techniques using benzocyclobutene (BCB) as the bonding and sealing material.

For more information on the 2001 IEDM, contact **Phyllis Mahoney, Conference Manager, 16220 South Frederick Rd., Suite 312, Gaithersburg, MD 20877; (301) 527-0900 ext. 103, FAX: (301) 527-0994, e-mail: phyllism@widerkehr.com, Internet: www.ieee.org/conference/iedm.** MRF

Analyzer offers real-time remote monitoring

THE P9116 SATELLITE-COMMUNICATIONS spectrum analyzer can be located at a base station and operated remotely from any PC. The P9116's virtual spectrum-analyzer front panel eliminates the need for third-party software or hardware, as the spectrum display can be viewed and controlled in real time from anywhere with a LAN, modem, or Internet connection. The unit is optimally configured to analyze frequencies ranging from 100 kHz to 1.60 GHz. A complete Pentium PC and Windows NT operating system is built into the spectrum analyzer's industrial chassis. Multiuser simultaneous access, data logging, and multi-input switches are optional. A CD-ROM demo of a fully functional P9116 is available.

Morrow Technologies Corp., 2300 Tall Pines Dr., Largo, FL 33771; (727) 531-4000, FAX: (727) 531-3531, e-mail: sales@morrowcorp.com, Internet: www.morrowcorp.com.

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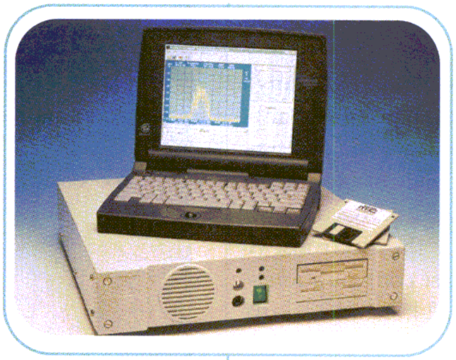

MORROW TECHNOLOGIES CORP.

Generator targets field-testing applications

THE NOVASOURCE X2TM dual RF Signal Source is a programmable RF signal generator that combines the functionality of two individually controllable signal sources in a single package. The unit is suitable for applications where the use of two RF signals is required simultaneously or in tandem. The unit is available in bands from 45 MHz to 2.5 GHz with various step sizes, allowing customers to mix and match two separate frequency ranges to meet their various requirements. Once set to an exact frequency, the nonvolatile memory allows the units to be used repeatedly in the field or lab without reprogramming.

Nova Engineering, Inc., 5 Circle Freeway Dr., Cincinnati, OH 45246; (800) 341-NOVA, (513) 642-3000, FAX: (513) 642-3300, e-mail: info@nova-eng.com, Internet: www.nova-eng.com.

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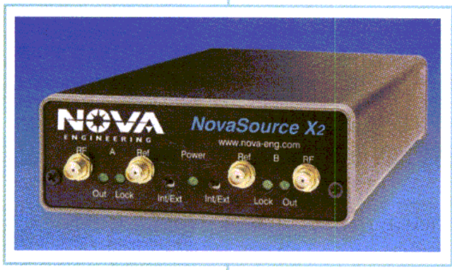

NOVA ENGINEERING, INC.

Amplifiers minimize cable-loss effects

OPERATING FROM THE standard telecommunications −48-VDC supply, a line of transmitting and receiving multicarrier IF line-compensation amplifiers minimizes cable loss and crossband slope in broadband microwave wireless systems without introducing any significant degradation of the multicarrier signal, enabling smaller-diameter cable to be used to connect ground-level enclosures to masthead microwave Txs, Rxs, or transceivers. A bias tee supplies DC power to the masthead unit through an input or output cable. MTBF exceeds 150,000 hours. A gain profile compensates for the transmission characteristics of commonly used cables. Each unit has four switched-gain settings so that the user can quickly adjust the gain to the cable length and type deployed at each individual site. The 1-dB compression point (+36 dBm minimum for the transmitting amplifier and +23 dBm minimum for the receiving amplifier) makes the units suitable for point-to-multipoint LMDS networks.

Pascall Electronics Ltd., Westridge Business Park, Cothey Way, Ryde, Isle of Wight PO33 1QT; 01983 817300, +44 1983 817300, FAX: 01983 564708, +44 1983 564708.

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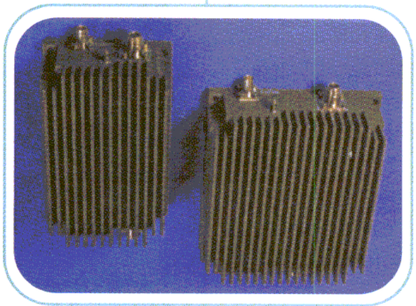

PASCALL ELECTRONICS LTD.

Switch operates from DC to 3 GHz

MODEL MS SMA 033 is a normally open, low-cost, SP3T RF mechanical switch that operates from DC to 3 GHz. The switch offers a guaranteed operation of one million cycles per switch position. Actuating current is +28 VDC at 140 mA maximum and insertion loss is 0.2 dB. Temperature range is from −10 to +60°C. VSWR is 1.2:1 and isolation is 80 dB. P&A: $225.00 (1 to 24 qty.) and $205.00 (25 to 49 qty.).

Narda Microwave, 435 Moreland Rd., Hauppage, NY 11788; (631) 231-1700, FAX: (631) 231-1711, Internet: www.dept26.com.

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NARDA MICROWAVE

3G Wireless Rises In The Orient

HOWEVER TENTATIVELY, THE first 3G wireless communications system based on the WCDMA technology took to the air in Japan on October 1, 2001. The mobile-phone service was launched by NTT DoCoMo, the country's leading mobile telecommunications provider. It is known as Freedom of Multi-Media Access (FOMA) and, at least initially, service will be limited to a 20-mile radius of Tokyo.

NTT DoCOMo is betting that customers will increase their monthly phone spending to latch onto high-speed wireless services such as Internet surfing, videoconferencing, and listening to music. But the company must first clear the hurdle of handset cost, estimated at $560 for the standard version and $800 for a set that doubles as a video camera. The pricey handsets will probably limit the early adopters to professional and corporate users rather than the general public. Nevertheless, NTT plans to open the service in other areas of Japan by December, and to the entire country by Spring 2002.

Although being first in any market has traditionally given a company a head start toward industry leadership, 3G wireless is filled with potholes in uncharted territory. Even now, NTT's current advanced i-mode service, which offers e-mail, Web browsing, and games, generates only 10 percent of the company's sales. The company's own estimates for its 3G system are to have one in 10 subscribers in the next three years. Another problem is that advanced wireless features have not been fast out of the gate. An example is the highly-touted WAP that was introduced in Europe a few years ago and is still seeking widespread acceptance.

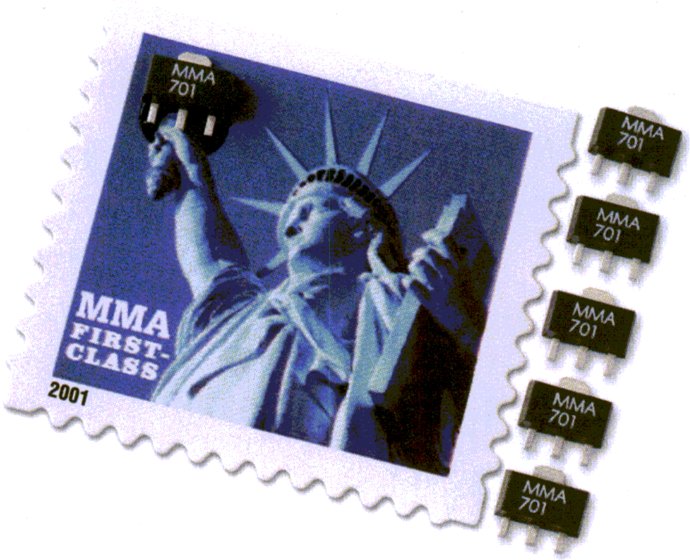
By being first with 3G, NTT hopes to gain substantial shares of the European and American markets. Europe, in particular, has proven to be shaky ground for telecommunications, as many industry observers feel that companies have already spent too heavily on 3G licenses. Some analysts place little worth in the fact that NTT is first on the market. One likened the coming battle among competitors as a long race rather than a sprint, while another believes that 3G may not turn out to be the panacea that many expect. MRF

InGaP HBT AMPLIFIERS

MCE METELICS

You asked for more power...

NEW MMA-700 FAMILY



The **MMA701-SOT89** is a low cost packaged InGaP HBT ideally suited for Cellular, PCS, 2.5/3G, MMDS, WLL and other types of wireless infrastructure applications where flat gain and good linearity are required. This device offers an exceptional combination of performance, efficiency, and versatility to quickly bring a superior solution to market.

The **MMA710-SOT89** is a broadband fully matched packaged InGaP HBT ideally suited for narrow or broadband performance applications. This device offers a flat gain/power response from 1 MHz through 5 GHz, with usable gain to 6 GHz. This device delivers an outstanding combination of broadband P_{-1dB} compression, linearity, and efficiency and is ideally suited as a general purpose gain block or driver.

These devices have been designed and tested to offer the highest standards of reliability and performance you have come to know from Metelics.

MMA 701 PERFORMANCE

- More Power .... +27 dBm
- High Linearity .... +48 dBm
- PAE ... . > 50%
- Available from stock ....

...we delivered.

HBT AMPLIFIERS

Model	Frequency Range (GHz)	Vcc (V)	Icc (mA)	Gain* (dB)	P_{-1dB}** (dBm) Typical	IP3** (dBm) Typical	Thermal Resistance (°C/W)
PACKAGE DEVICES							
MMA701-SOT89	0.001-4.0	7.0	130	12.5	+27	+48	70
MMA710-SOT89	0.001-4.0	7.0	95	12.0	+22	+37	70
AMPLIFIER DIE							
MMA601	0.001-5.0	7.0	130	12.5	+27	+42	70
MMA602	0.001-5.0	7.0	95	12.0	+21	+37	70

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* Matched SSG at 2.0 GHz
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CONTRACTS

TECOM Industries, a TRAK Communications Co.—Was awarded a contract by Spacelabs Medical to provide an antenna solution for the active telemetry portion of LANs within hospital environments.

AR/Kalmus—Has signed a contract with United States Special Operations Command (USSOCOM) for the purchase of 27 of its model M512-125 RF PAs. The amplifiers are valued at $482,000.

Schema, Inc.—Announced a nationwide contract with a major US TDMA carrier to optimize and increase their spectrum capacity. Schema was selected due to the ability of its technology to increase the existing spectrum of wireless networks up to 40 percent, without additional infrastructure costs.

Motorola's Global Telecom Solutions Sector (GTSS)—Has been awarded a $57 million contract from Econet Wireless Nigeria Ltd. to provide a GSM network in the populous northern region of Nigeria. The first phase of network installation is under way and is scheduled for completion by the end of this year.

EMS Technologies, Inc.—Announced that its SATCOM division has won a contract valued at $2.5 million from the Thailand Department of Aviation for ground-based equipment to support search-and-rescue operations over the Cospas-Sarsat satellite system. The US, Russia, Canada, and France jointly operate the Cospas-Sarsat system, which provides distress alert and location data to assist search-and-rescue operations.

Aethercomm, Inc.—Has been selected by the Northrop-Grumman Corp. to design, develop, and manufacture the high-power solid-state LO driver amplifier for an airborne application.

InnoWave ECI Wireless Systems Ltd.—Has won a contract for supplying Botswana Telecom Corp. (BTC) with the MultiGain Wireless (MGW), the company's advanced FWA solution. The implementation of phase one of the $13 million contract commenced in April 2001 and is targeted for completion by April 2002. The MGW installations will cover urban, suburban, and remote regions of the country and will operate over a 3.5-GHz frequency band.

FRESH STARTS

Agere Systems—Announced that NEC Corp. is using Agere's chips for two Internet-enabled cellular phones that NEC plans to introduce to the GSM/GPRS market by the end of the year. The two companies are also working together to develop solutions for 3G cellular phones.

Eaton Corp.—Has been given approval by Underwriters Laboratories, Inc. (UL) for higher ampere ratings for two of the company's lines of Heinemann brand circuit breakers. The Heinemann GJ breaker is now approved to handle up to 280-A applications at +125 VDC. The GJ1P circuit breaker can now handle up to 1200-A applications at +65 VDC and 700-A applications at +160 VDC. While the UL current ratings have increased, the physical packaging stays the same.

ITS Networks, Inc.—Announced that, after a long study, it has decided to refocus its investment and expansion strategy. In particular, it has postponed the acquisition of controlling interests in WestEnd Communications, Inc. and 4Site Internet. It has also decided to concentrate more on developing its market share in Spain.

Intersil Corp.—Announced that Panasonic's latest portable PC incorporates the PRISM® WLAN chip set. The Mobile Data Wireless Display (MDWD) and Toughbook 07 Mini-PC are targeted for use under tough conditions, including wireless computing at construction sites, on factory floors, and for on-patrol police officers.

Decibel Products—Has launched a new and enhanced website. The site, which is located at www.decibelproducts.com, has been updated to provide greater customer convenience, serve as a resource for up-to-the-minute information, and reflect Decibel's position as a manufacturer of wireless antenna systems, site-management equipment and cable, and accessories.

Sprint—Revealed that MiCTA, a national association for non-profit entities, has chosen Sprint ION®, the integrated on-demand network service from Sprint, as the endorsed converged network solution for the organization's approximately 12,000 members. Under the terms of a three-year custom-service agreement, MiCTA members are eligible to purchase and enjoy savings on Sprint ION, as well as the portfolio of value-added voice and data services offered by Sprint. MiCTA's membership includes colleges, universities, K-12 school systems, state and local governments, governmental agencies, municipalities, health-care providers, libraries, and other nonprofit entities.

Andrew Corp.—Has acquired the selected assets of Deltec Telesystems International Ltd. of Wellington, New Zealand. The acquisition brings to Andrew the assets of Deltec's Teletilt™ sales and development division, including its IP and product-development facility in Wellington.

Accelerated Technology, Inc.—Has partnered with Interspeak of Stockholm, Sweden to offer embedded-network security products to Nucleus users that are developing embedded applications to access the Internet. Accelerated Technology's Nucleus RTOS expands Internet security through Integration with Interspeak's network security products.

Hybrid Networks, Inc.—Announced that Thomcast Communications, Inc. will provide Metromedia, Inc., an Austria-based Internet service provider, with Hybrid's base station and Wireless Broadband Routers™ to deliver fixed broadband wireless service to residential and business customers in Vilnius, Lithuania. The system will be the first two-way fixed broadband wireless installation in Lithuania and Hybrid's seventh outside the US. MRF


BERNHARDT

ITT Industries, Avionics Names Bernhardt

CHRISTOPHER C. BERNHARDT has been named vice president and director of programs at ITT Industries, Avionics Division. He previously served in executive management positions with General Electric, Smith Industries, and Allied Signal.

Kivera—MICHAEL FISHER to executive vice president; formerly held the title of COO of GlobeXplorer.

Touch America—BILL LANNAN to vice president of operations; formerly employed as a consultant with Price Waterhouse Coopers.

Rohde & Schwarz—WULF-DIETRICH OERTEL to executive vice president of the International Sales and Service Division; formerly held the title of authorized officer for sales in North America and Latin America.

BAE SYSTEMS' Information & Electronic Warfare Systems (IEWS)—H. MARSHAL WARD to the position of vice president of the Space Systems Operations area; formerly a major general in the US Air Force, serving as director of Special Programs at the Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics at the Pentagon.

EMS Technologies, Inc.—JAMES S. CHILDRESS to company vice president as well as president and general manager of the LXE, Inc. subsidiary; formerly vice president of business development at LXE.

Mericom Corp.—ROY R. MARKERT II to vice president of sales and marketing; formerly national sales director for Sprint Sites USA.

The Montana Power Co.—THOMAS ASHBURN to the board of directors; formerly held the title of vice president and general manager of HP Services at Hewlett-Packard Co.

IPC—ROBERT VITAS to vice president of professional development; formerly employed as regional training manager for Qualex, Inc.

Channel Master, LLC—WILLIAM "BILL" FITZGERALD to director of program management; formerly held the title of vice president of sales at COM DEV International, Wireless Group.

U.S. Cellular—DAVID H. BENSON to director of product development and management; formerly director of business application integration.

AirNet Communications Corp.—GLENN EHLEY to president and CEO; formerly senior vice president.

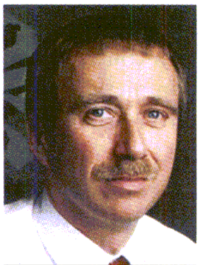
QualMark Corp.—JOSEPH A. RUTH to vice president of sales and marketing; formerly manufacturer's representative covering the Southeastern US.

Atlas Venture—JAY SHIVELEY to principal in the Menlo Park, CA office; formerly senior vice president of worldwide field operations of Vitria Technology.

Battelle—CARL F. KOHRT to president and CEO; formerly executive vice president and chief technology officer at Kodak.

CenturyTel—JOE SPENCER to vice president of emerging applications; formerly product manager for frame-relay services at BellSouth Business Services.


SPENCER


SOULE

Thermshield, LLC—CHRISTOPHER A. SOULE to engineering director; formerly employed at Aavid Thermalloy.

Pascall Electronics—DAVID PHYALL to wireless communications director; formerly managing and operations director at Basys Technology Ltd. MRF

SHORT COURSES

58th ARFTG Microwave Measurements Conference: RF Measurements for a Wireless World
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(303) 497-5490, FAX: (303) 497-3970
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Advanced Wireless and Microwave Techniques
December 3-7 (Mountain View, CA)
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Dept. of Engineering Professional Development
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RF Analog IC Design
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MEETINGS

2001 IEEE International Electron Devices Meeting (IEDM)
December 3-5 (Hilton Washington and Towers, Washington, DC)
IEDM 2001
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101 Lakeforest Blvd., Suite 400B
Gaithersburg, MD 20877
(301) 527-0900 ext. 103
e-mail: phyllism@widerkehr.com
Internet: www.ieee.org/conference/iedm

COTScon West 2001 Conference and Exhibition
December 4-5 (San Diego Concourse and Civic Center, San Diego, CA)
PennWell
98 Spit Brook Rd.
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(603) 891-9267
e-mail: atdregistration@pennwell.com
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Bluetooth Developers Conference
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Challenges For Miniaturizing PCS Antenna Designs

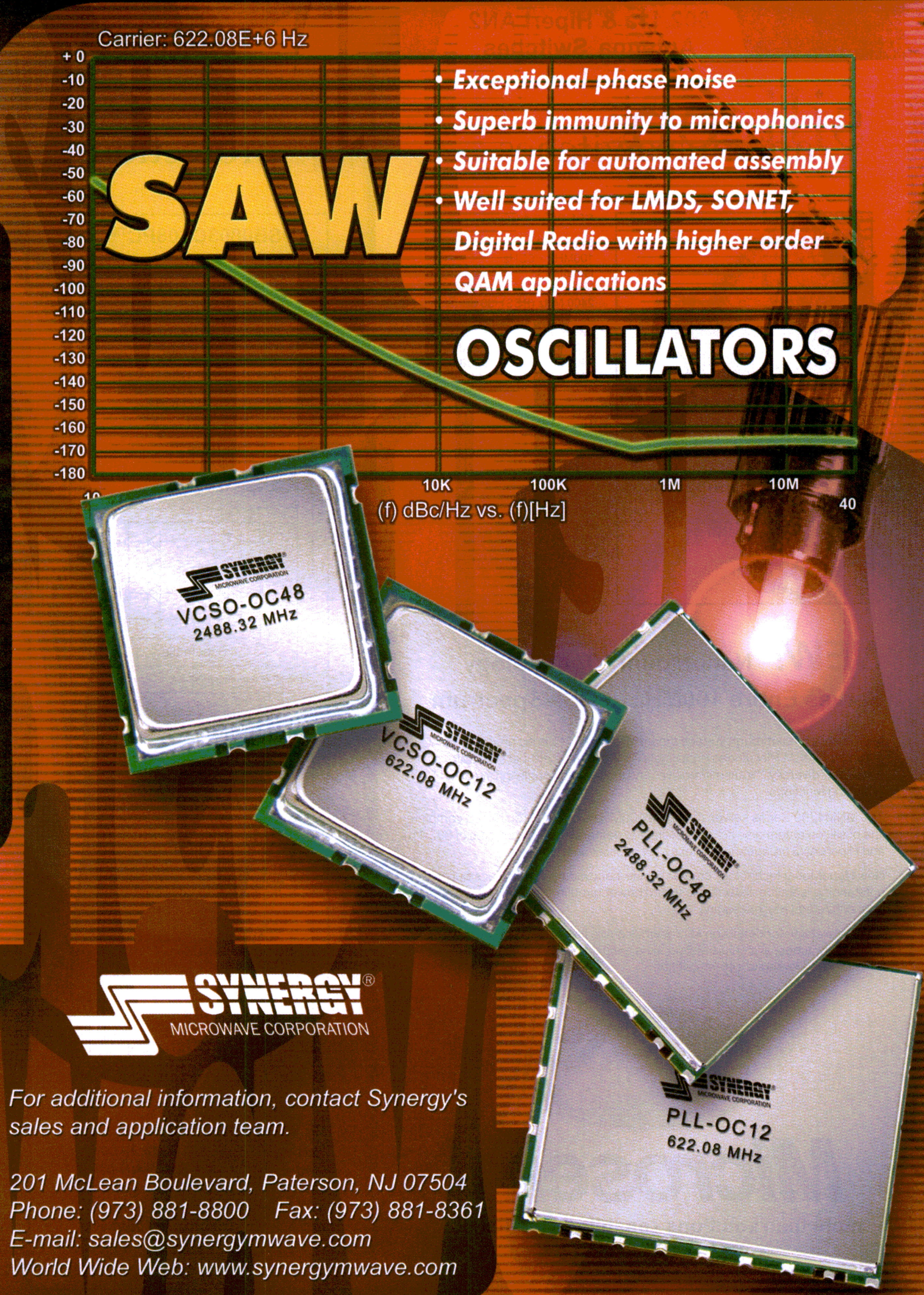
ANTENNAS FOR PCS applications, especially mobile devices, must be virtually invisible. The size of the antenna, unfortunately, is generally dictated by wavelength and the laws of physics, although with some clever design techniques, it is possible to shrink the size of PCS antennas. A.K. Skrivervik, J.F. Zurcher, O. Staub, and J.R. Mosig of the Laboratory of Electromagnetics and Acoustics, Ecole Polytechnique Federale de Lausanne (Lausanne, Switzerland) explore the physical limitations of electrically small antennas and suggest various ways to shave the size of these antennas. The chief methods for miniaturizing antennas (commonly used in mobile communications systems) include loading the antenna with lumped elements, high-dielectric-constant materials, or conductors; using ground planes and short circuits; optimizing the geometry of the antenna; and using the antenna environment (such as its enclosure) to reinforce the antenna's radiation patterns. A more recent approach is to combine two antennas into one, offering multiple-frequency-band coverage and versatility of polarization. The authors review several unique designs for miniature antennas, including a patented smart integrated-L antenna (SMILA) fabricated on temperature-stable TMM-10I substrate material from Rogers Corp. (Chandler, AZ). The antenna, which was designed for use with GPS Rxs, has a diameter of only 35 mm and a thickness of 1.27 mm. Circular polarization results from two small notches in the structure, which allow two orthogonal modes to be excited at two slightly different frequencies. Other designs for miniaturization include a dual-frequency planar inverted-F antenna (PIFA) and a dual-frequency SMILA. For more information on the antennas and the methods used by the authors to measure the performance of these designs, see "PCS Antenna Design: The Challenge of Miniaturization," *IEEE Antennas & Propagation Magazine,* August 2001, Vol. 43, No. 4, pp. 12-25.

Use DSP For Phase-Noise Measurements

PHASE-NOISE MEASUREMENTS on high-frequency signals have long been one of the great challenges for metrology laboratories and developers of test equipment. Several (generally expensive) commercial test solutions are available which deliver relatively good accuracy with varying degrees of operator difficulty. But there is hope for engineers who are involved with phase-noise measurements, since several researchers from Italy have developed a method of applying DSP to the measurement of phase noise at a variety of offset frequencies. L. Angrisani of the Dipartimento di Informatica e Sistemistica of the Universita di Napoli Federico II (Napoli, Italy) along with M. D'Apuzzo and M. D'Arco of the Dipartimento di Ing. Elettrica of the Universita di Napoli Federico II have developed an approach that offers an alternative to analog measurement systems as well as time-interval analyzers. By properly oversampling the input signals, and applying an optimized quadrature demodulation scheme, the method enables the analysis of noise on sinusoidal carriers at offsets from a fraction of a Hertz to hundreds of megaHertz. The goals of the researchers' development program included the creation of an approach that would deliver a noise floor lower than that possible with dedicated measurement systems and a quantization noise power lower than that possible with high-performance time-interval analyzers. To learn more about the measurement technique, see "A Digital Signal-Processing Approach for Phase Noise Measurement," *IEEE Transactions On Instrumentation And Measurement,* August 2001, Vol. 50, No. 4, pp. 930-935.

Tackling Digital Data Rates At Microwave Bus Speeds

INCREASING DATA RATES are blurring the line between traditional digital and microwave design. Where transmission-line lengths and parasitic circuit elements were once of little concern in digital designs, they now impact the performance of high-speed digital systems. But developers Haw-Jyh Liaw, Gong-Jong Yeh, Pak Shing Chau, and Greg Pitner of Rambus, Inc. (Los Altos, CA), writing in the technical journal *Insight* from Agilent Technologies (Santa Rosa, CA), provide some insights into designing PCBs and circuits for high-speed data buses. They report on simulations of the transfer function of an eight-device bus operating at 1.6 Gb/pin and what types of measurements and analysis can be performed to minimize PCB skin loss, PCB dielectric loss, and device resistive loss. They examined coupling noise from pin to pin of packaged devices. More information is available by visiting the Agilent website at www.agilent.com/find/RandD and viewing "A 1.6 Gbit/pin Multilevel Parallel Interconnection."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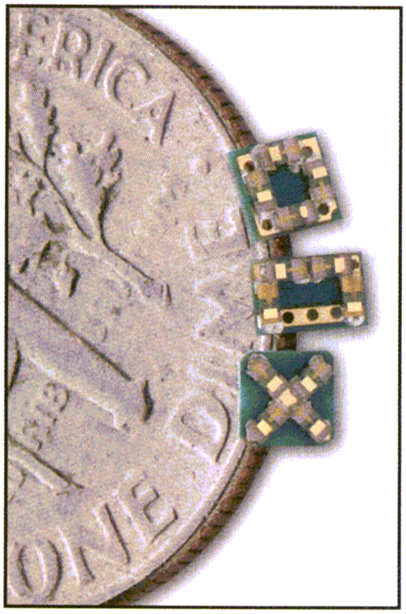

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Bandwidth:
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Isolation:
900 MHz (LMDS): 40 dB(typ.)
2400 MHz (PCS): 30 dB (typ.)
5600 MHz (WLAN): 20 dB (typ.)
Insertion loss:
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2400 MHz (PCS): 0.5 dB (typ.)
5600 MHz (WLAN): 1.0 dB (typ.)
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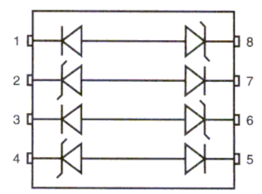

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APPLICATIONS

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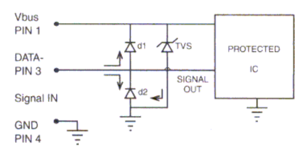

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DESIGN

Noncoherent Detection Improves FQPSK System Performance

Eight noncoherent detection techniques are examined to determine which offers the best BER performance for FQPSK signals.

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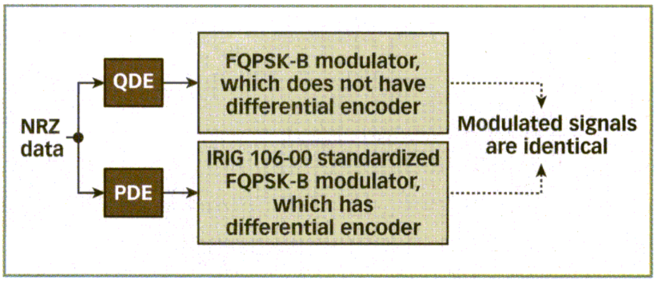
Multiyear studies by the US Department of Defense (DoD), NASA, American Institute of Aeronautics and Astronautics (AIAA), and the International Committee Consultative on Space Data Systems (CCSDS) have confirmed that Feher quadrature-phase-shift-keying (FQPSK) technologies patented by Kamilo Feher offer the most spectrally efficient and robust (smallest degradation from ideal theory) bit-error-rate (BER) performance of nonlinear-amplifying (NLA)-RF power-efficient systems.[1-7] This has led to their standardization in many applications.

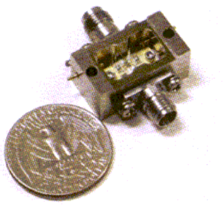
For coherent FQPSK-B detection, a signal-to-noise ratio (SNR), E_b/N_0 = 9.8 dB is required for a BER = 10^{-4} if the simplest symbol-by-symbol detection is used. To obtain the same BER for FQPSK-B with trellis decoding using the Viterbi algorithm, the reduced E_b/N_0 of 9.1 dB is required.[8] These NLA requirements of FQPSK-B are 1.4 and 0.7 dB worse, respectively, than that of the suitable theoretical QPSK operating in a linear-amplified system.[5,8] However, since phase noise is caused by oscillators and frequency synthesizers, and relatively large Doppler spread[2,9] may degrade the performance of relatively low-bit-rate coherent demodulators and increase synchronization time, noncoherent detection is preferred for certain mobile applications.[10] In this article, eight noncoherent detection techniques for FQPSK-B signals are proposed and their BER performance in a Gaussian channel is compared using a simulation study as well as hardware evaluation.

In the FQPSK-B modulator, the amplitude parameter A of the cross correlator is chosen to be $1/\sqrt{2}$ for the modulated signal to have a quasi-constant envelope. And the instantaneous phase of FQPSK-B signals is chosen by the waveform-shaping rule of FQPSK-B modulation.[1,3,4] These characteristics of FQPSK-B signals allow them to be interpreted

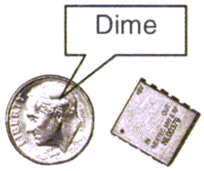


1. A special coding scheme, QDE without a differential encoder, is equivalent to the IRIG standard requiring a differential encoder.

NEW ! Small Enough, Good Enough



Broadband Amplifiers (2-8 GHz | 6-18 GHz | 18-26.5 GHz | 26-40 GHz) have been modified to have a smaller size. Four models (NB00375, NB00376, NB00377 and NB00378) are available now. Each model covers 2-8 GHz, 6-18 GHz, 18-26.5 GHz and 26-40 GHz, respectively. Typical gains of those models are around 20 dB and output powers are about 20 dBm.



New Tiny LNA's (NF: 1.1 dB, 1810-1910 MHz | 1710-1780 MHz) have been developed. Four models (NL00379, NL00380, NL00381 and NL00382) are available now with Noise Figure as low as 1.1 dB. Two of them covers 1850-1910 MHz and the other two models cover 1710-1780 MHz. Typical gain is 25 dB. Output IP3 are 33 - 39 dBm. **Two more models** will come out in October 2001 with higher gain of 36 dB covering 1850-1910 MHz.

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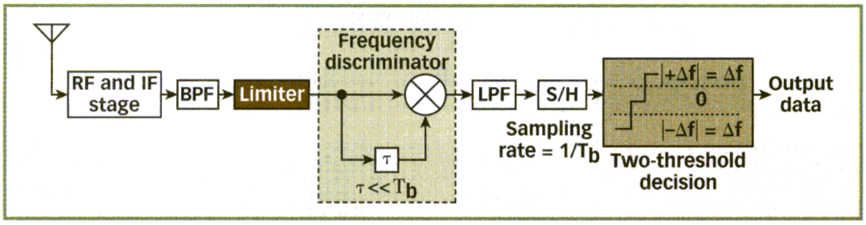
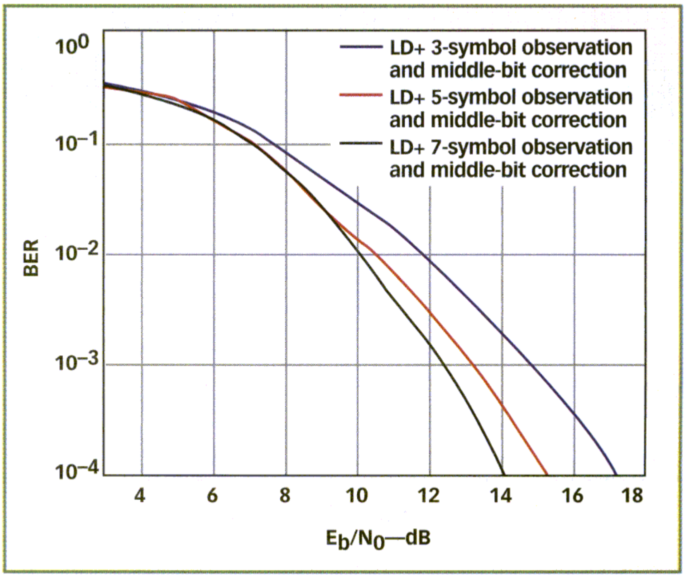
as a continuous phase modulation (CPM).[11-13] The interpretation of the FQPSK signals as a nonquadrature CPM[11-13] enables the detection of a FQPSK-B modulated signal noncoherently by differential decoding of the in-phase (I) and quadrature (Q) channel data separately. Observations 1 and 2 of refs. 11 through 13 permit the use of a limiter-discriminator (LD) detection scheme for noncoherent detection with the instantaneous frequency-deviation characteristic. And observation 3 of the aforementioned references supports the use of the differential detection of the phase change or LD followed by integrate-and-dump (I&D) detection schemes for noncoherent detection with the characteristic phase transition at the T_b interval.



2. This Rx structure based on LD, followed by symbol-by-symbol detection for the QDE FQPSK signal, provides good BER performance.



3. The BER performance of LD followed by multiple-symbol observation and middle-bit decision schemes with various symbol observation intervals is shown in these curves.

Detection Techniques

The FQPSK-B signal can be detected symbol-by-symbol using LD detection (Method 1). Observations 1 and 2 support the detection of the FQPSK-B signal using 3-level frequency discrimination (i.e., +Δf, 0, and −Δ).

In addition, differential decoders in the respective I and Q data channels are required for noncoherent detection techniques for FQPSK-B signals. Differential decoding experiences error propagation. Thus, a special encoding scheme, known as quadrature differential encoding (QDE), is proposed to solve this problem. This is to encode differentially for the I and Q data channels separately:

$$y_{2n} = y_{2(n-1)} \oplus x_{2n}$$
$$y_{2n+1} = y_{2n-1} \oplus x_{2n+1} \qquad (1)$$

where:
x = the nonreturn-to-zero (NRZ) input data,
y = the QDE output, and
both equations = modulo-2 addition. The IRIG 106-00 standardized FQPSK-B also specifies the use of a differential encoder.[7] This is somewhat different from QDE. However, QDE is equivalent to a cascaded precoding differential encoder (PDE) and differential encoder in the IRIG 106-00 standard, as shown in **Fig. 1**. PDE is represented by Eq. 2.

$$y_{n+1} = y_n \oplus \overline{x_n} \qquad (2)$$

where:
$\overline{x}$ = the inversion of NRZ input data,
y = the PDE output, and
the equation = modulo-2 addition.

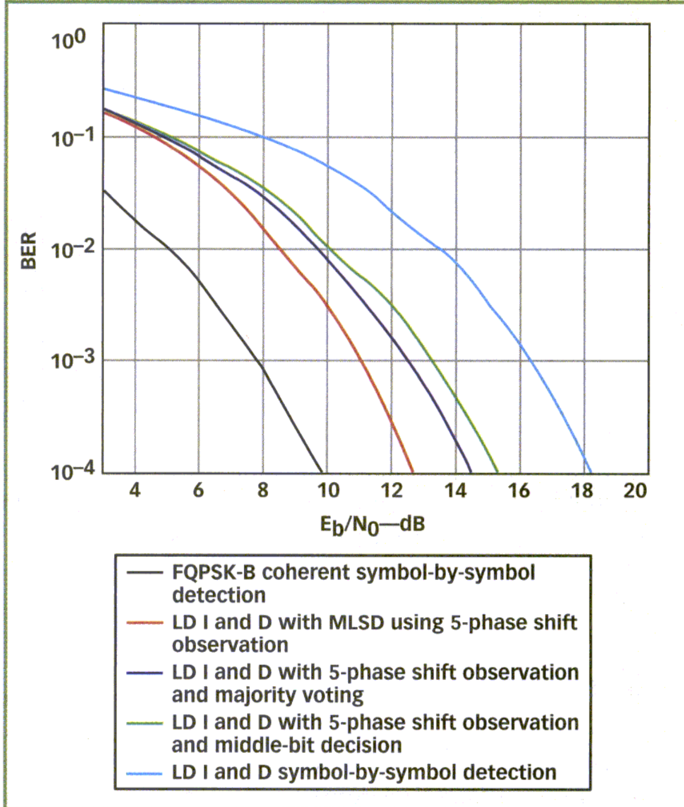
Note that if QDE is employed, then a very simple receiver (Rx) structure can be obtained, as displayed in **Fig. 2**, which also provides better BER performance.

Also, only certain combinations of phase changes of FQPSK-B-modulated signals are permitted (i.e., the FQPSK signal has memory). In this case, it is well-known that the detection based on multiple-symbol observation performs better than symbol-by-symbol detection.[14-15] For multiple-symbol observation based on noncoherent detection, an instantaneous frequency-deviation vector that is composed of "N" instantaneous frequency-deviation components is required. However, it is obtained by a N + 3 data sequence.[1,11] This means that many of the input vectors (N + 3 data sequence) are mapped into the identical vector ("N" instantaneous frequency-deviation components), in m-space. As the symbol observation interval increases, the ratio (m/M), of the number of supported instantaneous frequency-deviation vectors to the total number of random combinations of symbol-by-symbol data (3 level in this case) is reduced significantly. This means that the correction ability for the erroneous LD output value improves greatly.

Three detection techniques with multiple-symbol observation are studied: multiple-symbol observation and middle-bit decision (Method 2), multiple-symbol observation and majority voting (Method 3), and maximum likelihood sequence detection (MLSD)[16] with multiple-symbol observation (Method 4). In Method 2, the detector calculates the distance between the N-tupled vector formed by consecutive LD output symbols and those in m-space, chooses the vector with the smallest distance, and makes a decision on the middle bit. In Method 2, only the middle bit is decided from the best-matched vector which, however, also has some information on other bits. One simple way to consider this is to decide on a bit based on the majority voting among those found from the nearest N vectors. It is Method 3.

Better BER performance than the two methods mentioned before is expected when using the MLSD of multiple-symbol observation data. In the proposed MLSD, the states of trellis consist of permitted instantaneous frequency-deviation vectors in m-space. The branch metric is defined as the distance between the N-tupled vector formed by consecutive LD output signals, and that by the permitted instantaneous frequency-deviation vectors. The survival path is that which has the smallest accumulated branch metric (i.e., state metric). Output data are the middle bits of states, which are permitted instantaneous frequency-deviation vectors in m-space, on the survival path.

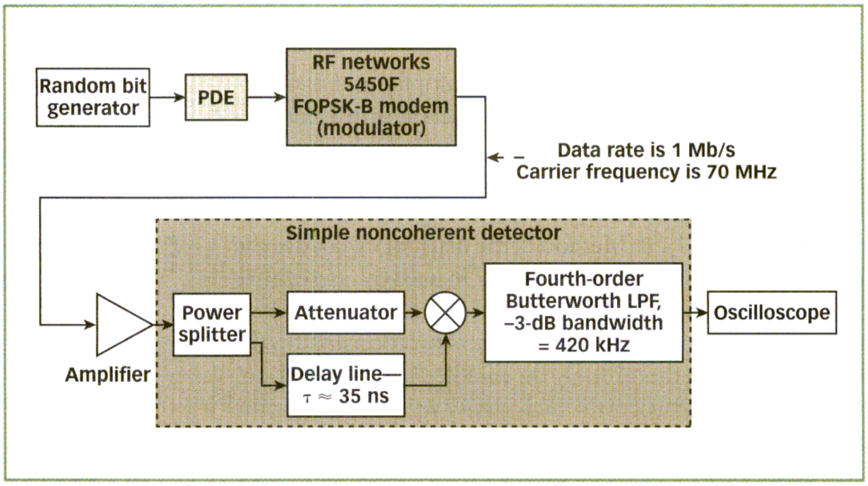
Also, it is well-known that I&D detection can provide better BER performance than simple sampling-based detection.[17] Thus, better BER from I&D of LD output signals is expected, which is only the phase transition. It can be



4. BER performance for various LD I&D noncoherent detection techniques is shown here.

shown that when differentially encoded bit 0 is transmitted, the absolute value of the sum of the two-phase transition values between $t = (n - 1)T_b$ and $t = (n + 1)T_b$ interval is less than or equal to $\pi/4$, and it is larger than $\pi/4$ when 1 is transmitted. Thus, transmitted data can be detected on a symbol-by-symbol basis from the observation of the total phase transition in $2T_b$ periods. It is the LD I&D followed by symbol-by-symbol decision (i.e., Method 5).

Similarly, in LD-based detection techniques, the multiple phase-transition observation method can improve the performance of LD I&D detection. There are also three methods: multiple phase-transition observation and middle-bit decision (Method 6), multiple phase-transition observation and majority voting (Method 7), and MLSD with multiple phase-transition observation (Method 8). The permitted multiple phase-transition vectors and element values differ from that of LD detection.

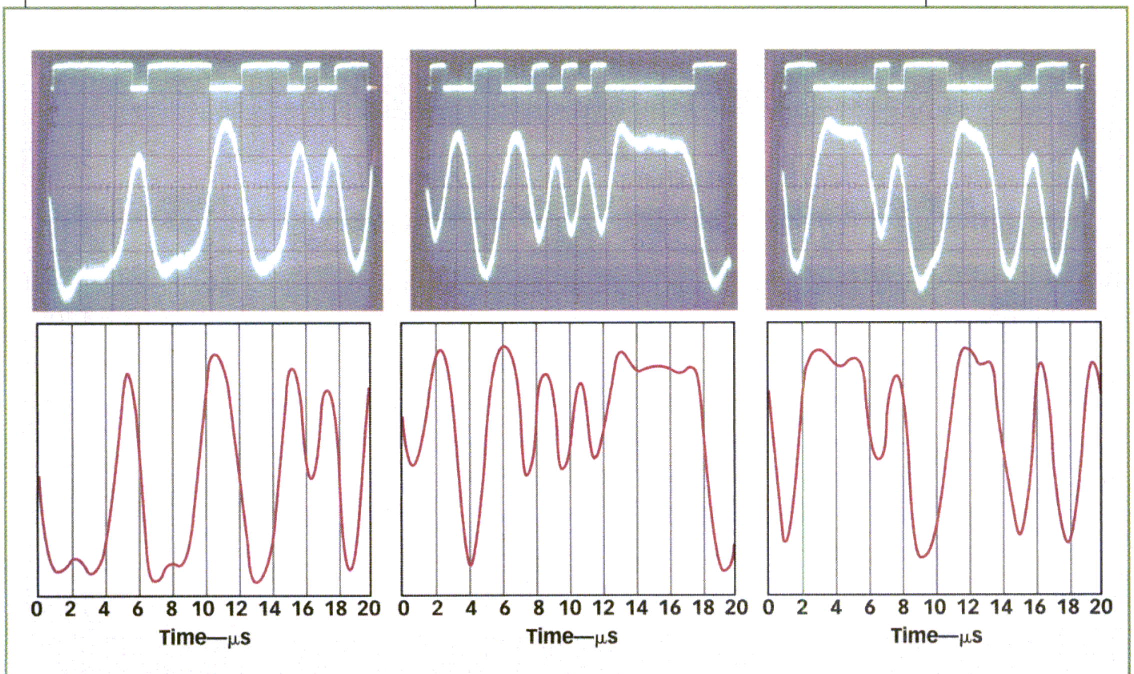


5. This noncoherent detector block circuitry was implemented for detector-output measurements.

Simulation Results

To show the BER performance of the proposed noncoherent detection techniques, MATLAB simulation is performed using a baseband equivalent model.[18] The Rx BPF, which is implemented with equivalent LPF in MATLAB, is the phase-equalized fourth-order Butterworth filter, $BT_b = 0.5$. The LPF of LD output signals is a raised cosine filter with roll-off factor = 0.5 and −6-dB bandwidth = $0.42(1/T_b)$. Hard limiter is assumed to approximate the nonlinear amplifier in the transmitter (Tx). Suitable symbol synchronization is assumed.

The LD followed by symbol-by-symbol decision scheme suffers as large as 9.5-dB degradation at BER = 10^{-4} from the best symbol-by-symbol coherent detection.[5] But this degradation decreases significantly as observation time is increased. Middle-bit decision, majority voting, and MLSD based on 5-symbol observation leads to 5.3-, 4.6-, and 3.8-dB degradation at BER = 10^{-4} compared with best symbol-by-symbol coherent detection of FQPSK-B performance. **Figure 3** shows the BER-performance comparison of different symbol-observation intervals with LD followed by multiple-symbol observation and middle-bit decision schemes. It is shown that the performance is increased as the symbol-observation interval increases. **Figure 4** represents the BER performance of the various detection techniques with LD I&D scheme. The number of observed symbols is chosen at N = 5. The LD I&D, followed by symbol-by-symbol decision scheme, suffers 8.6-dB degradation at BER = 10^{-4} from the best symbol-by-symbol coherent detection of FQPSK-B performance. But this degradation decreases significantly as observation time increases. Middle-bit decision, majority voting, and MLSD based on 5-symbol observation leads to 5.6-, 4.7-, and 2.9-



6. A comparison of actual (upper) and computer generated (lower) waveshapes of the noncoherent-detector output shows a close resemblance to one another.

dB degradation at BER = 10^{-4} compared with best symbol-by-symbol coherent detection of FQPSK-B performance. However, simulation results are not optimized. BER performance results of various detection schemes for FQPSK-B are summarized in **the table**.

To measure the noncoherent detector output of FQPSK-B signal, the simple noncoherent detector is implemented **(Fig. 5)**. In the experimental system, the data rate is 1 Mb/s, the carrier frequency of the transmitted signal is 70 MHz, the delay time for the noncoherent detection is approximately 35 ns—approximately 1/30 of the bit period—and the −3-dB bandwidth of the Butterworth LPF is 420 kHz. The implemented noncoherent detector is an approximate model of the LD detector with small delay time (i.e., $\tau \approx 35$ ns $\approx 1/30(T_b)$. The measured time patterns of detector output are compared with the computer-generated patterns as shown in **Fig.6**, noting that the measured and generated time patterns are similar to each other.

Based on the CPM-based interpretation, eight noncoherent detection techniques for FQPSK-B are proposed. It is shown that the BER performance of the LD and LD I&D-based noncoherent detection techniques improves significantly using the inherent memory in the FQPSK-B-modulated signal phase (i.e., multiple-symbol observation followed by middle-bit decision, majority voting, and MLSD).

Simulation results show that LD followed by MLSD with 5-symbol observation performs BER = 10^{-4} at E_b/N_0 = 13.6 dB. Also, LD I&D, followed by MLSD with 5-phase-transition observation, performs BER = 10^{-4} at E_b/N_0 as low as 12.7 dB. These noncoherent Rxs suffer 3.8- and 2.9-dB degradation at BER = 10^{-4} from the best symbol-by-symbol coherent detection of FQPSK-B performance, respectively. MRF

BER performance comparison of various detection schemes for nonlinearly amplification (NLA) FQPSK-B signals

DETECTION SCHEMES			E_b/N_0 for 10^{-4} BER (dB)
Ideal coherent detection of linearly amplified QPSK			8.4
Coherent detection of FQPSK-B NLA	Viterbi demodulation[8]		9.1
	Symbol-by-symbol detection without differential encoder in Tx[5]		9.8
	Symbol-by-symbol detection with differential encoder in Tx[7]		10.2
Noncoherent detection of FQPSK-B NLA	Limiter-discriminator (LD) Integrate and dump (I&D)	MLSD with 5-symbol observation (Raised cosine post LD LPF)	12.7
		5-symbol observation and majority voting (Raised cosine post LD LPF)	14.5
		5-symbol observation and middle bit correction (Raised cosine post LD LPF)	15.4
		Symbol-by-symbol detection (Raised cosine post LD LPF)	18.4
	Limiter-discriminator (LD)	MLSD with 5-symbol observation (Raised cosine post LD LPF)	13.6
		5-symbol observation and majority voting (Raised cosine post LD LPF)	14.4
		5-symbol observation and middle bit correction (Raised cosine post LD LPF)	15.1
		Symbol-by-symbol detection (Raised cosine post LD LPF)	19.3

ACKNOWLEDGEMENT

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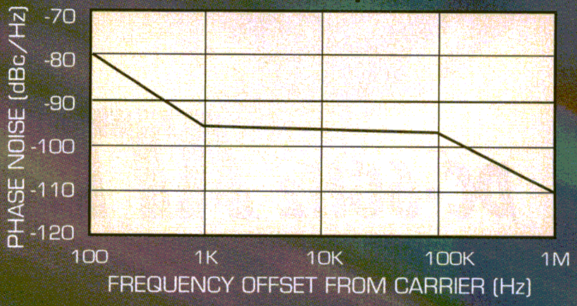

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Phase noise	See graph
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VAT-2	HAT-2	2	2	0.20	0.10	1.20	1.2
VAT-3	HAT-3	3	3	0.15	0.12	1.15	1.1
VAT-4	HAT-4	4	4	0.15	0.08	1.15	1.1
VAT-5	HAT-5	5	5	0.10	0.06	1.15	1.1
VAT-6	HAT-6	6	6	0.10	0.02	1.15	1.1
VAT-7	HAT-7	7	7	0.10	0.05	1.15	1.1
VAT-8	HAT-8	8	8	0.10	0.04	1.20	1.1
VAT-9	HAT-9	9	9	0.10	0.02	1.15	1.1
VAT-10	HAT-10	10	10	0.20	0.03	1.20	1.1
VAT-12	HAT-12	12	12	0.10	0.05	1.20	1.1
VAT-15	HAT-15	15	15	0.30	0.05	1.40	1.1
VAT-20	HAT-20	20	20	0.75	0.18	1.20	1.1
VAT-30	HAT-30	30	30	0.30	0.38	1.15	1.1

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Considering Antenna Options For LMDS

One key to the success of LMDS will be to provide adequate antenna gain at low cost, while also meeting the radiation-mask requirements of applicable standards.

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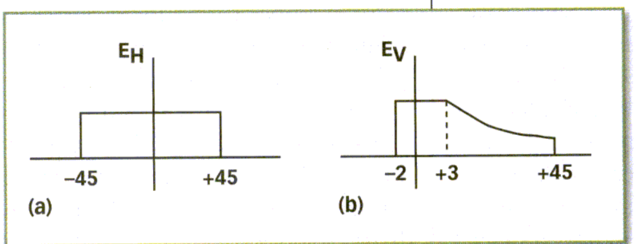
Local multipoint-distribution service (LMDS) represents strong candidates for broadband wireless Internet and other services. To bring LMDS to the masses, however, certain technical hurdles will have to be overcome, including the development of high-gain antennas at millimeter-wave frequencies. This article will focus on some of the design options for these antennas.

As the spectrum at lower frequencies becomes scarce, wireless-systems developers look to higher millimeter bands for wireless connectivity. The potential for LMDS, or local multipoint-communication system (LMCS) as it is known in Canada, appears to be enormous. These systems, which range in frequency from 10 to 66 GHz, could someday provide ample bandwidth for households, businesses, and governments at affordable prices. But before these great market opportunities could be realized, numerous technical challenges must be resolved.

Various domestic and international standards committees are hard at work developing guidelines for these promising technologies.[1-2] Primarily, there are two standard development bodies—one is section 802.16 of the IEEE and the other is ETSI–BRAN—in an effort to develop unified standards for wireless broadband access (WBA).

Why consider LMDS for broadband access? Simply put, it is due to its promise of broadband wireless connectivity at "potentially" much lower deployment cost than wiring (fiber-optic lines or coaxial cables) systems everywhere. But successful deployment of LMDS still requires provision of a supporting infrastructure similar to, although more advanced than, second-generation (2G) and third-generation (3G) cellular systems, with the further distinction of being for fixed, rather than mobile use, requiring data rates of many tens of megabits per second rather than a couple of megabits per second.

It is difficult to predict the level of success of the LMDS market. Its probability of success could be improved by technical innovations leading to lower-cost systems for developers and customers. The



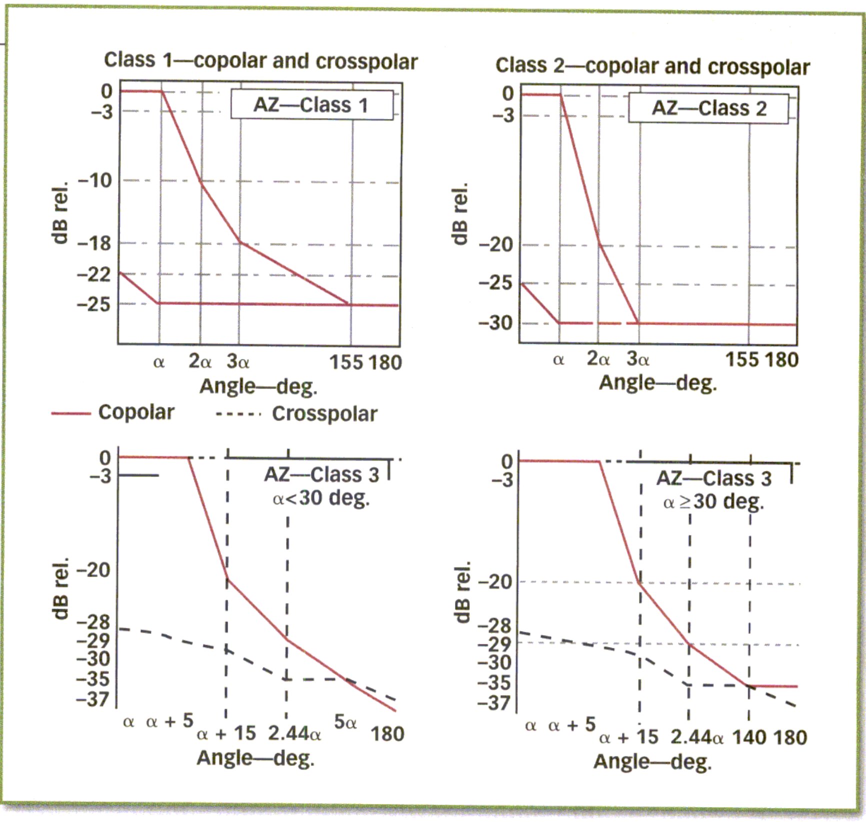
1. Typical distributions of the sector antenna coverage are shown for azimuth (a) and elevation (after ref. 3) [b].

antenna is key to this. The antenna's primary function will impact the customer premises equipment (CPE) and the base-station units. The antenna ultimately will determine the Quality of Service (QoS) and determine the ability of a system to coexist with other systems in adjacent frequency bands. It could be considered one of the most critical parts of the system design.

Successful LMDS CPE units will have highly integrated baseband chips and radio components. In addition to the antennas, the LMDS high-power amplifier and low-noise amplifier (LNA) must also provide high performance with low cost. The high-power amplifier must be very linear to prevent intermodulation (IM) pollution with the high-performance antennas to adhere to the radiation mask as dictated by the applicable standard. At millimeter-wave frequencies, where LMDS will be mass produced, the challenege will be to provide the high levels of antenna performance that are required at low cost.

Perhaps the most dominant architectural method for LMDS is the cellular approach, which requires a network of base stations and hubs serving numerous customers equipped with a CPE. There are also alternative proprietary approaches that are being developed, although antennas remain as critical elements in each approach.

The base-station antenna must provide impeccable performance, since it ultimately determines the QoS. For this reason, LMDS base-station antennas will be more complex, challenging, and higher in cost than those that are used in CPEs, and network owners must be prepared to invest in the proper development and deployment of these base-station antennas. There will probably be several versions of base-station antennas to meet the requirements of various markets and cell architectures. For this reason, antennas can be categorized into several service classes. For example, different types of cell coverage involve omnidirectional, sector, and/or shaped-beam antenna patterns. Often, the antenna must have a shaped elevation pattern to provide optimum coverage for a cell site. **Figure 1a and b** shows a simplified description of a 90-deg. cell site for azimuth and elevation.[3] Although conceptually simple, the implementation of this antenna could be difficult.



2. These are typical azimuth radiation-pattern masks proposed for LMDS antennas, using three classes of sectored base-station antennas (after ref. 4).

Base-station antenna emissions must also comply with the limits of standardized radiation masks. These masks are usually recommended by standardizing bodies and enforced by the regulatory agencies of each government. For LMDS, there are several categories of radiation mask that may be approved, and some proposed masks for azimuth and elevation are shown in **Figs. 2 and 3** for three classes of service, according to the permitted sidelobe level.[4]

Traditionally, masks are expressed in terms of the beamwidth of the main beam, such as one beamwidth. Figure 2, for example, shows three classes of azimuth masks with respect to angle α. For Class 1, the sidelobe level at 2α is -10 dB; at 3α, it is -18 dB; and at 155 deg., it is -25 dB. The requirement for Class 2 (in Fig. 2) is more stringent, as shown by the -20- and -30-dB levels, respectively at 2α and 3α. In Fig. 2, Class 3 is proposed in two separate categories of $\alpha < 30$ deg. and $\alpha > 30$ deg. Note also that the requirement masks apply not only to copolarization, but also place a limitation on the amount of crosspolarization.

Figure 3 shows proposed radiation masks for antenna elevation patterns, below and above the horizon. Class 1 is relatively less restricted, but Classes 2 and 3 are highly restricted on the permitted radiation above and below the horizon.[4]

The standard development process requires that these and similarly proposed masks be studied by committees, commented upon, and voted upon for approval or rejection. Once approved as part of a standard, they will be enforced by the appropriated regulatory agencies.

One requirement for base-station antennas is an omnidirectional design with high gain. This requirement is usually difficult to achieve and requires careful development of array and aperture technologies, with sectoring and combining. However, a clever approach is proposed in reference 3 and is shown in **Fig. 4** in the form of a "mushroom" antenna. The wave off a parabolic dish

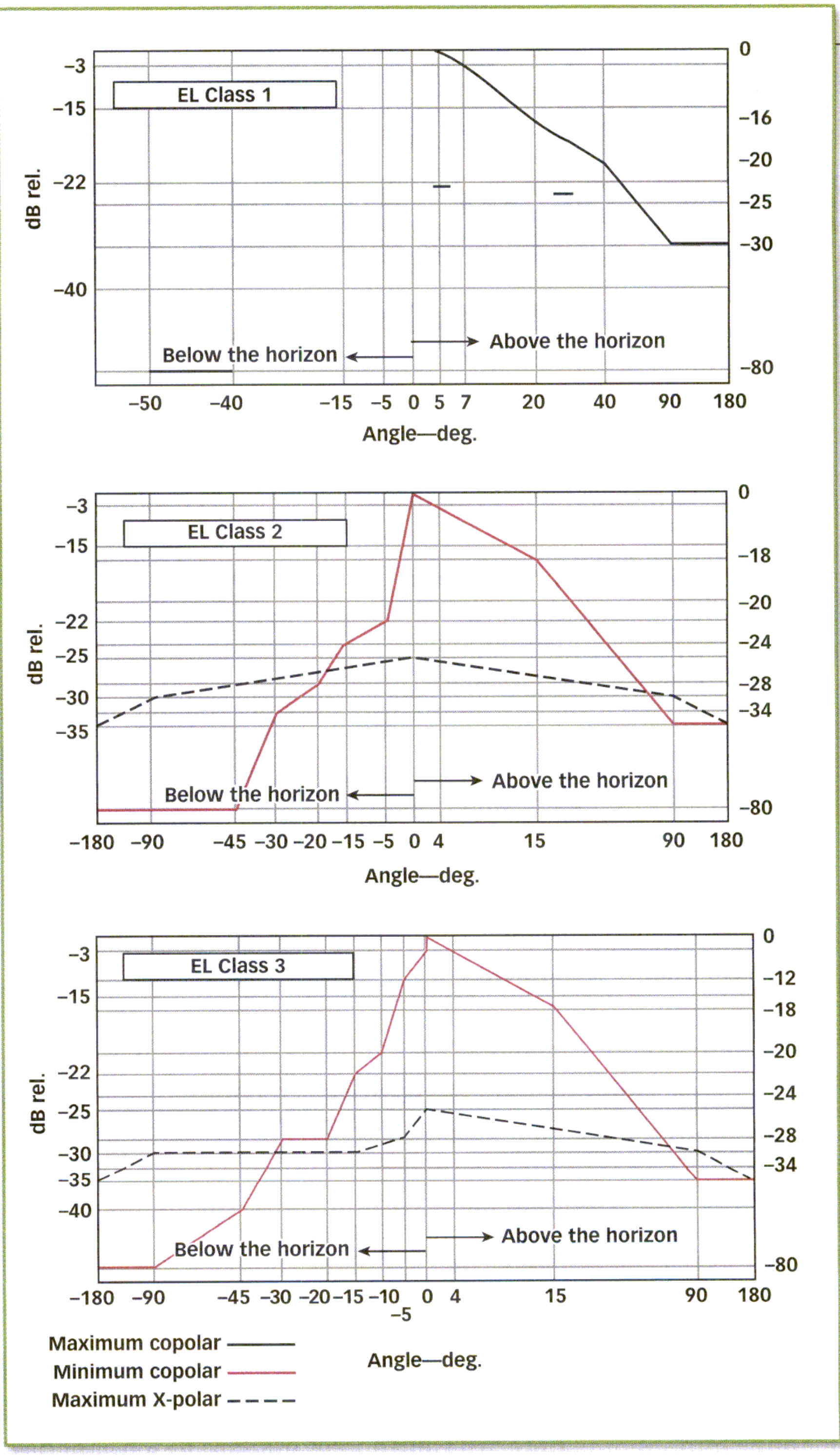
on top is deflected in azimuth by the conical reflector. Conceptually, this design may seem simple, but pattern shaping in elevation could still provide some difficulties in manufacturing.

The traditional base-station antenna is usually based on a circular cell overlapping at the boundaries, using an omnidirectional antenna such as the one shown on the lefthand side of **Fig. 5.** However, an advanced LMDS system could benefit from a square cell shape (see righthand side of Fig. 5). This type of square cell requires a very sharp aperture distribution **(Fig. 6).**[3] Although this might appear difficult to implement, the performance benefits of this design might outweigh any additional costs in manufacturing.

CPE Antenna

For the CPE antenna, performance goals must be met at minimal cost. However, the CPE antenna must also adhere to the radiation mask that is required at a particular location to support coexistence of the LMDS system with nearby services and provide the highest possible QoS. Two proposed antenna radiation masks are shown in **Fig. 7,**[4] for two directivity categories and three different classes of service. Category one could be suitable for uncluttered service areas such as rural markets, and category two could be used for more metropolitan markets.[4]

CPE antenna cost adds to the affordability of an LMDS system to the end user or customer. What follows is an examination of three approaches to the CPE antenna: the planar array, the Fresnel Zone Plate (FZP), and the parabolic reflector. Depending upon the frequency and the application, the required gain of a CPE antenna may be between 18 and 45 dBi approximately. These types of gain requirements (for frequencies from 10 to 66 GHz) usually dictate that the antenna be tens of wavelengths in physical size, and perhaps of an aperture-type design. When comparing these three antenna approaches, a frequency of 40 GHz will be assumed, with a gain requirement of 40 dBi. For the

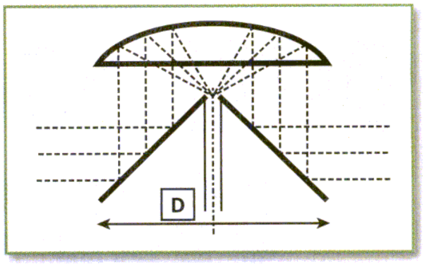


3. These are typical elevation radiation-pattern masks that were proposed for LMDS antennas, using three classes of sectored base-station antennas (after ref. 4).

sake of illustration, assume that the antenna efficiency is 50 percent and that a directivity of 43 dBi will be necessary. The three approaches will be examined with reference to the same radiation mask, a variation of the Federal Communications Commission (FCC) Category A mask (for illustration purposes only).

First, consider a planar-array implementation. To quickly evaluate the physical parameters of a planar array, several approximations will serve as a good starting point. For instance, the standard uniform aperture formula will be used to estimate the size of the array aperture.

$$D_u = 4\pi\left(A_p/\lambda^2\right) \qquad (1)$$



4. This conceptual design represents an omnidirectional antenna for LMDS base stations (after ref. 3).

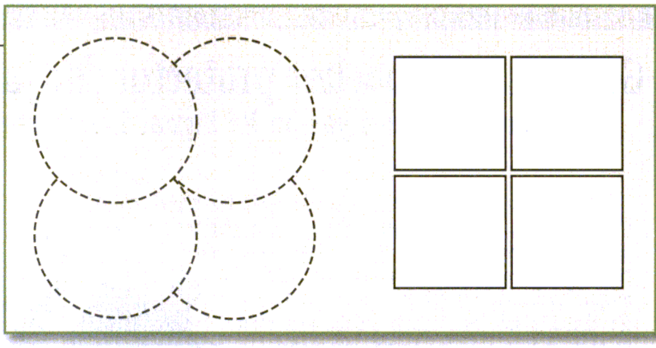
This is the formula for standard directivity, according to the IEEE,[5] for a uniform aperture of physical area of A_p. Working backward from the required directivity of 43 dBi, the necessary square aperture size will be approximately 11.82 in. (30.02 cm) on a side.

To provide a useful discussion of a planar-array antenna, isotropic elements can be used for simplicity. Furthermore, assuming element spacing of one-half wavelength, approximately 80 × 80 elements will be needed. This is a huge number that can perhaps be reduced by increasing the element spacing. As a matter of fact, the optimum will be determined when the elements are also specified and other optimizations are made.[6] Now it is desirable to try this antenna for a uniform array excitation. (Simple array-radiation pattern formulas are available from the author at www.antennem.com and are included in Appendix A of the Internet version of this article at www.mwrf.com.).

Figure 8 shows the radiation pattern of this antenna compared to the desired radiation mask. The first step is to check the pattern of Fig. 8 to see if the directivity is as expected, which can be performed by using Eqs. 2 and 3. Eq. 2 appears on the next page.

$$Do := \frac{4 \times \pi}{\Omega a} \quad (3)$$

where Eq. 2 refers to the antenna beam solid angle, which integrates the power-radiation pattern of the array antenna over the solid angle. Once this is solved, Eq. 3 can be used to find the directivity. However, it is possible to use a



5. Traditional overlapping circular cells can be replaced with square cells for best results in an LMDS system. A specific antenna aperture distribution must be designed to accommodate this, however.

$$\Omega a := \int_0^{2\times\pi}\int_0^{\pi} P(\theta,\phi)^2 \times sin(\theta)\, d\theta d\phi \qquad (2)$$

quicker approximate approach based on the main beam half-power beamwidth (HPBW):[5]

$$D_{ur} = 32,383/(HP_E HP_H) \qquad (4)$$

For a rectangular uniform aperture, the two HPBWs are the same, so from Fig. 8, the half-power of approximately 1.2 deg. provides approximately 43-dBi directivity. Thus, with 50-percent efficiency, a gain of 40 dBi results.

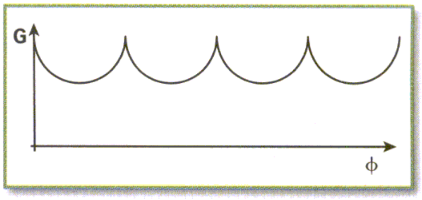
For a linear-array approximation, at an element spacing of one-half wavelength, the directivity of the array is approximately the number of elements for the isotropic elements. For a planar array, it is possible to approximate the array directivity by:

$$^{6}D = 2D_x \times D_y \qquad (5)$$

This approximation provides an estimate of the directivity of a planar array that is comprised of two orthogonal linear-array directivities. The gain is, therefore, simply G = eD, where e is the antenna efficiency.

Note that the ideal antenna of Fig. 8 seems to meet the gain requirement, but fails to meet the limits of the radiation mask. For the uniform array, the sidelobe level is approximately −13.3 dB, as expected, but is too high for the desired radiation mask. The next step is to achieve this mask for the desired sidelobe levels. The sidelobes will also be a function of the ultimate element separation, the radiation pattern of elements, the coupling, and the diffraction, among other things, which are not included in this approximation. A full-scale computer-aided design (CAD) and optimization would be needed to achieve the design objectives when considering all factors. Any tapering of the amplitude distribution to reduce sidelobes will come at the cost of reducing directivity, requiring an iterative process or full CAD analysis.

The most likely method is to use a



6. This azimuth aperture distribution is for the proposed base-station antenna of Fig. 5.

pattern synthesis approach.[7] A basic synthesis approach for a smaller linear array will now be discussed. An 18-element array has been designed for simplicity, to provide gain and a radiation mask. For a uniform array, the gain is higher and the sidelobes are at −13.3 dB. A Taylor Line Source expansion was used with −30 dB and n = 4, to synthesize the distribution. With this power-distribution taper, the radiation pattern meets the mask, but note that the main beam has widened, which translates into lower directivity and, therefore, lower gain.

Note that this example was highly simplified to illustrate the mechanism of development. Other shapes and forms of arrays are possible. In these cases, a computer-aided-synthesis technique can be developed to optimize the design. Furthermore, achieving the design objective on paper does not guarantee practical implementation. A series of prototypes must be developed and tested, and the process iterated until a viable design is obtained. At that stage, the emphasis will have to change to low-cost manufacturing of the antenna.

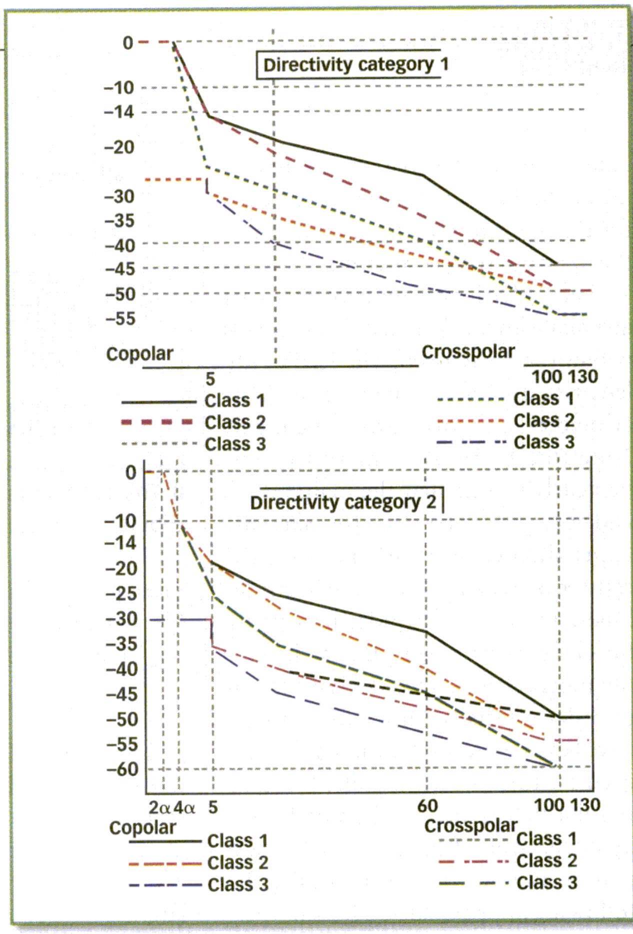
Furthermore, the array antennas are practical only if the power distribution to the elements can be achieved efficiently. This means the that array elements and size must be minimized for an optimum design, and the material selection must be made with lower loss tangent. Cost will always be the ultimate issue. One advantage of this approach is that these antennas could be made to be lightweight with a very-low profile.

Lenses provide an alternative approach, but, with some trade-offs. The focus now shifts to the sample implementation of the antenna using FZP technology. Again, use a simplified and approximate approach. The FZP is a holographic antenna that, in one form, consists of a set of concentric rings or dark and light regions. There are other versions which will not be considered here. (Approximate formulas for the radiation pattern of a circular lens with a flat face are available from the author at www.antennem.com or in the Appendix B of the Internet version of this article at www.mwrf.com.) These approximate formulas were derived from the physical optics, and have been verified against measured data at 94 GHz. For the approximate lens diameter, the aperture formula for an equivalent dish antenna was used. This approximation works reasonably well as a starting point:

$$D_{uc} = \left[\pi(D/\lambda)\right]^2 \qquad (6)$$

This directivity is calculated for a uniform-distribution circular aperture. For the 43-dBi directivity, this translates into a diameter of 13.3 in. (33.8 cm). To obtain 14 rings, adjustments were made to diameters, and the final lens ended up as approximately 14.4 in. (36.6 cm) in diameter. This FZP was used as a reflective lens with a feed point at F/D = 0.355. The alternate rings were reused by quarter-wave

7. These are suggested radiation-pattern masks for CPE antennas. Three classes of antennas are proposed here.

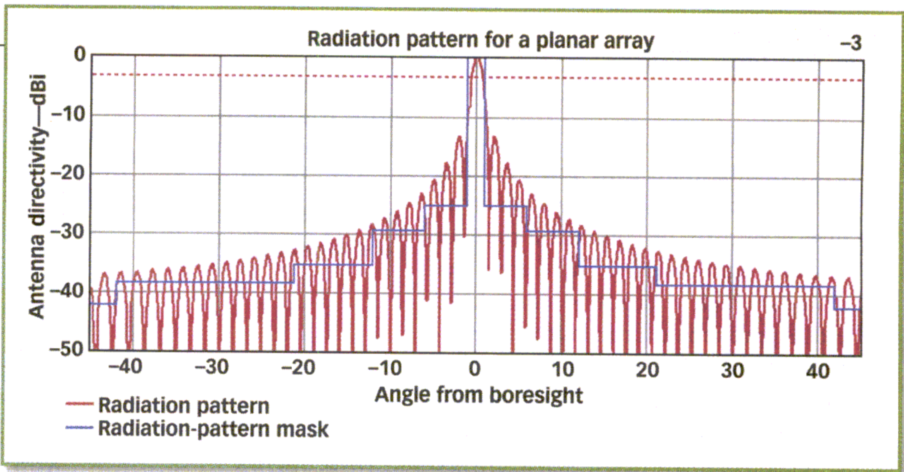


chokes for additional gain. Essentially all of the lens surface was used and, for this reason, the approximation of the aperture seemed to hold.

The radiation pattern of this lens antenna with the desired radiation mask will now be discussed. The feed of the lens was assumed to be a scalar (axisymmetric pattern) with cosine taper. Note that the radiation mask seems to be nearly met at near the main beam, and not met at outer sidelobes. Since the approximate formulas that are used cannot be relied on for accurate sidelobes, it is difficult to judge how badly the sidelobes are missing the mask without more sophisticated analysis. Higher-order effects, such as diffractions, have been developed for the lens but not used for this quick example. It is also possible to find the directivity of the lens by integration of the power-radiation pattern as noted before or by using the following approximation for the aperture antennas. This approximation is used for a circular aperture with some tapering,[5] and rotationally symmetric pattern:

$$D_C = 39,000/HP^2 \qquad (7)$$

From the radiation pattern that was just discussed, the HPBW is approximately 1.35 deg., thus translating into about 43.3-dBi directivity from Eq. 7. The slight discrepancy is due to the slightly larger diameter mentioned before. Evidently, more work needs to be done to reduce the sidelobe levels. This antenna is flat (in contrast to having a parabolic shape), and uses a feed similar to that of reflector antennas. For some classes of LMDS, FZP may provide a viable option for CPE antennas at very low cost.



8. This is a normalized radiation pattern of an 80 × 80 planar array of uniformly distributed isotropic sources compared to a sample radiation mask.

Parabolic Reflector

The reflector-antenna approach was also considered for LMDS. Parabolic reflector antennas offer the best performance, although production cost may be an issue. Furthermore, to meet some stringent antenna-radiation masks, such as ETSI, a reflector antenna design may have to be more complex (i.e., requiring multiple reflectors with shaping and surface synthesis, such as the Cassegrian and Gregorian antennas), thereby increasing complexity, cost, and overall size.

The radiation pattern for a simple prime-focused parabolic antenna similar to the previously mentioned lens, with a diameter of 13.3 in. (33.8 cm), is for a cosine-tapered scalar feed for example. With the HPBW being 1.4 deg., it provides approximately 43-dBi directivity.

This pattern suggests that the sidelobe level could be met for a selected antenna-radiation mask, but the main antenna beam must be made slightly narrower. This suggests increasing the aperture diameter. Feed tapering due to spherical spreading of the wave may be included. If this spreading was excluded, the sidelobe level of −17.6 would

(Continued on page 107)

VHDL Approach Improves Nonlinear Simulation

A new approach to harmonic-balance simulation uses a frequency-domain-extended standardized modeling language to support the use of "black boxes" in simulations.

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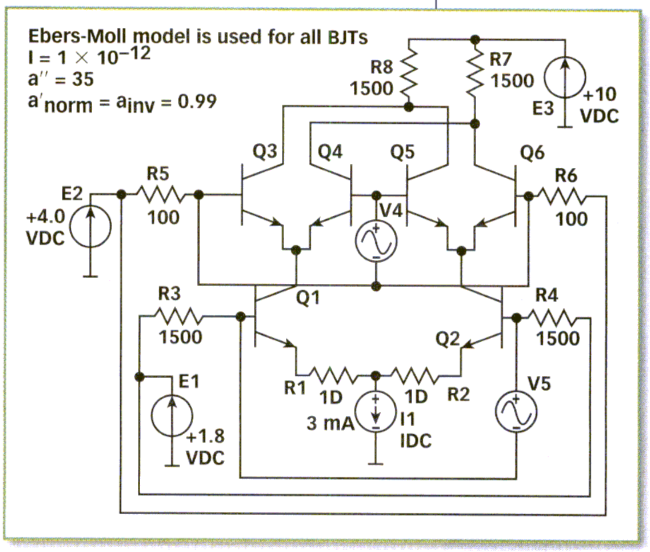
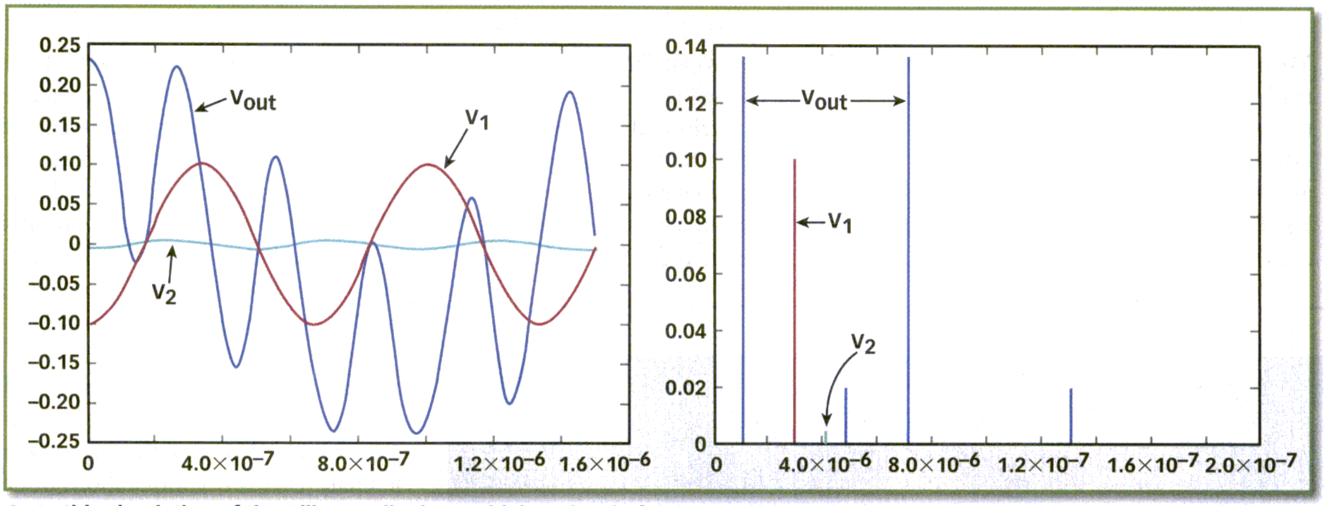
Microwave and RF designers have long sought higher levels of performance and accuracy in their simulation tools. Due to the special considerations in the microwave and RF region, there has been a complicated evolution ranging from the application of linear approaches of Touchstone and Simulation Program with Integrated-Circuit Emphasis (SPICE) simulations on nonlinear circuits to more advanced, up-to-date approaches, applying harmonic balance and complex time-domain techniques for fast simulation of nonlinear analog circuits. Fortunately, an approach has been developed to enhance the performance of harmonic-balance simulation through the use of extensions to standard very-high-definition-language (VHDL) models.

In the low-frequency area, the SPICE circuit description format is considered a de-facto standard. For high-frequency modeling (above approximately 100 MHz), this has not been the case, however. The wide variety of RF and microwave elements has demanded more advanced description languages to accurately describe their behavior over varying conditions. To that end, most EDA suppliers created their own proprietary description languages to describe these components. However, it appeared to be a situation in need of standardization.



1. A Gilbert-cell mixer was chosen as the sample circuit for analysis in the new harmonic-balance simulator.

For modeling digital circuitry, proprietary and standards-based languages were created. The latest and most useful versions—VHDL and Verilog—entered the public domain and became widely used standards. Increasing demands for simulating complex analog, digital, and mixed digital ana-



2. In this simulation of the Gilbert-cell mixer, a high LO level of 100 mV was used.

log circuits led to development of extensions of these languages, VHDL-AMS and Verilog-AMS, although the microwave and RF simulation area remained without a standard description language. Fortunately, the use of extensions to a standard language, such as VHDL, may be able to accommodate the needs of microwave and RF design applications.

Apart from harmonic balance, a technique that simulates the circuit in the frequency domain, certain time-domain techniques are also useful for high-frequency simulations, although they carry certain limitations. These time-domain methods include Microwave SPICE, the shooting approach, and SpectreRF.

The use of SPICE (specifically,

$$F(X) \equiv L(\omega, \tau_i) \times X + N\left(X, j\omega X, e^{-j\omega\tau_i} X\right) + I = 0 \qquad (1)$$

Microwave SPICE) is perhaps the most traditional high-frequency modeling techniques and one of the oldest methods. This approach uses numerical integration of component equations and Kirchoff's laws in the time domain to create a solution for each time step. The time steps can then be graphed to examine the behavior of an overall circuit under various drive conditions. SPICE suffers from the usual drawbacks of time-domain techniques, including long computation times due to large time-constant differences found in microwave circuits, and an inability to handle transmission lines well, including the need for using lumped-element approximations and long computation times. Among the advantages of SPICE are the ability to solve simple circuits and the simplicity of the software itself. Most engineers are familiar with SPICE and can apply the software quickly.

A new technique using the shooting approach has also been introduced to deal with the differing time-constants issue.[1] The shooting approach eliminates excessive computations while a steady-state solution is being found. There is also an appropriate technique to find the transient response with different time constants present (such as with SpectreRF). These tools are adequate for their tasks, but the library of components with complex frequency dependency lacks. Both aforementioned techniques are suitable for ordinary differential equations (ODE) but not for equations with complex frequency-dependent components, which are not described by ODE.

The use of harmonic balance overcomes both limitations found in the shooting or SpectreRF approaches—neither different time constants nor complex frequency-dependent passive components impact the technique's ability to accurately solve circuit equations and provide meaningful results.[2] Harmonic-balance equations usually are formulated by Eq. 1, where:

ω = the angular frequency in radians,

τ_i = the explicit delay component in circuit,

$L(\omega, \tau_i)$ = the complex linear operator, representing the linear part of the circuit,

X = complex spectrum of variables,

$j\omega X$ = the image of the variables' derivatives,

$e^{-j\omega\tau_I}X$ = the image of the delayed variable component,

$N(X, j\omega X, e^{-j\omega\tau_I}X)$ = the complex response of the nonlinear subcircuit, and

I = the vector of the free sources in the frequency domain (complex amplitudes).

Parameter X usually contains all of

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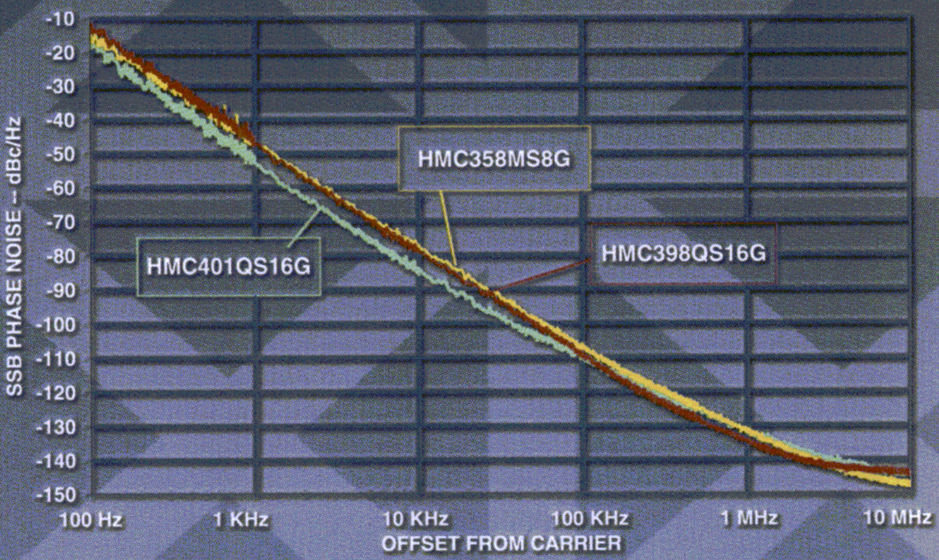

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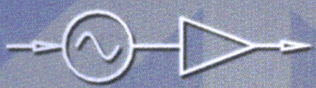

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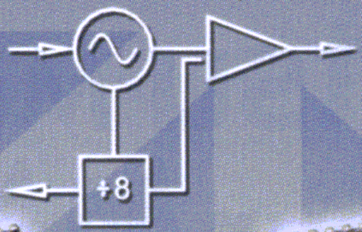

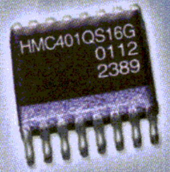

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Most complex calculations are contained in the N term of Eq. 1. There is no closed-form formula to calculate response of the nonlinear elements in frequency domain, excluding only some special cases (e.g., polynomials). To deal with this, frequency-transformation techniques are applied.

With frequency-transformation techniques, the response Fast Fourier transform (FFT) is typically used. First, the time-domain waveform of the stimulus is computed through an inverse FFT. Then, its time-domain response is computed using nonlinear functions of element(s), and its frequency-domain response is calculated through the forward FFT. Multidimensional FFTs are used to enable transformation of quasi-periodic waveforms.

The Newton method is used to solve the harmonic-balance equation. Modern implementations use modifications that provide the capability to handle large and complex systems. The Krylov subspace approach is an example of this.[3]

To simplify a depiction of its function, assume that the usual Newton method is applied. Then, according to Eq. 1, the sequence of steps is:

$$X_{i+1} = X_i + k_i \times S_i \qquad (2)$$

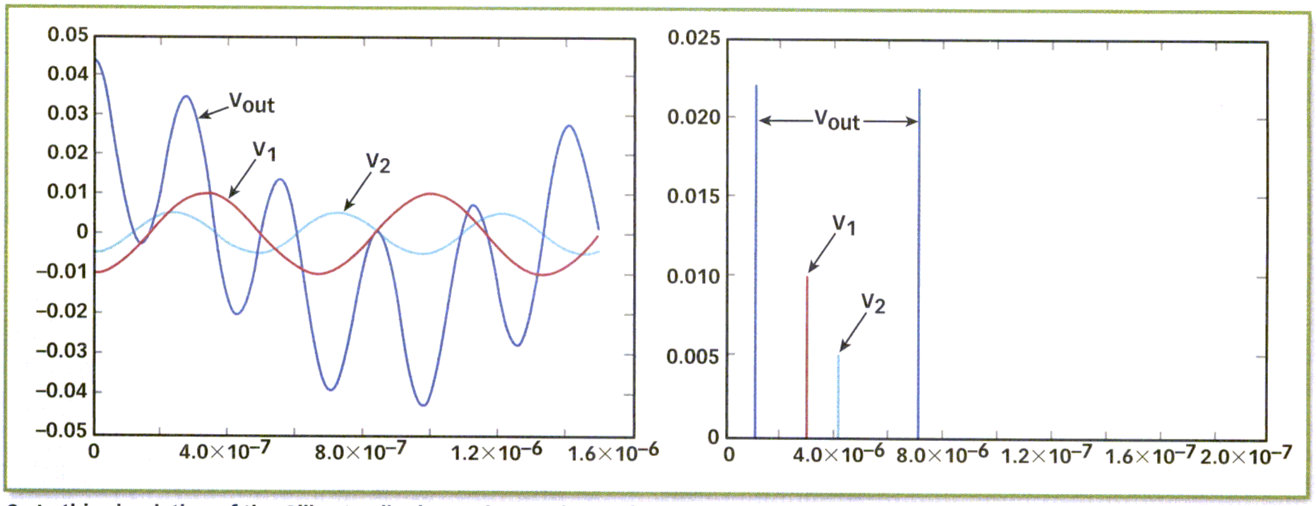
$$Si = -J_i^{-1} F_i$$

$$J = \frac{dF}{dX} \qquad (3)$$

which should converge to the solution of Eq. 1.

This is guaranteed only if the initial point, X_0, is close enough to the solution point.[4] If not, different globalization strategies are helpful.[5] Usually it consists of choosing proper value of k_i to allow Eq. 2 to converge to a solution, where F = 0.

As usual, the described approach carries advantages and drawbacks that must be assessed. The ability of harmonic balance to obtain a steady-state solution is often mentioned among its main advantages. This follows directly from the formulation of Eq. 1. Another key advantage is its ability to handle circuits of any linear circuit, including black boxes with measured frequency responses. Referring to the term $L(\omega, \tau_i)X$ in Eq. 1, L can represent any possible linear transformation of X in the complex plane, so any imaginable linear circuit (as long as Kirchoff's laws are satisfied at its ports) may be represented by L. This includes elements with complex frequency-dependent behavior, such as microstrip lines, lines under layered substrates, under anisotropic substrates,



3. In this simulation of the Gilbert-cell mixer, a low LO level of 5 mV was used.

and others. Using the multidimensional FFT in harmonic balance supports the solution of circuits under quasi-periodic excitation, so different time constants are not an issue.

The main disadvantage of harmonic balance is the large computational time needed to provide a solution. The harmonic-balance task has an approximate cubic algorithm complexity, which is defined as a "bottleneck" of the algorithm (solving Eq. 3 to define the step). Another time-consuming procedure is calculating the response of the nonlinear subcircuit term N in Eq. 1. It requires many nonlinear function calculations, along with forward and reverse FFT. Harmonic-balance-based envelope techniques,[6] mixed shooting/time-integration schemes such as in Spectre RF, and/or direct time-domain integration are more suitable.

The need for microwave and RF engineers to have a standard description

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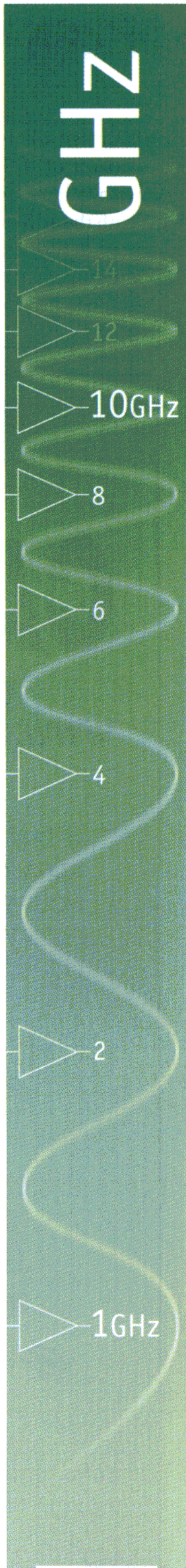

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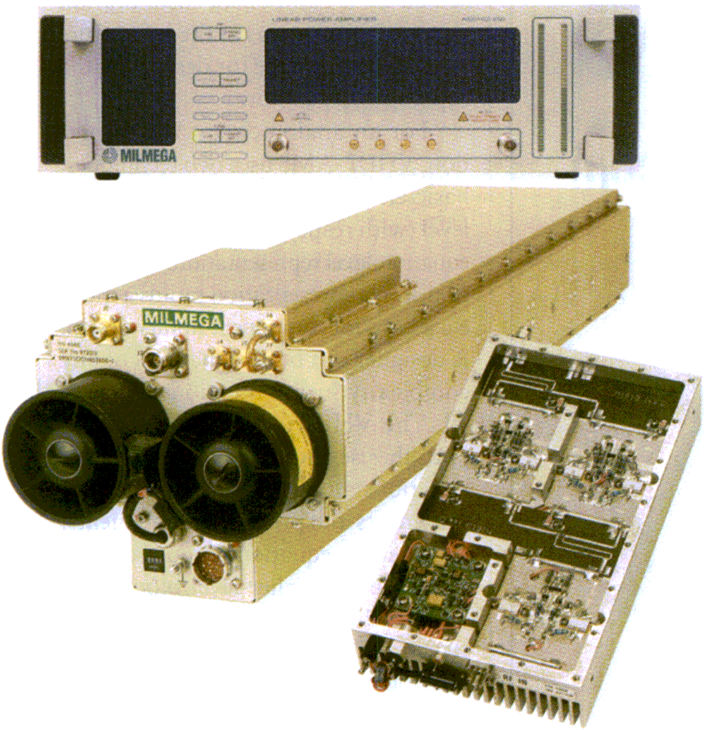

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language points to a frequency-domain version of VHDL that is compatible with a harmonic-balance simulator. With the advent of VHDL-AMS, which provides for the description of analog and mixed-signal models, the foundation has been laid for an extension of that language into the frequency domain. This further extension is referred to as VHDL-FD.

Referring to the VHDL-AMS Language Reference Manual (LRM),[7] VHDL language may be divided into digital and analog components, as well as a third circuit-descriptive component, which handles circuit decomposition into elements or vice-versa (combining elements and circuit sub blocks). This third component supports the construction ability of the language.

The digital component is implemented using signals, processes, and the methods for their interconnections: concurrent statements and sequential statements. The analog component is implemented through quantities, terminals (such as the special case of structure of quantities with conservation semantics), and simultaneous statements. The descriptive component is represented by a component-instantiation statement and serves as the infrastructure of the language for describing the topology of a circuit.

For an analog circuit representation, VHDL-AMS uses two techniques: basic-element representation and low-level (with respect to design hierarchy) equation-level representation. The equation-level representation builds a modeling basis for component-library design. A designer can build equations of any complexity, using functions as needed. The VHDL-AMS language supports the use of standard, physics-based equations along with branching "if" statements and procedural statements.

Given the equation support, designers can build higher-level blocks and connect them to create more complex structures.Two approaches are available for this: making connections using "quantities" and making connections through "terminals." Quantities are standard variables in the scope of VHDL-AMS. Several blocks can share the same variables, and connection via quantities facilitates this. It is convenient to describe signal-flow diagrams and simple closed systems using quantities.

Terminals carry out additional work—they assume preservation of conservation laws—such as Kirchoff's laws in electrical engineering. Terminals contain two quantities: an "across" variable and a "through" variable. The "across" quantity acts similar to the voltage at a node (or branch) and the "through" quantity acts like the incident current of the node.

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Another useful feature of the behavioral approach is that it is multidisciplinary. It is possible to describe and simulate mixed systems, such as electromechanical and electrohydraulic systems, using this approach. These extremely useful characteristics provide a significant inducement to use VHDL-AMS as the basis language for adaptation in the microwave-design realm, as a frequency-domain form (VHDL-FD).

Consider the classes of circuits that may be represented through this analogous subset of VHDL-AMS. The following items can be used in equations as part of the language:

- Variables (or quantities, using the terminology of VHDL-AMS).
- Derivatives of variables (which are mapped onto 'DOT attribute).
- Integrals of variables ('INTEG attribute).
- Delayed values of variables ('DELAYED attribute).

These values may be combined through algebraic functions to form the equations. This mechanism creates the ability to express any system of differential-algebraic-equation (DAE) sets when modeling. In terms of circuit simulations, this is equivalent to incorporating nonlinear and common linear-reactive elements, such as inductors and capacitors. Since the methods for modeling of distributed systems are not yet available with VHDL-FD, except as lumped-circuit approximations, it will be necessary to create the necessary extensions to accommodate frequency-domain modeling capabilities that have distributed reactive elements.

The high-frequency, extremely linear parts of microwave circuits are best described in the frequency domain, while the nonlinear parts are best modeled in the time domain. Thus, the microwave-design tool should be able to describe a model in the frequency domain. However, while not precluded, it is not an initial VHDL objective.[7]

To enable frequency-domain modeling, it is necessary to operate with quantities in the frequency-domain and time-domain together in one module. Thus, a frequency-domain extension is proposed to accommodate this need for handling quantities with VHDL in both domains. Under this scenario, an extended description capability is:

$$ui'FD = Zk(frequency) \times iinFD \quad (4)$$

where:

ui'FD and iin'FD = the images of ui and iin in the frequency domain (complex values) and

Zk(frequency) = some complex value of (frequency-dependent) impedance.

This notion enables the use of fre-

(Continued on page 102)

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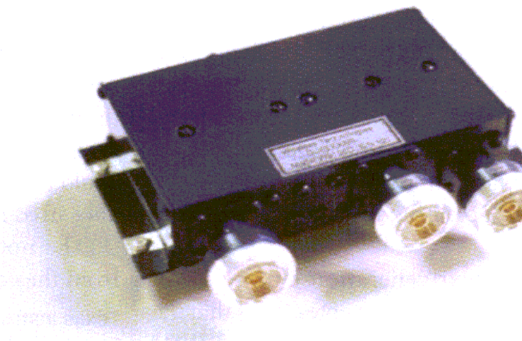

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New architectures needed for 3G wireless

THE RECENT introduction of a 3G wireless network in Japan marks the world's first deployment of this highly anticipated technology. But this system is in its very early stages and probably bears little resemblance to what the quickly evolving technology will look like a few years down the road. Some interesting speculation on the subject comes in the form of a 10-page Texas Instruments (Dallas, TX) application note entitled "Evolving Cellular Handset Architectures but an Insatiable Desire for DSP MIPS."

After providing a brief roundup of cellular-telephony standards from analog to 2G to 2.5G, the note describes the state of handset architecture today (i.e, a 2G voice-centric cellular phone). This phone relies heavily on its DSP for numerous functions, including modulation and demodulation, encryption and decryption, and compressing and decompressing the speech signal. But as 3G approaches, the function and processing capability of the DSP will have to change to handle an increasing transition from voice to data.

Although next-generation handsets will remain very DSPcentric, the note claims that the current microcontroller, which is based on a RISC architecture, will either have to be enhanced or a second RISC device will be added to the architecture. The reason for this second processor is to support operating systems, such as Windows CE and PalmOS, that will allow a user to gain access to advanced features such as personal-information management, multimedia communications, image mail, navigation, and others.

At the same time, 3G will also impose a new set of functional and performance demands on the DSP. The software environment of the DSP will have to change to support downloadable applications such as the type previously mentioned. The device will also have to operate at much greater speed to support the increased communications load that is imposed by high-bandwidth 3G standards. Moreover, DSPs may also be called upon to process functions, such as speech recognition and image/video coding, thereby increasing their MIPS load. If the processing load becomes too great, a second DSP could be needed for the handset or other appliance used for communications.

The note, SPRA650, can be downloaded from the company's website.

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But as 3G approaches, the function and processing capability of the DSP will have to change to handle an increasing transition from voice to data.

Prevent probe distortion in oscilloscope measurements

NO FUNCTION is as fundamental to the practice of electrical engineering as testing and measuring electronic circuitry with an oscilloscope. Modern scopes have exceptional measuring and computational capabilities, but the probe can be a weak link that masks what is actually happening in a circuit. A useful application note that reminds designers of the pitfalls of probes is entitled "Are You Measuring Your Circuit or Your Scope Probe" from Agilent Technologies (Englewood, CO).

Most designers should know that capacitive loading by the probe poses the greatest measurement problem. As the note points out, capacitive loading effects can lead users down blind alleys, creating problems that do not actually exist. A number of practical suggestions for minimizing capacitive loading are provided. Of course, a probe can also load a circuit resistively or inductively.

Inductive loading in the probe shows up on the scope as ringing in the observed signal. A simple formula for the ringing frequency of a LC circuit is provided, yielding the maximum signal rise time that the user can measure without the ringing having an effect. Ground-lead and tip inductance of the probe must be considered when figuring the total inductance in the measuring circuit.

Resistive loading is not as heavily considered as capacitive or inductive, but it is a factor in measurements. The lower the probe resistance is, the greater the loading effect on the circuit being measured is, resulting in an erroneous amplitude reading.

Also covered in the note are sections on active and passive probes and the importance of good mechanical design in probe performance. The note was published in Agilent's *Insight* Magazine, Vol. 5, No. 3, 2000, p. 15.

Agilent Technologies, Inc., 395 Page Mill Rd., P.O. Box 10395, Palo Alto, CA 94303; (650) 752-5000, Internet: www.agilent.com.

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cover story

Agile Synthesizer Reaches 6.4 GHz

The benefits of direct frequency synthesis, including fine frequency resolution, fast frequency-switching speed, and high spectral purity, are now affordable from 1 to 6400 MHz.

JACK BROWNE
Publisher/Editor

Test applications vary widely, with some requiring complex modulation and others only needing a clean source of sine-wave (unmodulated) signals. But the characteristic that is common to many modern test applications is speed—generators with fast frequency-switching speed to increase test throughput or accommodate spread-spectrum signal formats. For those test applications through 6.4 GHz, the PTS 6400 frequency synthesizer from Programmed Test Sources (PTS; Littleton, MA) is a cost-effective solution with microsecond switching speed and low phase noise.

PTS has been a dependable supplier of signal sources based on direct frequency synthesis since 1975. The firm's earliest test solutions operated at frequencies below 1 GHz although, several years ago, the company pushed its frequency coverage to 3.2 GHz with the PTS 3200 (see *Microwaves & RF,* May 1998, p. 248). And now, with the PTS 6400 **(Fig. 1),** that frequency coverage extends to 6.4 GHz, without sacrificing the spectral purity and switching speed associated with a PTS frequency synthesizer.

While direct frequency synthesis is still the basis for PTS synthesizers, the company has also blended other synthesis techniques, such as direct digital synthesis (DDS), to achieve improved frequency resolution. In direct frequency synthesis, a number of auxiliary or standard frequencies are derived from a low-noise reference oscillator, usually a temperature-compensated crystal oscillator (TCXO) or oven-controlled crystal oscillator (OCXO). By performing arithmetic operations on these frequencies through the use of filters, switches, mixers, multipliers, and dividers, a wide range of output frequencies can be generated with relatively high resolution and minimal delays between frequency steps. The mix-and-divide approach to direct frequency synthesis lends itself to modular manufacturing methods, supporting the use of common modules across a wide range of frequency synthesizers with different frequency ranges.

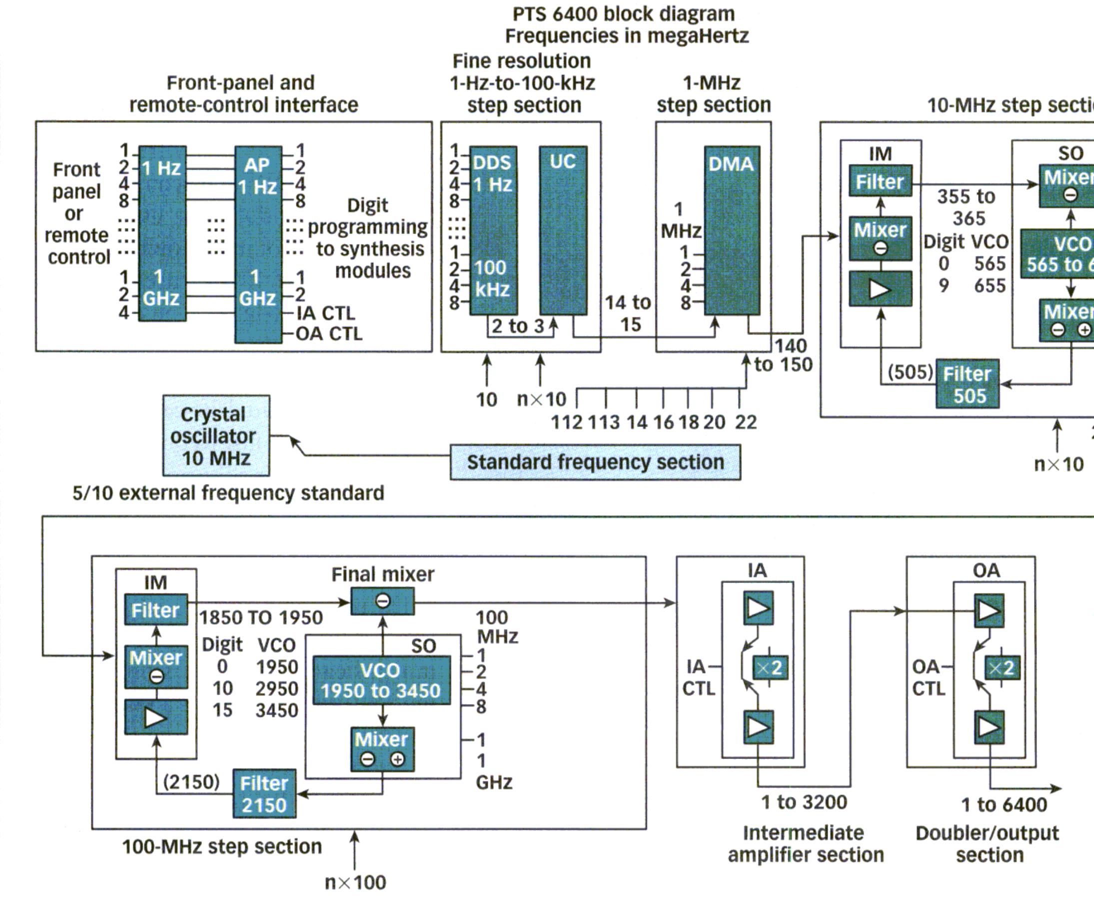
In contrast, indirect frequency synthesizers typically employ phase-locked loops (PLLs) to stabilize a tunable oscillator to the phase of a reference source, tuning the oscillator with the PLL's loop filters when a new frequency is needed. A variety of approaches is available for indirect synthesis, including the use of conventional PLLs, the use of fractional-N synthesis integrated circuits (ICs), and the use of mix-and-divide architectures with embedded loops. In each case, the loop is governed by some derivative of the frequency standard (a crystal oscillator). The switching speed of an indirect frequency synthesizer is on the order of milliseconds, while the switching speed of a direct frequency synthesizer is on the order of microseconds.

1. The PTS 6400 blends direct analog and digital frequency-synthesis techniques to achieve high spectral purity and fast frequency-switching speed from 1 to 6400 MHz.

With the introduction of the PTS 6400, developers of automatic-test-equipment (ATE) systems can add the microsecond switching speed of a PTS synthesizer to their racks for applications through 6.4 GHz. Similar to other synthesizers in the PTS line, the PTS 6400 combines direct analog and DDS technologies. The most significant digits of frequency resolution down to 1 MHz are produced by direct analog techniques (arithmetic operations on main and auxiliary frequencies), whereas DDS or repetitive mix-and-divide modules are used for frequency resolution down to 1 Hz.

The PTS 6400 features three distinct sections **(Fig. 2)**. The company's proprietary DDS circuitry is used to achieve fine resolution in steps of 1 Hz to 100 kHz. Two drift-canceled loops (DCLs) achieve fast frequency switching while avoiding the no-lock failures common to PLLs.

In the PTS 6400, an internal 10-MHz crystal oscillator (or external 10-MHz reference source) is processed into various standard frequencies through multiplication and division. A DDS module, which contains a DDS source and frequency upconverter, generates signals from 2 to 3 MHz (in step sizes of 1 Hz to 100 kHz) which are upconverted to 14 to 15 MHz and then fed to a direct-memory-access (DMA) module in the 1-MHz step section. The



2. The PTS 6400 incorporates a modular construction with arithmetic operations on standard and auxiliary signals derived from a reference source to achieve its final frequency range of 1 to 6400 MHz.

DMA module feeds 140-to-150-MHz signals to the 10-MHz step section, which includes mixers, filters, a voltage-controlled oscillator (VCO), and amplification to produce 200-to-300-MHz signals to feed a 100-MHz step section. Signals from the 100-MHz step section feed an intermediate amplifier module with frequency doubler to produce output signals ranging from 1 to 3200 MHz. These signals are doubled again to produce 1 to 6400 MHz, in steps consisting of 1 Hz to 100 MHz.

The switching speed, which is defined as the time required to settle within 0.1 radian of a new frequency, is a mere 20 μs when switching with 1-GHz, 100-MHz, and 10-MHz resolution. The switching time is less when switching with smaller digits, typically only 5 μs.

Output signals are available at levels from −3 to +7 dBm with output flatness of ±1 dB. When measured at full output level (+7 dBm), discrete spurious content is −60 dBc from 1 to 3200 MHz and −55 dB from 3200 to 6400 MHz. Subharmonic levels are −45 dBc from 1600 to 6400 MHz, while harmonics are −30 dBc.

For carriers ranging from 1600 to 3200 MHz, the SSB phase noise is −99 dBc/Hz offset 100 Hz from the carrier, improving to −108 dBc/Hz offset 1 kHz from the carrier, −116 dBc/Hz offset 10 kHz from the carrier, and −118 dBc/Hz offset 100 kHz from the carrier. For carriers spanning 1 to 1600 MHz, the single-sideband (SSB) phase noise is improved by 6 dB (thus, the phase noise offset 100 Hz from a 1-GHz carrier is −105 dBc/Hz) while, for carriers from 3200 to 6400 MHz, the SSB phase noise is degraded by 6 dB (thus, the phase noise offset 100 Hz from a 4-GHz carrier is −93 dBc/Hz). The PTS 6400 supports a noise floor of −130 dBc/Hz above 3200 MHz. Below 3200 MHz, the noise floor is also improved by 6 dB.

The PTS 6400 is available with an internal 10-MHz TCXO or OCXO. The TCXO features an aging rate of 1×10^{-8}/day, while the OCXO provides an aging rate of 3×10^{-9}/day. The synthesizer can also operate with either a 5- or 10-MHz external reference oscillator.

The PTS 6400 can be controlled manually by its front-panel keyboard or remotely with TTL-level parallel binary-coded-decimal (BCD) logic or optional GPIB. For those applications that do not require complex modulation, but demand clean signals with fast switching speed, the PTS 6400 may be the answer through 6.4 GHz. **Programmed Test Sources, Inc., 9 Beaver Brook Rd., Littleton, MA 01460; (978) 486-3400, FAX: (978) 486-4495, e-mail: sales@programmedtest.com, Internet: www.programmedtest.com.**

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Vector Signal Generator Keeps Pace With 3G

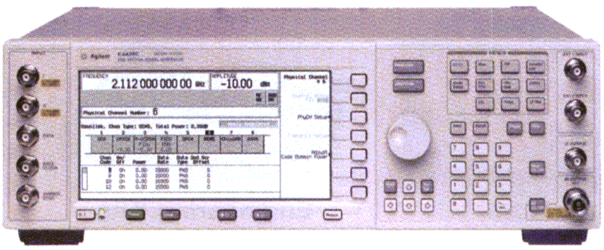
This vector signal generator offers the fast sampling rates, broad modulation bandwidth, and large waveform memory needed to emulate 2.5G and 3G waveforms.

JACK BROWNE
Publisher/Editor

Generating test signals that can meet the requirements of emerging wireless standards requires power and flexibility. The latest addition to the ESG line of digital signal generators from Agilent Technologies (Santa Rosa, CA), the E4438C ESG vector signal generator, features a generous dose of both traits, with wider RF bandwidth, expanded connectivity, greater waveform memory, and faster processing and switching speeds than earlier generations of the instrument. The E4438C is available in five frequency ranges spanning 250 kHz to 1, 2, 3, 4, or 6 GHz.

The E4438C **(see figure)** features +17-dBm output power across each full frequency range, with typical output-power flatness of ±0.5 dB through 2 GHz. The phase noise is less than −134 dBc/Hz offset 20 kHz from a 1-GHz carrier. The frequency and amplitude switching speeds are 15 ms or less.

The instrument's impressive 160-MHz external RF modulation bandwidth and 100-Msymbols/s internal baseband generator can meet the modulation needs of the latest two-and-a-half-generation (2.5G) and third-generation (3G) wireless-communications standards. This increased modulation-bandwidth ESG provides flatter amplitude performance over the typical 20-MHz span of 3G multicarrier amplifiers, especially critical for designers working to improve adjacent-channel-power-ratio (ACPR) performance through the use of predistortion techniques.



The latest ESG test-signal source, the EE4438C vector signal generator, is available in models operating from 250 kHz to 1, 2, 3, 4, or 6 GHz.

The in-phase/quadrature (I/Q) symbol builder and faster microprocessor allow the E4438C to create all physical-layer channels for wideband-code-division-multiple-access (WCDMA) conformance testing. It can provide fully coded signals on the traffic channels, compressed mode, and 16 OCNS for WCDMA. The E4438C also has an integrated high-performance additive white Gaussian noise (AWGN) generator that allows CDMA users to set a calibrated level for E_b/N_o, E_c/N_o, or carrier-to-noise ratio (CNR).

The E4438C's 100-MHz sample rate is achieved through 16-b, 400-MHz analog-to-digital converters (ADCs) and digital-to-analog converters (DACs)

operating at a four-times oversampling rate. The high sample rate eliminates the need for multiple reconstruction filters that are typically required to remove undesired signal images in the sampled spectrum. These filters are traditionally required because when an analog signal is digitally sampled in the time domain, multiple copies of the spectrum are returned (separated by the sample rate), rather than a single signal spectrum. Reconstruction filters remove the extra images, returning the digitized signal to a single spectrum. But if the sample rate is too low for the spectrum of interest, the digitized signal resolution will be limited and close-together images will be difficult to filter without removing portions of the desired spectrum. The E4438C's high sampling rate allows the images to be sufficiently spread with high-enough digital resolution to support a single reconstruction filter.

The arbitrary waveform memory in the E4438C has been increased to 160 MB, supporting 32 MSamples. Memory allows multiple waveforms to be loaded simultaneously, with high-crest-factor and error-vector-magnitude (EVM) scenarios to be loaded at the same time. The built-in waveform sequencer allows operators to quickly and easily build up test-signal sequences with multiple waveforms and power levels, helping to reduce the test time needed to evaluate linear, high-intercept-point power amplifiers (PAs) that require a sequence of many different waveforms. Custom waveforms can be imported from their source to the instrument's memory or 6-GB hard drive.

The E4438C supports current and evolving wireless-communication standards, including 3GPP WCDMA, cdma2000, cdmaOne, 1xEV-DO, Global System for Mobile Communications (GSM)/Enhanced Data Rates for Global Evolution (EDGE), wireless local-area network (WLAN) [802.11a and b], and Bluetooth. Each format can be widely customized to create high crest factors and unique payload sequences. When the E4438C is configured with an optional baseband generator, it can exploit the company's Signal Studio software tools. Signal Studio is a Windows-based software utility that creates waveforms for specific communications formats, including 802.11a and b, 1xEV-DO, and Bluetooth, while providing wide flexibility in tailoring each waveform characteristic.

Other features are alternate timeslot power control that simulates a real GSM/EDGE transmitter (Tx) and sending multiple signals at rapidly varying power levels to ensure testing under realistic conditions. P&A: $16,750 and up; stock. **Agilent Technologies, Test and Measurement Organization, 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; (800) 452-4844 ext. 7603, Internet: www.agilent.com/find/esg.** MRF

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(Continued from page 88)
quency-domain modeling. If the model in the time domain is described as:

$$i = C \times v'dot \qquad (5)$$

It may be simply and automatically transformed into frequency-domain—see Eq. 6 on page 102

The time-domain model can be simply represented in the time-domain as well, but many complex frequency-domain models (e.g., with dispersion) have a very complex time-domain description. Using frequency-domain extensions, such as that shown in Eq. 6, it is possible to extend the modeling capabilities of VHDL-AMS to high-frequency bands.

Ridgetop Group (Tucson, AZ) has created a working simulator, Rincon™, that employs the VHDL-FD extensions with a harmonic-balance simulator **(see table)**. The simulator can be demonstrated through the analysis of a Gilbert-cell mixer **(Fig. 1)**. **Figure 2** shows the simulation results when using a high local-oscillator (LO) level of 100 mV, while **Fig. 3** shows the simulation results using a lower LO level of 5 mV. MRF

$$i'FD = C \times math\_j \times math\_2\_pi \times FREQUENCY \times v'FD \qquad (6)$$

Comparing different simulation and modeling techniques

SIMULATOR TYPE	RELATIVE COMPUTATION TIME	ACCURACY	MODEL LIBRARY	NEW MODELING CAPABILITY	COMMENTS
Harmonic balance	Average	Excellent	Proprietary	Limited	Model limitations
Rincon™ Simulator–harmonic balance with VHDL-FD modeling capabilities	Average	Excellent	Open	Extensive	Newly introduced
SPICE	Long	Poor	SPICE primitives	None	Widely understood
SpectreRF	Short	Medium	Proprietary	None	Limited library

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Miniscule Module Tracks 12 GPS Channels

One of the world's smallest GPS Rxs packs an RF Rx, baseband processor, Flash memory, and resonators into a module measuring only 13.00 × 15.00 × 3.75 mm.

JACK BROWNE
Publisher/Editor

GPS Rxs are invaluable for navigation and position location, as many users of onboard automotive GPS units are discovering. Due to the increasing trend of integrating GPS electronics into other wireless products, such as cellular telephones and PDAs, there is a strong need for miniature GPS Rxs with low power consumption. The GPS2020 GPS Rx module from SyChip (Warren, NJ) is a suitable solution for that need, providing 12 GPS channels and onboard Flash memory in a module package measuring only 13.00 × 15.00 × 3.75 mm.

The tiny GPS2020 module contains several ICs, including a baseband processor, an RF Rx, and memory. The baseband chip includes a 50-MHz ARM7 processor core, a DSP engine, a GPS core, dual UARTs, and power-management software. This IC is capable of retrieving all necessary GPS data from a received signal while providing a complete navigation solution through the module's serial port. Digital processing is used to remove the effects of Doppler shift, while the ARM processor computes the position, velocity, and time from the received GPS signals.

The radio IC features a crystal resonator, VCO, PLL synthesizer, dual-stage LNAs, IF and RF filters, and AGC circuitry. The module also contains boot ROM, SRAM, 1-Mb EDO RAM, and 8 Mb of Flash memory to support a wide range of custom application firmware. The module also includes a GPS crystal resonator with a center frequency of 24.5535 MHz. A second crystal, the RTC, is external to the module. The RTC, which is normally found in cellular and PDA applications, can be made available for GPS applications.

SyChip, a venture of Lucent Technologies, has successfully leveraged the CSM technology that was originally developed at Bell Laboratories into the development of the GPS2020 module. It operates at the standard GPS frequency of 1.57542 GHz, running on a power-supply voltage of +3.3 VDC. The 12-channel Rx features 100-ms reacquisition time and can detect signals as low as −140 dBm. The Rx can acquire signals at speeds as fast as 1852 km/h and provide position accuracy of typically 15 m.

For dedicated GPS designs, or low-power portable designs requiring an additional GPS function, the GPS2020 module offers a ready-to-use solution with small size, low power consumption, and time to market. **SyChip, Inc., 30 Technology Dr., Warren, NJ 07059; (908) 941-1111, FAX: (908) 941-1174, e-mail: sales@sychip.com, Internet: www.sychip.com.** MRF

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MEMS Animates Miniature RF Switch

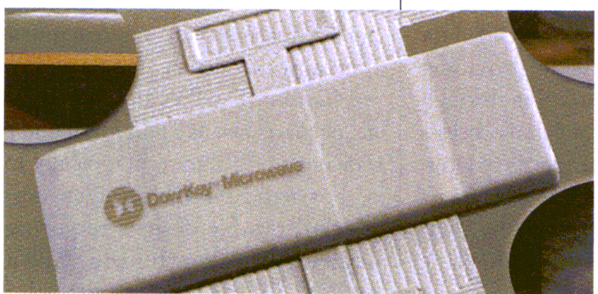
MEMS research has received much attention among optical designers, although the technology is also suitable for such devices as RF and microwave switches.

MEMS is often associated with its potential for miniature medical machine systems as well as optical switching, but the technology also has promise for RF and microwave applications. A case in point is a miniature MEMS SPST latching switch that is available from Dow-Key Microwave Corp. (Ventura, CA) with extremely low insertion loss through 4 GHz.

JACK BROWNE
Publisher/Editor

A MEMS is a machine fabricated to the scale of a semiconductor device. A MEMS switch is fabricated with semiconductor processing, yet it is a device with moving parts, such as a cantilever.

The low-power switch **(see figure)** is the result of a team effort between Dow-Key and researchers from MEMS specialist Microlab, Inc. (Chandler, AZ). The company brings its unique micro-magnetic-latching (MagLatch™) technology to the Dow-Key product development effort, allowing the MEMS switch to remain in an on or off state with zero power consumption.



MEMS technology allows this miniature SPST microwave switch to operate over an extremely long lifetime with minimal RF performance degradation and power consumption.

Basically, a MagLatch switch consists of a cantilever, an embedded planar coil, a permanent magnet, and electrical contacts. The cantilever can be thought of as a miniature child's "see-saw," with an electrical contact at one end and the coil at the other end. The contact can be made or broken by passing current pulses through the coil. The permanent magnet holds the cantilever in the up (open) or down (closed) position after switching.

The Dow-Key/Microlab MEMS switch has been tested to 4 GHz and provides usable performance through 8 GHz. The insertion loss through 4 GHz is only 0.22 dB, with approximately 40-dB isolation. The SPST MEMS switch die measures only 1.50 × 1.25 mm, with future versions expected to be a fraction of that size. The device is rated for switching speed of 100 µs and power-handling capability of 2 W CW. It is also rated for an impressive operating lifetime of 100 million switching cycles.

Designed for +5-VDC operation, the switch draws only 60-mA current. Using Au-contact interfaces, the design achieves contact resistance of only 50 mΩ. The firm is currently offering the device on chip carriers or as part of a MEMS RF switch test board for evaluation. Dow-Key Microwave Corp., 4822 McGrath St., Ventura, CA 93003-7718; (805) 650-0260, FAX: (850) 650-1734, Internet: www.dowkey.com.

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SiGe Tuner Targets Advanced Set-Top Boxes

The promise of SiGe semiconductor technology pays off in high-performance, low-power, small-form-factor tuners for next-generation multimedia set-top boxes.

JACK BROWNE
Publisher/Editor

Designers of advanced cable set-top boxes are discovering that there are many new tuner requirements due to multiple audio, video, and data streams in digital as well as analog formats. A traditional tuner cannot satisfy the needs of integration, power, and performance that is required by the latest set-top boxes that offer picture-in-picture, e-commerce and home banking, interactive viewing, Internet access, streaming media, PVR, as well as programming using analog and digital signals, including HDTV. To meet the stringent demands of modern set-top boxes, Microtune (Plano, TX) has developed a high-performance tuner based on a patented microcircuit architecture fabricated with a high-speed SiGe semiconductor process.

The demands for new set-top-box tuners can challenge the best designs, but the MicroTuner™ MT2111 satisfies these new requirements **(see figure)**. With an input range of 45 to 870 MHz, it is the first cable tuner to be fabricated with a SiGe BiCMOS process. The process allows the MT2111 tuner to achieve reduced interference and distortion, delivering clear video signals that are free of visual artifacts even at low signal levels.

The MT2111 tuner takes advantage of a patented circuit architecture and high-speed SiGe BiCMOS process to achieve low noise and low distortion in cable STB designs.

Based on Microtune's patented microcircuit architecture, the MT2111 tuner package measures 8 × 8 mm and consumes 1.5-W power. Housed in a 56-pin package, the tuner includes on-chip, fully integrated VCOs. In the MT2111, a variable-gain IF amplifier, which maintains constant input voltage to the demodulator, is also on-chip. In other Si solutions, this function is contained in a second chip.

Dynamic range and noise are critical specifications in next-generation set-top boxes, and the MT2111 tuner offers the levels of performance needed for trouble-free end-product designs. For example, the MT2111 achieves CTB performance of −63 dBc, CSO performance of −60 dBc, and cross modulation of −57 dBc at up to +3-dBmV take-over point. The MT2111's noise figure is specified at 9 dB maximum, while SSB phase noise is better than −85 dBc/Hz offset 10 kHz from the carrier, and typically −88 dBc/Hz. **Microtune, Inc., 2201 10th St., Plano, TX 75074; (972) 673-1600, FAX: (972) 673-1602, Internet: www.microtune.com.** MRF

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(Continued from page 74)
be obtained for uniform distribution, (i.e., with no cosine tapering), and approximately a −24.6-dBi sidelobe level would be obtained for a cosine spreading, which should be similar to the parabolic feed distribution. (The various approximate formulas for the radiation pattern of a parabolic reflector antenna are available from the author at www.antennem.com and are included in Appendix C of the Internet version of this article at www.mwrf.com.).

The antenna is a highly critical element of the LMDS. It is the key to the system's ability to coexist with others and provide the highest QoS. If LMDS is to be a viable commercial success, it is imperative that the antennas be developed with high performance and very low cost. This article merely touched upon some possible approaches for the CPE antennas and the challenges that lie ahead.

Furthermore, once CAE synthesis and optimization techniques for CPE antennas are developed, the same techniques can be applied to the development of more complex base-station antennas. It should be remembered in this presentation that various approximations were used in the interest of getting an overall idea of trends for design. Specifically, no diffraction, mutual coupling, and other higher-order considerations were included. It is hoped that these simplifications will aid the LMDS audience to appreciate the technical obstacles that must be overcome before successful deployment of LMDS. MRF

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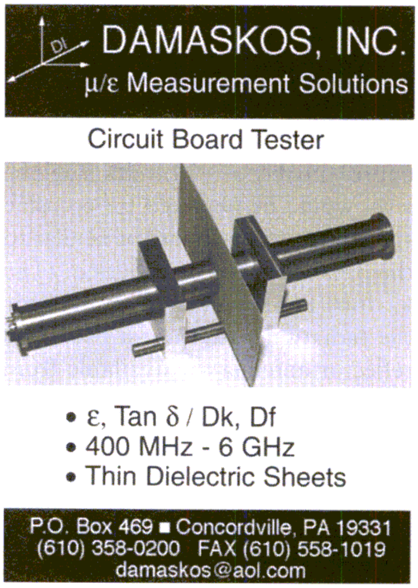

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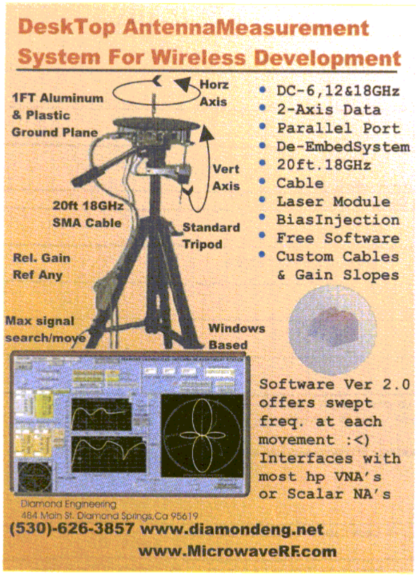

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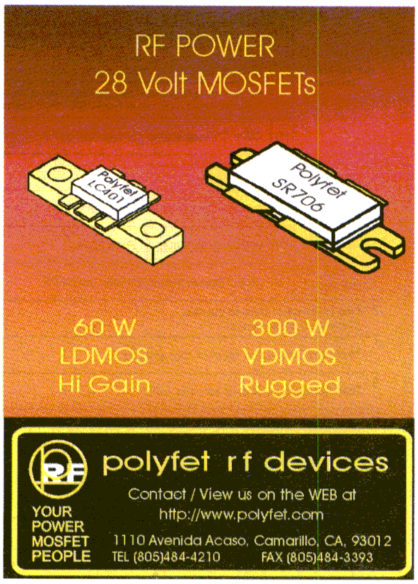

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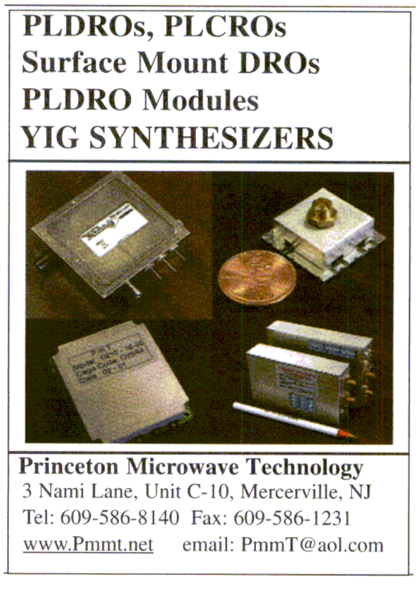

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Capacitors Tune 0.4 To 1.2 pF

THE A2W1 AND A2DW1 are trimmer capacitors for high-frequency use. The parts tune from 0.4 to 1.2 pF. The A2W1 has a single 0.090-in. (0.229-cm)-wide lead and the A2DW1 has two 0.90-in. (0.229-cm)-wide leads 180 deg. apart. DC working voltage is 250 and DC withstanding voltage is 500. Temperature coefficient is 0 ±150 PPM/°C from –65 to +125°C. P&A: $2.76 (10,000 qty.); 1 week for samples and 4 wks. (more than 1000 qty.).

Voltronics Corp., 100 Ford Rd., Denville, NJ 07834; (973) 586-8585, FAX: (973) 586-3404, e-mail: info@voltronicscorp.com, Internet: www.voltronicscorp.com.

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Kit Serves 13.56-MHz RFID Devices

THE 13.56-MHZ RFID microID™ MCRF355/450 Developers Kit (DV103005) contains an advanced dual-microcontroller circuit. The interrogator also features three different sizes of modular antennas for fast evaluation of multiple design trials. An anticollision reference reader/interrogator, schematics, source code, functional tag samples, and a design reference guide complete with PICmicro® microcontroller code files are included. Accompanying RFLAB 3 user-interface software showcases the advanced features of the MCRF3XX and MCRF4XX series transponders. P&A: $1999 each.

Microchip Technology, Inc., 2355 West Chandler Blvd., Chandler, AZ 85224-6199; (480) 786-7200, FAX: (480) 899-9210, Internet: www.microchip.com.

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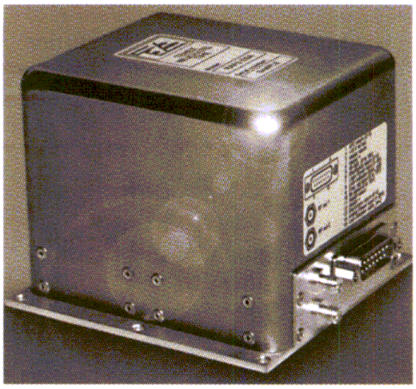
Oscillator Suits Satellite Communications

A SERIES OF Rb atomic clock oscillators has a temperature sensitivity of



less than 1×10^{-13}/°C. This was accomplished using a double-oven construction with an SC-cut crystal oscillator The RAFS exhibits short-term stability of less than 5×10^{-14}/10,000 s and a drift of less than 3×10^{-13}/day. The first year's long-term stability of less than 1×10^{-10} is controlled by a systematic burn-in and preaging process. Input voltage is +22 to +26 VDC or +8 to +12 VDC and is connected through a 15-pin sub-D and two surface-mount-architecture (SMA) connectors.

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

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Materials Target Test And Measurement

THE MICROLAM FAMILY of dielectric materials is built upon ePTFE structures that are impregnated with various filled resins. MICROLAM 200 dielectric material is engineered with a low-loss tangent (0.0036 through 10 GHz), making it suitable for laser HDI printed wiring boards or RF module applications. The coefficient of thermal expansion MICROLAM 400 dielectric material (19 PPM/°C) is isotropically matched to Cu, supporting fabrication of fine-pitch chip-package substrates.

W.L. Gore & Associates, Inc., 750 Ott's Chapel Rd., Newark, DE 19714; (800) 445-4673, (302) 292-5100, FAX: (302) 737-2819, Internet: www.gore.com/electronics.

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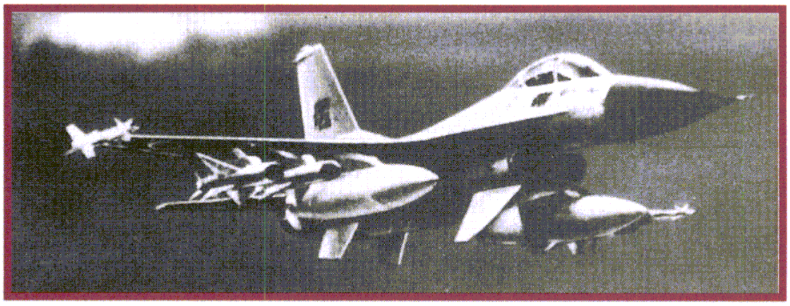

MORE THAN 11 YEARS AGO, a report by then Senior Editor Ron Schneiderman examined a growing defense industry in Japan. At that time, imports were projected to be a small part of an estimated $30 billion defense budget, with the FSX fighter representing a key business opportunity for US contractors.

next month

Microwaves & RF December Editorial Preview

Issue Theme: Wireless Show Preview

News

While TIAs are usually eclipsed by other optical-communications-systems components, they play a pivotal role in determining overall performance. That role is poised to grow further, as data rates will increase from 10 (OC-192) to 40 Gb/s (OC-768) in the next few years. With bandwidths greater than 40 GHz, these systems pose a millimeter-wave design problem that requires a solution based on InP, a compound that has its own set of positive (and negative) characteristics. A Special Report in December will examine the TIA marketplace, from the 10-Gb/s CMOS, SiGe, and GaAs devices that are currently offered by many vendors, to the 40-Gb/s development environment that is commanded by InP, and explore what manufacturing and test problems remain to be solved.

Design Features

December's Design Features section offers a detailed look at active and passive RFID technologies, especially concerning their compatibility with 2.45-GHz WLAN and Bluetooth systems. An author from Motorola will provide a geometric interpretation of error-vector magnitude and show how it can be simply applied to RF system design.

Product Technology

The December Product Technology section highlights a new IF digitizing subsystem IC from a leading supplier. The IC, which simplifies the design of narrowband mobile base stations and handsets and provides better than 80-dB selectivity, can work with IF signals from 10 to 300 MHz. Additional product features will examine a line of microwave substrate materials from a new supplier, a line of low-cost coaxial connectors, a software package that helps guide the selection of antenna/cell sites for wireless communications systems, and a line of HBT PAs that employ active bias control in order to save energy under changing signal conditions.