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FOR DESIGNERS AT HIGHER FREQUENCIES

Microwaves & RF

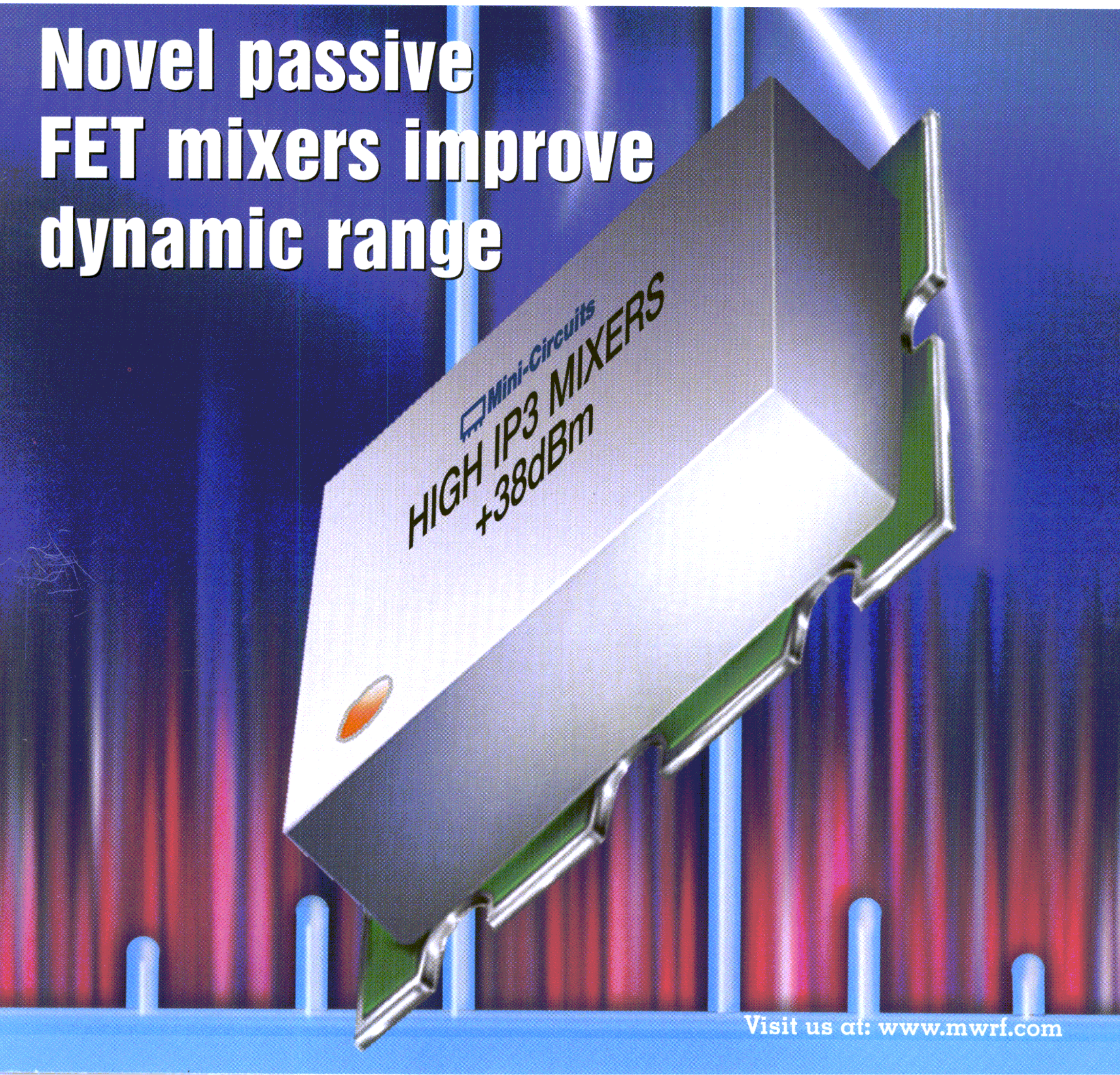
Wireless Show Issue

NEWS
Turbulence muddies the telecom waters

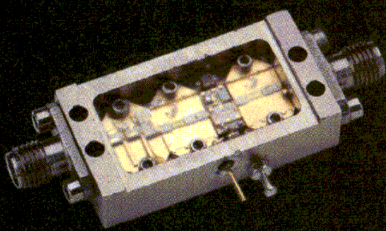
DESIGN FEATURE
Check amplifier dynamic behavior with test signals

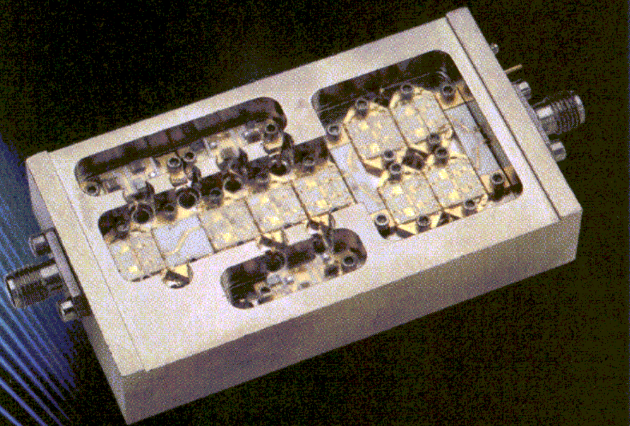
PRODUCT TECHNOLOGY
Model, analyze, and simulate fractional-N synthesizers

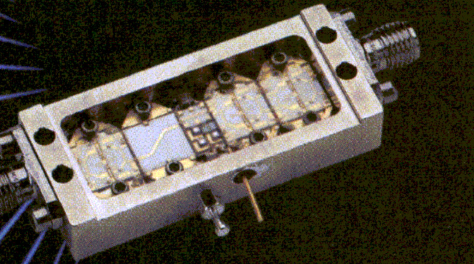
Novel passive FET mixers improve dynamic range



AMPLIFIERS
for every application







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ULTRA BROAD BAND

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

MULTI OCTAVE AMPLIFIERS

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

MEDIUM POWER AMPLIFIERS

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

LOW NOISE OCTAVE BAND LNA'S

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

NARROW BAND LNA'S

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

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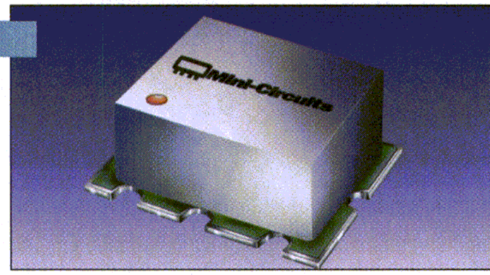
COVER FEATURE



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DESIGN FEATURES

PRODUCT TECHNOLOGY

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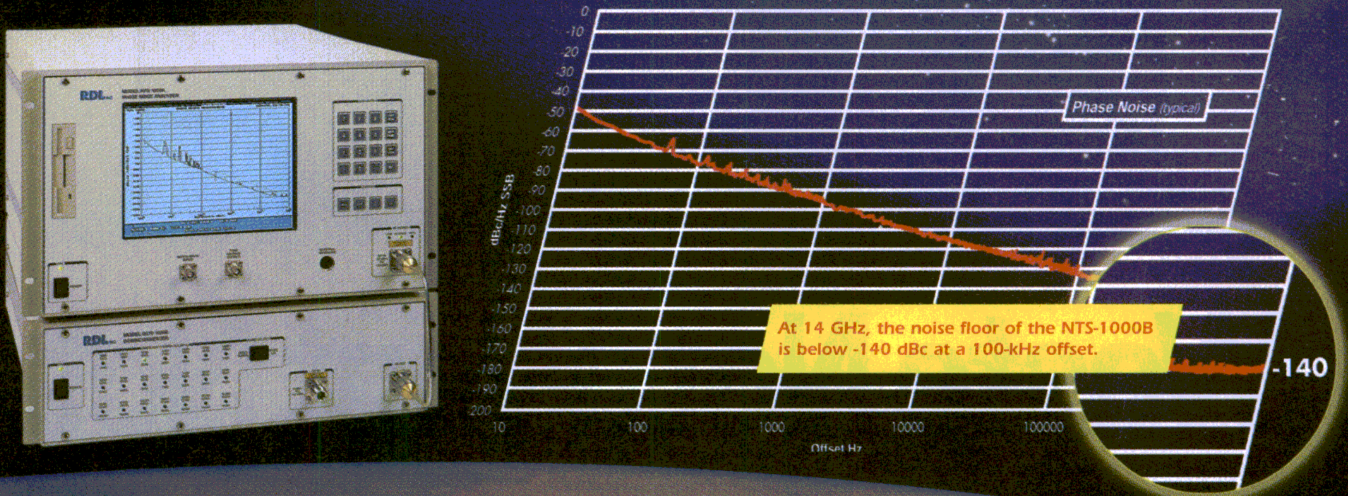

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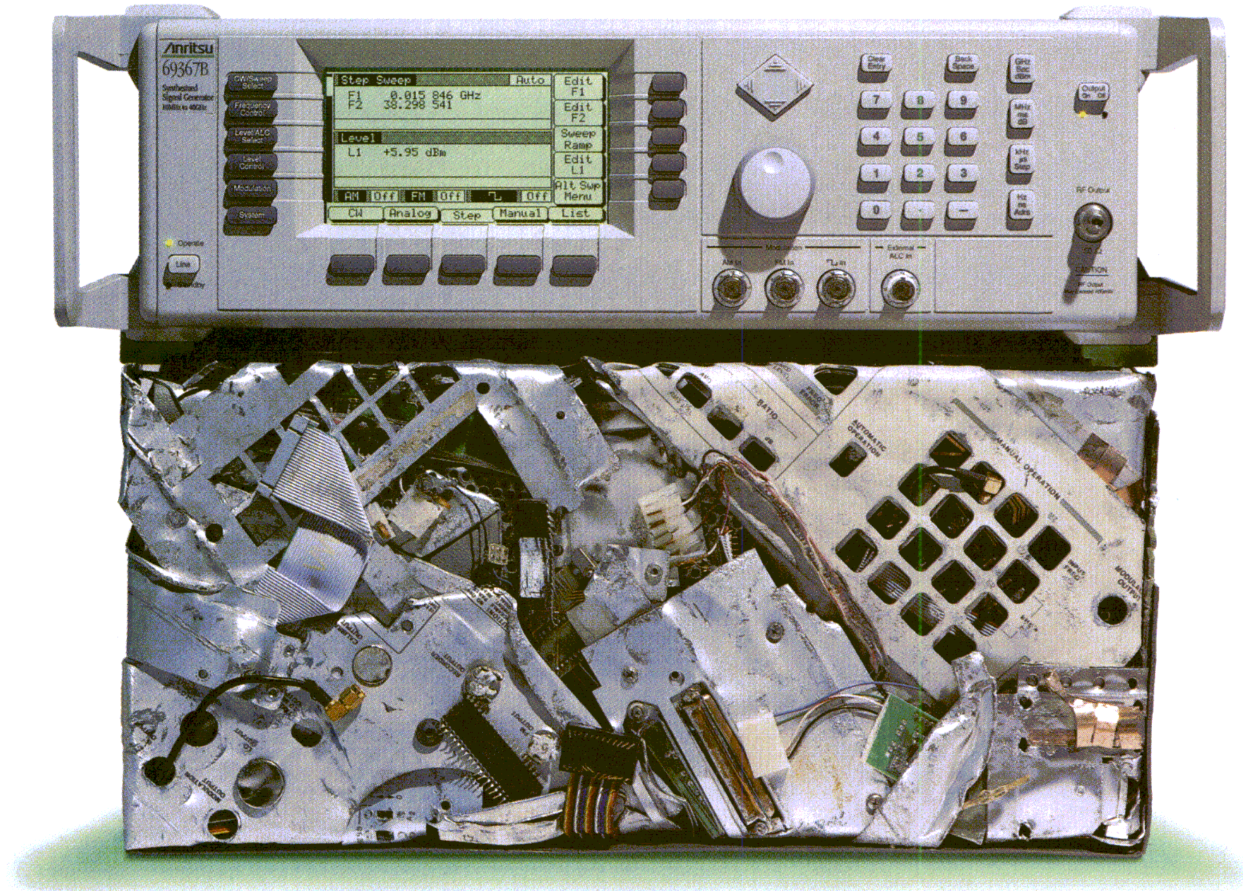

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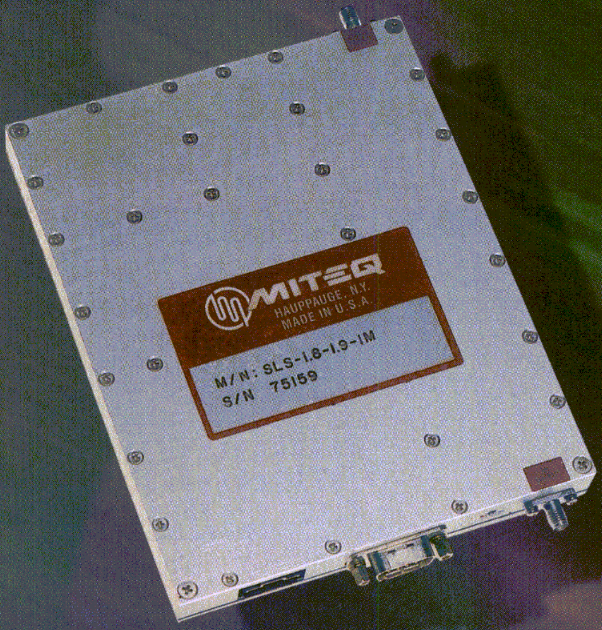

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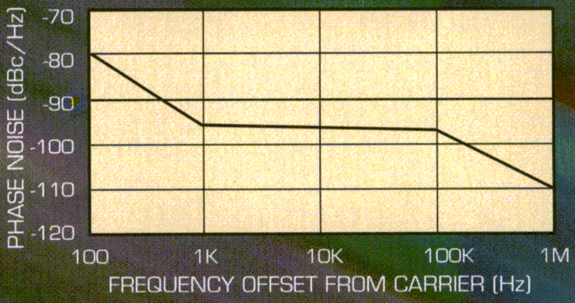

SPECIFICATIONS

MODEL	SLS SERIES
Frequency	1–15 GHz
Frequency step size	200 kHz to 10 MHz
Tuning range	Up to half octave
Switching speed	500 µs*
Output power	10 dBm min.
Output power variation	±2 dB min.
In band spurs	70 dBc min.
Harmonics	20 dBc
Phase noise	See graph
Reference	Internal or external
External reference Frequency Input power	 5/10 MHz 3 dBm ±3 dB
Frequency control	BCD or binary
DC power requirement	+15 or +12 volts, 200 mA 5.2 volts, 500 mA
Operating temperature	-10 to +60°C
Size	5" x 6.5" x 0.6"

* Acquire time depends on step size (low as 25 µs).

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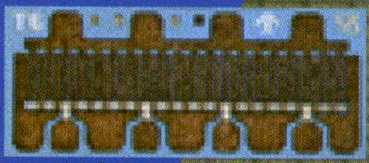

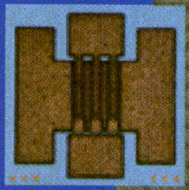

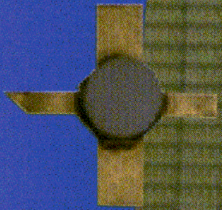

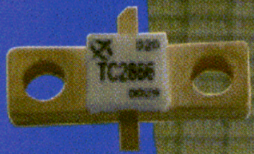

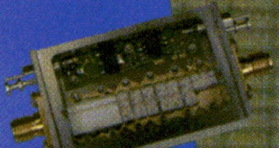

Low Noise GaAs FETs

Product No.	Frequency (GHz)	NF (dB)	P-1 (dBm)	G-1 (dB)	Type
TC1101	12	0.6	17	13	Chip
TC1201	12	0.6	21	13	Chip
TC1301	12	0.6	23	12	Chip
TC2261	12	0.6	21	11	Package

GaAs Power FETs

Product No.	Frequency (GHz)	P-1 (dBm)	G-1 (dB)	IP3 (dBm)	PAE (%)	Type
TC1402	12	27	8	37	35	Chip
TC1502	6	30	13	40	43	Chip
TC1591	6	30	13	40	43	Chip/Non-Via
TC1602	6	33	12	43	40	Chip
TC1802	2.45	36.5	13	47	40	Chip
TC2866	2.45	36.5	12.5	47	40	Package

Amplifiers

Product No.	Frequency (GHz)	Gain Flatness (dB)	G-1 (dB)	NF (dB)	P-1 (dBm)	IP3 (dBm)	Input VSWR	Output VSWR
TC5381	5.9-6.9	±1	48	3	39	49	2:1	2:1
TC5521	12.5-15.5	±1	32	3	33	43	2:1	2:1
TC5901	0.8-5.5	+3dB Slope	20		25	34	2:1	2:1
TC4511	13.75-14.75	±2	30	3	30	40	2:1	2:1

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FORMULA QUESTION

To the editor:

Recently, I have had more time to read your magazine. I enjoy the Feedback section because I feel it reflects the democracy and might of our country and also of your magazine.

I have seen some papers in your magazine, however, that contain incorrect results with faint information.

In the December 1999 article on "Calculate Power In Gaussian-Modulated Wireless Systems," there is a formula (1) that represents the impulse response of a root-raised-cosine filter. This formula is really the impulse response of a raised-cosine filter, not its square root one. Formula (1) still has two printed errors compared to the correct one. In Fig. 1, a square unshaped pulse g(t) is shaped by a root-raised-cosine function f(t).

I do not understand the meaning of "shaped." f(t) is the response of a very narrow pulse, but g(t) is not a narrow one. If g(t) passes through a filter and has a response of f(t), the output is the convolution of both. To draw the curve f(t) in Fig. 1, there must be a value of "a" in formula (1). What is the value of "a"? As a result of this question, the other part cannot be reasoned out.

Fu-Nian Ku
Consultant
Rockville, MD

PROPER CREDIT

To the editor:

I get very upset each time that your articles come out in the magazine about Dick Moss inventing the Polyfet. In the November 2000 issue (p. 176), it stated that it was his transistor. This is not true.

If you care to check into this, you will find that Fred Quigg is the inventor, designer, and process engineer of the Polyfet. He did most of the fabrication of the wafers in San Jose, CA and the assembly in Newbury Park, CA. Later, Dick Moss left 3dBm and became the marketing manager at Polycore. The patent numbers are 5,121,176, and 5,179,032. Fred Quigg assigned the patent rights to Polycore.

I know that Fred did not want to embarrass Dick Moss or the magazine over the situation, but each time Dick Moss gets the credit for Fred Quigg's transistor, it hurts.

Dixie Lee Quigg
President
Point Nine Technologies, Inc.
Newbury Park, CA

FIGURE ERRORS

To the editor:

In the August 2000 issue, the article "Modulation Schemes Affect The Linearity Of An HBT Amp" contained some figure errors. We apologize for the mistakes that we discovered. Basically, the drawing for Fig. 2 should be for Fig. 4. Figure 4 should be Fig. 5, and the drawing for Fig. 5 should really be for Fig. 2. Our website, http://www.eiccorp.com, contains the revisions.

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FABRICATION

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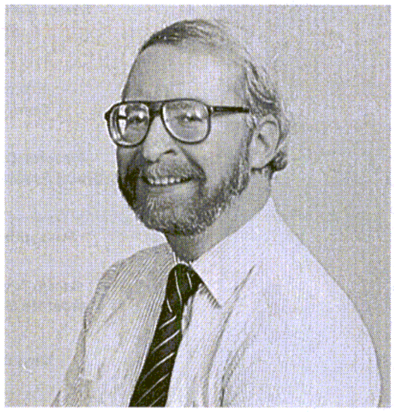
LOOKING BACK AND LOOKING AHEAD



Some may say that this was the first year of the new Millennium, while some may think of it as the last year of the old Millennium. In any case, it was a year that was representative of these strange and uncertain times. It was a year when financial markets finally started to take on the nature of a bear rather than a bull, and it was a year when investor confidence, which has been strong in the previous decade, began to decline. Perhaps the most symbolic event of these strange times is the manner in which America has chosen its next President—as of this writing, last month's election is still not decided.

The end of any year is always a good time for reflection. Such reflection is important. Without it, life appears to be too much of a continuum, without stopping (or resting) places. This issue, in fact, is representative of this philosophy, with several articles that take "a look back" at what occurred during the year. On p. 29, for example, senior editor Gene Heftman reviews some of the key events of 2000 and what effects they had on the high-frequency industry. Page 173 begins coverage of the traditional Top Products awards. The article recognizes some of the important engineering feats of the year, on the component, system, and test-equipment levels. This recognition implies that credit should be given to the marketing efforts of these same companies. They got the word out on these engineering developments, making it possible for a magazine such as this to provide information to its readers.

This was a year where formerly novel device technologies—silicon germanium (SiGe) and silicon carbide (SiC)—gained ground. And several companies, including Radiata (San Jose, CA), announced integrated circuits (ICs) capable of working past 5 GHz with "old-fashioned" silicon (Si) technology. It was a year when technical conferences touted a future electronics industry dominated by extremely low-power single-electron transistors.

What lies ahead? All we can offer of the future is a summary of the technical topics planned for next year's editorial calendar, which is as follows:

Issue	Theme
January	Semiconductors
February	Fiber-Optics Technology
March	Wireless Technology
April	Military Electronics
May	MTT-S Show Issue/Radar & Antennas
June	Communications
July	Test Equipment
August	Wireless Applications
September	Amplifiers & Oscillators
October	Integrated Circuits
November	Military Electronics
December	Wireless Show Issue/Communications

Jack Browne

Publisher/Editor

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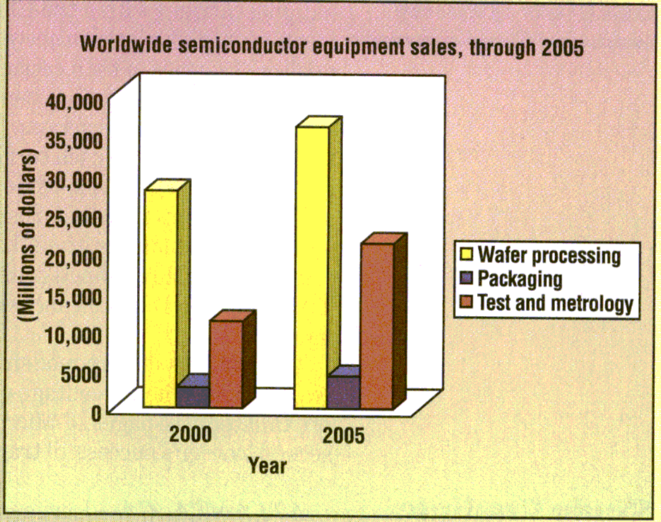
Semiconductor Equipment Market To Reach $61 Billion By 2005

NORWALK, CT—The semiconductor industry is a growing but cyclical market. Due to this, the semiconductor equipment market trails it by approximately one year in sales changes. The semiconductor industry is capital intensive. It takes more than $1 billion to construct a new fab with a lead time of 12 to 18 months. With the long lead time of construction and high equipment cost, it is imperative to make the best equipment decisions so that the fab does not become obsolete quickly.

According to *RG-247 Semiconductor Process Equipment*, a study from Business Communications Co., Inc., the worldwide market for semiconductor equipment sales is expected to cross $41 billion in 2000. To reach the goal of $200 billion worldwide semiconductor sales, new fabs for semiconductor fabrication are under construction worldwide. Their new equipment will handle submicron geometry integrated circuits (ICs) and larger, 300-mm silicon (Si) wafers. The ICs manufactured on these new lines will have up to 0.5 billion transistors and 10,000 m of electrical conductors.



The worldwide semiconductor market is likely to grow at an average annual growth rate (AAGR) of 8.3 percent during the five-year forecast period, and is thus expected to reach $61.3 billion by 2005 (see figure).

The wafer-processing end of the semiconductor-equipment market is expected to maintain its dominance through the five-year forecast period, as it grows at an annual average growth rate (AAGR) of 5.5 percent to reach $35.7 billion by 2005. In 2000, this sector comprises nearly 67 percent of the worldwide market.

FCC Approves Wireless Internet Trial License

SAN JOSE, CA—ArrayComm, Inc. announced that the Federal Communications Commission (FCC) has awarded a spectrum license to the company that will trial its i-BURST™ wireless Internet system commercially in San Diego, CA. Optimized to provide low-cost portable broadband access for businesses and consumers, the i-BURST system will enable a wide range of applications, such as telemedicine, high-speed file transfer, streaming audio and video, and networked gaming.

i-BURST is an access system that can deliver in excess of 40 Mb/s in a 10-MHz slice of spectrum, for online access to the full range of rich media applications that the Internet has to offer, through laptops, palmtops, and next-generation fixed and portable Internet appliances. ArrayComm and its partners will deliver user data rates of 1 MB/s or more—even when the network is operating at full capacity—at costs similar to today's dial-up Internet access.

The commercial market trial in San Diego will service thousands of users beginning in mid 2001. Full-scale commercial deployment blanketing the nation's top 100 metropolitan areas will follow.

"The intent of this trial is to demonstrate the commercial viability of an advanced technology that allows users to experience a vast range of applications and services within a portable broadband Internet system at very low cost," says Nitin J. Shah, ArrayComm executive vice president and general manager for i-BURST. "We are grateful to the FCC for having the vision to showcase this highly spectrally efficient system in a major commercial trial."

i-BURST leverages ArrayComm's patented IntelliCell@adaptive-array-antenna (spatial-processing) technology enabling networks that can deliver 400 times the performance of third-generation (3G) systems currently in development.

Differences Found In Wireless Internet Service Quality

CHICAGO, IL—Wireless Internet services still vary significantly from carrier to carrier. Telephia proved this as it collected wireless data-network performance information live from the convention floor at the Personal Communications Industry Association's (PCIA's) GlobalXChange 2000.

In the first test of its kind, Telephia tested the wireless Internet networks of two major national carriers within the Chicago market on the first day of the PCIA show and found meaningful differences in network performance. The testing measured the availability and quality of service of both carriers' wireless 'dial-up' and Internet browsing services inside the McCormick conference center.

In testing the two carriers, Telephia first measured how quickly a phone could access the Internet through each carrier's portal. Telephia found that one carrier had an average connection time of 21.4 s, while the average connection time for the second carrier was 2.6 s. The maximum time that a user had to wait for a connection on the first carrier's network was 150 s. The longest time that a user had to wait for a connection to the second carrier was 17 s. Telephia defined connection time as the period between when a user presses the TALK or SEND button and when the portal browser actually appears successfully on the handset.

The wireless dial-up modem performance was also significantly different between the two carriers. The percentage of successful transfers of a 75-kB file—the equivalent of approximately six pages of Microsoft Word text—for the first carrier was 75 percent. The second carrier's successful transfer rate was only 24 percent.

Study Predicts Properties Of Si Nanowires

ATLANTA, GA—Large-scale simulations of silicon (Si) nanowires measuring several atoms in diameter have provided device designers with new clues as to how these nanometer-scale devices will one day perform. The work provides a basis for anticipating how the quantam mechanical effects that dominate material of this size scale will alter the operation of future electronic devices.

Writing in a recent issue of *Physical Review Letters*, Uzi Landman, Robert Barnett, and Andrew Scherbakov from the Georgia Institute of Technology, and Phaedon Avouris from the IBM T.J. Watson Research Center, report on a number of issues pertaining to the atomic structure, electronic properties, and electrical transport in Si nanowires that will have to be considered by designers using devices this small.

To boost speed and reduce energy use, engineers are being pushed to make electronic devices smaller and to pack more of them onto a chip. This pressure will eventually drive them to use features as small as 1 nm (one-billionth of a meter, or a hundered-thousandth the width of a human hair). When that happens, device operation will be dominated by quantam mechanical effects—and the expectations that have long governed device design will no longer apply.

CAD Data Store Supports Open Account Purchases

PALO ALTO, CA—Agilent Technologies, Inc. announced recently that the Agilent CAD Data Store (http://www.caddatastore.agilent.com) now supports online purchases using its "Open Account" format in addition to the existing credit-card method.

The Agilent CAD Store helps printed-circuit-board (PCB) designers and librarians increase quality and reduce the time spent in creating the computer-aided-design (CAD) data (symbol and footprint) for parts used in designs. The CAD Data Design Store offers a data base of commonly used parts with the respective electronic CAD data for sale online. Parts are available from more than 1000 component vendors worldwide and range from resistors and connectors to large digital integrated circuits (ICs).

Users can search the CAD Data Store for parts without charge by parametric values, manufacturer part number, keyword or component type, and view the symbols and footprints before purchasing. After registering, users can purchase, download, and instantiate the CAD data directly into the schematic of their PCB tool.

Agilent encourages customers to try out the service by registering, installing the Eeserve client software, and downloading any of the free parts listed on the home page. The CAD Data Store presently supports Mentor Graphics Board Station and Mentor Graphics Expedition PCB (previously sold by VeriBest) tool sets, while Agilent plans to support all major PCB tools.

Fiber Makers To Double Capacity

NEWPORT, RI—A fiber shortage that began in 1999 and will continue at least through 2002 has caused major fiber makers to invest $2.6 billion this year in capacity expansions. The expansions will boost worldwide capacity by 97 percent from 77 million fiber-km in 1999 to 152 million fiber-km in 2001, according to a KMI study, *Worldwide Markets for Optical Fiber and Fiberoptic Cable.*

The surge in announced capacity expansions comes on the heels of 38-percent growth in worldwide cabled-fiber demand in 1999. North America showed the strongest growth as network operators in long-haul, local, and cable-television (CATV) applications continued to build out their networks. Europe also showed significant growth as pan-European operators installed 4.5 million fiber-km in 1999. Several of the major US carriers contributing to this demand include long-haul carriers, Qwest, Williams, Level 3, and Broadwing.

A combination of more operators building larger networks using higher fiber-count cable with non-zero dispersion-shifted fiber exacerbated the tightness in supply. Production rates of non-zero dispension-shifted fiber (NZDSF) are slower than those of conventional single-mode fibers (CSMFs), which adversely affected the industry's ability to meet demand.

Portable Fuel Cell Shipments To Explode By 2007

OYSTER BAY, NY—Direct methanol fuel cells will be the most widely used, early technology of micro fuel cells. The rapid global expansion in the use of cellular phones, portable personal computers (PCs), personal-digital-assistant (PDA) devices, and the emergence of new mobile equipment to use with these devices, will continue to fuel market growth for high-end power supplies, particularly micro fuel cells. Portable fuel cells will enter the market with 50,000 units shipped in 2002. That number is expected to surge to 200 million units annually by 2007.

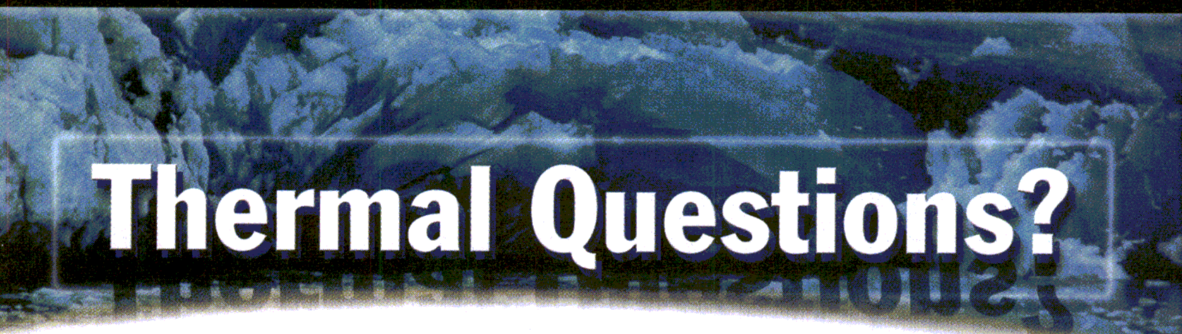
According to "Portable Fuel Cell Markets—Global Portable Fuel Cell Opportunities In Portable Applications With An Intense Focus On Wireless Applications," a report from Allied Business Intelligence (ABI), wireless handsets are the initial market for the first wave of portable fuel cells, which are miniaturized, replenishable energy devices.

"Portable fuel cells have the real potential of being profitable in a shorter time span than either stationary or automotive fuel-cell applications," says ABI senior energy analyst Atakan Ozbek, the report's author.

"Portable fuel cells will initially enter the market in large quantities to serve the high-growth wireless handset sector in the US. Japan and Europe will catch up and should take the lead by the second half of this decade," states Ozbek.

Kudos

Alpha Industries, Inc. has been named to *Forbes* magazine's annual list of the 200 Best Small Companies in America. Alpha ranked 138th overall on the *Forbes* list, which requires companies to exceed specific financial requirements based on value and growth...Keithley Instruments, Inc. was recently recognized by Ohio Governor Bob Taft as the 2000 Edison Award winner during a ceremony at the Center of Science and Industry (COSI) in Columbus, OH. Sponsored by the Ohio Department of Development and its Thomas Edison program, the Edison Award recognizes one outstanding Ohio company or organization that has demonstrated global leadership in fostering or implementing innovation. The award honors a firm that uses technology to impact not only its own operations, but also the quality of life in its community, the state of Ohio, and around the world...The US Patent and Trademark Office has awarded a patent to CTS Corp. for Resistor Network with Solder Sphere Connectors. The ball-grid-array (BGA) packaging virtually eliminates parasitic capacitance and lead inductance, major causes of poor performance of resistor networks in high-frequency data busses...Tality Corp. will provide $500,000 in sponsorships to Scotland's University of Edinburgh for the university's top electrical engineering students. The Tality five-year master program will provide internships, mentoring, and financial assistance with costs at the university...EMCORE Corp. has been named to Deloitte & Touche's "New Jersey Fast 50" program, which ranks the 50 fastest-growing technology companies in the state. EMCORE has had a five-year revenue growth rate of 222 percent. Deloitte & Touche computed all the calculations of revenue growth rate and rankings.



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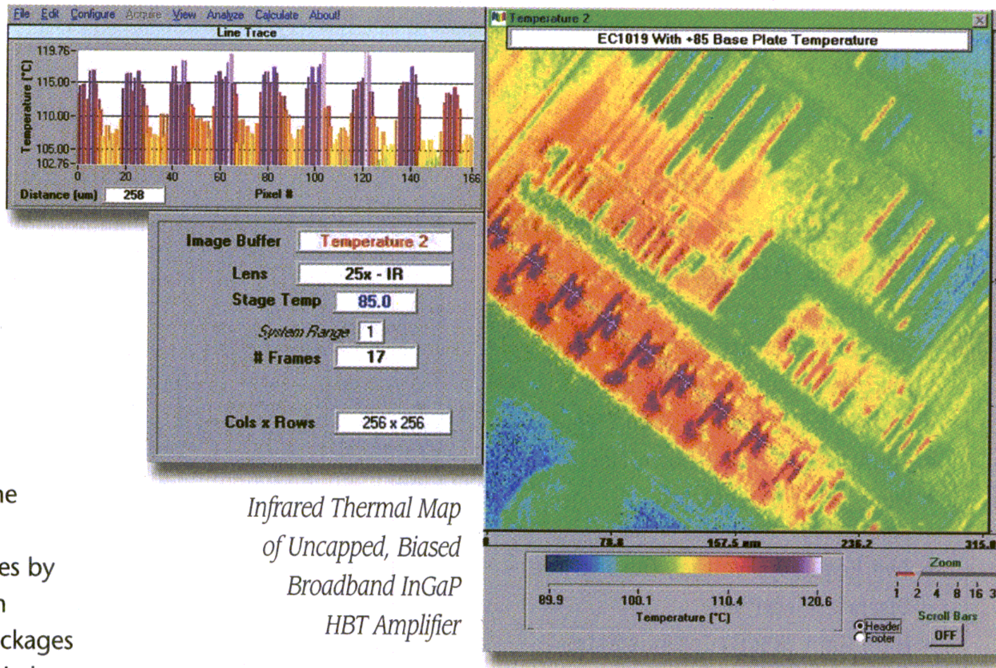

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ECG004	15dB	12dBm	26dBm	280° C/W	35°C	DC-6 GHz
ECG002	20dB	15dBm	29dBm	233° C/W	40°C	DC-6 GHz
ECG006	15dB	15dBm	30dBm	278° C/W	50°C	DC-6 GHz
ECG003	20dB	23dBm	39dBm	50° C/W	45°C	DC-3 GHz
ECG008	15dB	23dBm	40dBm	55° C/W	55°C	DC-3 GHz
ECG009	19dB	24dBm	41dBm	85° C/W	65°C	DC-2 GHz
ECG011	20dB	8dBm	20dBm	355° C/W	47°C	DC-6 GHz
ECG012	14dB	20dBm	36dBm	120° C/W	45°C	DC-2.5 GHz
EC-1089	15dB	23.5dBm	>42dBm	~85°C/W	~65°C	DC-2.5 GHz
EC-1019	18.5dB	19dBm	34dBm	120°C/W	40°C	DC - 3 GHz
EC-1078	19.5dB	21dBm	37dBm	120°C/W	60°C	DC - 3 GHz
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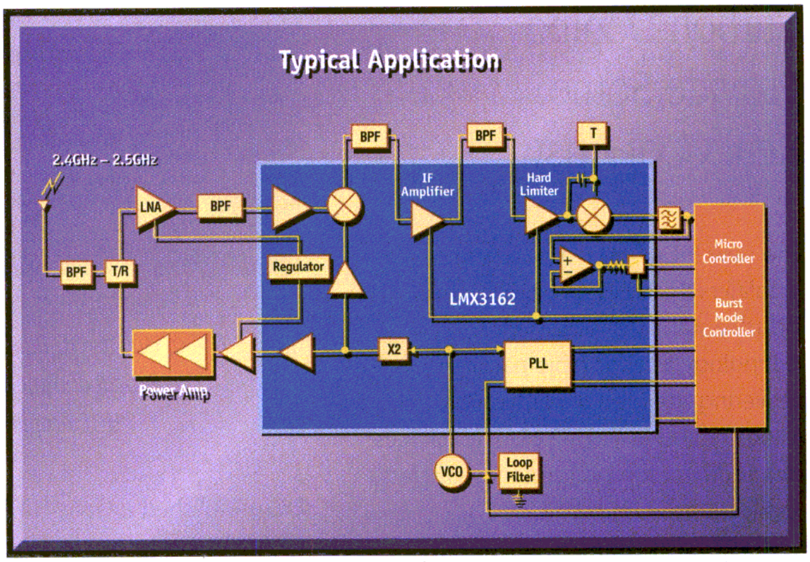

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Year In Review

A healthy dose of reality is reigning in the growth of communications companies who thought that there was nothing but clear sailing ahead.

Turbulence Muddies The Telecom Waters

GENE HEFTMAN
Senior Editor

AS the recent US presidential election proved, reaching premature conclusions can lead to confusing, erroneous, and unintended consequences. The same can be said of the telecommunications industry and its wireless communications offspring, which for the past few years have coasted merrily along, racking up profits, drawing new customers, and making large investments in infrastructure. It seemed as though it would be business as usual this year as communications continued to grow into the biggest and most important business in the world. But the pain and suffering of the most powerful companies of these industries in the last 12 months shows that that conclusion, like the election results, was premature. The broad perspective of it all comes from Wall Street, where the Nasdaq Composite Index, which on November 20, 2000 hit 2871.45, establishing a 52-week low, was down 43 percent from its 52-week high of 5048.62 in March. Since the Nasdaq is so heavy with high-technology stocks, it serves as the bellwether for all of the communications, computer, Internet, biotechnology, and other industries that are the backbone of the modern technological information economy. Although business conditions in the US tend to hog the media spotlight, the weakness in communications, like the industry itself, is worldwide.

The big telecom news of the year hit on October 30, 2000 when AT&T (Basking Ridge, NJ) the largest domestic long-distance carrier, announced that it would split itself up for the third time in its 125-year history, this time into four separate companies. The reasoning was that four smaller companies would be able to respond faster to the dynamic communications-market conditions and have better access to capital than a single mega-company. This decision is noteworthy, since the business strategy of the big telecoms over the past few years was to build global telecommunications giants that could offer consumers a basket full of information services: local calls, long distance, wireless, Internet access, multimedia, etc. It turns out that consumers are not as interested in this one-stop shopping approach with a single integrated bill as the carriers hoped. But AT&T's woes—the stock is down to approximately \$20/share from \$61 over the last year—were not unique as other big telecoms danced to the same music.

Not long after AT&T's reorganization, WorldCom, Inc. (Clinton, MS), the second-largest domestic long-distance carrier announced that it too would turn into a leaner, meaner, and smaller version of itself in order to better compete in the market. It also projected lower sales and profits for the coming year. The culprit for both telecom giants is the slowdown in the growth of the traditional core businesses; local and long-distance services. This is a result of price wars and competition from the regional Bell telephone companies. The shares of WorldCom met a fate similar to those of AT&T—down 55 percent this year after almost tripling over the past five years. Sprint (Westwood, KS), another leader in the telecommunications industry, has seen share prices plummet from a high of \$76 per share to approximately \$23 in early November.

Not surprisingly, the fortunes of European telecoms are similar to those of their US counterparts. A case in point is the short saga of British Telecom (BT) [London, England], which was under fire a year ago for not being deep enough in debt. That is, it was encouraged to borrow to swallow up smaller competitors in order to keep pace with its large competitors. It did just that. This year, the tables are turned. Financial analysts are telling the company to sell off those acquisitions to reduce its massive debt, expected to reach \$43 billion next year.

The dominoes continue to fall. National telephone companies such as Deutsche Telekom, France Telecom, and Royal KPN are being forced to scale back expansion in the face of rapidly rising debt to acquire third-generation (3G) phone licenses. Holders of these licenses hope to reap the rewards of electronic commerce (e-commerce) made possible by the high-speed data communications of the next generation of mobile telephony. If these phone giants continue with the high-stakes gamble of building of high-speed mobile networks, it will cost approximately $150 billion for the licenses won in government-run auctions and a similar sum to construct the networks over the next few years. To put these numbers in perspective, BT, France Telecom, and Telecom Italia are trying to add $25 billion in debt in this last quarter of the year alone. This is 75 percent of the debt acquired by all telecommunications companies for the first nine months of the year. One way to raise this kind of cash is to split a company up—à la AT&T—rather than last year's strategy of building it bigger through mergers and acquisitions.

CATCHING COLD

When the big telecoms start to sneeze, companies that supply the gear that builds the infrastructure catch a cold. Many of the sickly infrastructure suppliers are among the biggest names in the communications industry. In late October, Lucent Technologies (Allentown, PA), the world's largest telecommunications-equipment manufacturer, fired its chairman and chief executive officer (CEO), Richard McGinn. Most of Lucent's problems stem from a failure to take advantage of opportunities in the optical networking market. The company failed to foresee its customers desire to shift away from traditional telephone-switching networks and into high-speed fiber-optic systems. Needless to say, the company's short sightedness has shaken investor confidence badly. The stock, which traded at up to $78 in the past year, is now in the low $20s.

Although Lucent's woes may be a result of its own miscalculations, telecommunications-industry analysts believe that the big telephone companies will be forced to scale back their capital spending by up to 30 percent from earlier this year. That, of course, means less business for the suppliers of that equipment and diminishing expectations.

Also on the receiving end of a cold—although not as bad as Lucent's—was Nortel Networks (Brampton, Ontario, Canada), another leading supplier of equipment for optical networking. The funny thing about the optical-equipment business is that it is expanding and there is tremendous demand for fiber networks. Nortel, in fact, reported an increase of 90 percent in its optical revenue, yet it was hit hard by investors who apparently expected even better performance. The success of this technology has led investors to place unrealistic valuations on the shares, so failures by the company to meet forecast goals leads to large sell-offs. As Nortel took ill, it gave its disease to many smaller players in the optical business.

A third key optical-infrastructure supplier hit hard by projections for slower growth was Cisco Systems (San Jose, CA), a darling of the high-technology industry, and at one time, the market-capitalization leader of all US companies. Analysts downgraded the company in the fall because of a looming reduction in infrastructure spending in the first half of next year.

RELYING ON DATA SERVICES FOR GROWTH COULD TURN OUT TO BE LESS REWARDING THAN IT APPEARS ON THE SURFACE.

Just as cutbacks by big telecoms affect the business of network-equipment suppliers, those suppliers, in turn, impact companies one level down the food chain from themselves, the integrated-circuit (IC) manufacturers. Soon after Lucent, Nortel, and Cisco's problems became public knowledge, companies that supply them with ICs took a nosedive based on the fact that there would be fewer orders for semiconductors in the months ahead. For more on this aspect of the story, see "Report Sparks Slide Of Comm ICs" in this issue of *Microwaves & RF* (p. 36).

Telecommunications companies caught up in the decline of the pricing of traditional long-distance and local-phone service are looking to data as the next great wave of technology that will pull their irons out of the fire. AT&T, for example, is now the country's largest cable-TV operator, providing it with the opportunity to offer broadband distribution of high-speed Internet access (data) and other phone and data services, along with TV programming.

Relying on data for growth, however, could turn out to be less rewarding than it appears on the surface. A recent report on telecommunications concluded that bandwidth is increasing at the phenomenal rate of 79 percent a year to provide users with the ability to speed data ever faster over conventional and optical lines. While technology can supply this greater bandwidth, demand for it is increasing at the much-slower rate of 62 percent a year, according to the report. If this trend continues for the next few years, bandwidth availability will far outstrip user demand for it, and this will affect every type of bandwidth, from long-distance phone calls to the Internet. The net result will be a decline in prices for data services and a less rosy scenario for companies that were counting on this medium for the path to profitability. The effect of cheaper bandwidth is already having an effect on some large Internet-service providers (ISPs) who have reported lower revenues and profits in the past few months.

MACRO TO MICRO

While communications has gone through a rough year as an industry, the bottom line is will individual customers continue to support the industry in record numbers as they have done over the last few years? On the surface, the wireless phone business—the most-dynamic segment of the communications industry—continues to move at a rapid clip in signing up new subscribers, as evidenced by data collected by the Cellular Telecommunications Industry

Association (CTIA) [Washington, DC], the largest wireless communications trade group. As of June 2000, the CTIA estimated total US subscribership to be approximately 97 million, which is an increase of 20 million over June 1999. With new users signing on at a rate of 10 million every six months, it is probably accurate to say that as of this writing, 100 million Americans are wireless phone users.

Do these figures mean that everybody is happy? One way to judge this is to ask them, as is done each year by the CTIA when it contracts with Peter D. Hart Research Associates (Washington, DC) to conduct a survey among phone users. The questions posed in this year's report ("The Wireless Marketplace in 2000," February 2000) explored people's perception of the value of wireless phones and their interest in new wireless data services now getting underway.

Many of the results of the Hart Survey remain remarkably consistent over the five years that the report has been published. For example, phone users do not have much loyalty to their service providers, a view that has remained steady over the years. Only 30 percent of users are extremely loyal to their current provider and another 22 percent are very loyal. So, put another way, approximately half of all users are not satisfied with some aspect of the service provided by their companies. Phone providers should be aware that user dissatisfaction is growing. In 1996, 70 percent of users were satisfied with their services, while in 2000, only 52 percent expressed the same sentiment.

To see people with wireless phones glued to their ears in public places and while driving automobiles, the conclusion might be that the phone is absolutely indispensable. When asked if they could give up their wireless phone for a period of three months, almost half (45 percent) of users said it would not be a problem. For 17 percent of users, giving up the phone for three months would pose a real hardship. Another 36 percent said it would be a problem that would require some adjustment in their lives.

Since many telecommunications-service providers are counting on data to offset the decline of local and long-distance voice traffic, it is instructive to see what the Hart Survey found when it questioned users on their desire for wireless data services. As the report admits, such services are still in their infancy, so users have had little time to evaluate what is available and how to use it. The top-line results are that eight out of 10 phone users are satisfied with the services presently available. Only 18 percent want additional features and services. New users are slightly more interested in new services than are longtime users by a margin of 21 percent to 18 percent.

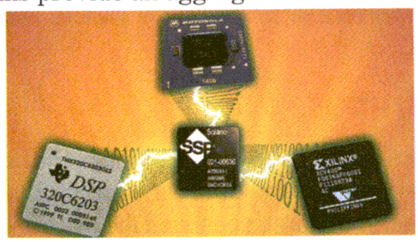
The survey reports that interest in Web-enabled wireless phones is concentrated among 25 percent of phone owners who have a strong (13 percent) or quite a bit (12 percent) of interest in a phone that offers data services including Internet access, e-mail, online shopping, and text messaging. On the negative side, only 30 percent of subscribers have a mild interest in a Web phones, while the largest group, 44 percent, have no interest at all. Wireless data services appeal mostly to a select group of users: 18 to 34 year olds, of whom 42 percent have a high degree of interest in such services.

Wireless data services will make their greatest inroads with business users rather than those who use phones for personal needs, says the survey. Most important to this segment are the ability to send and receive e-mail, access their office computer network and other business applications, and send and receive text messages. Far down the list is the ability to purchase goods and services over the Internet.

From the results of the survey and the focus of telecommunications companies, it appears that service providers and phone users are somewhat out of sync. Providers want to push more data services while the majority of users express a ho-hum attitude. How this situation plays out in the coming year could determine how this year-end roundup will read in December 2001. ••

Communications IC provides 12.8 Gb/s

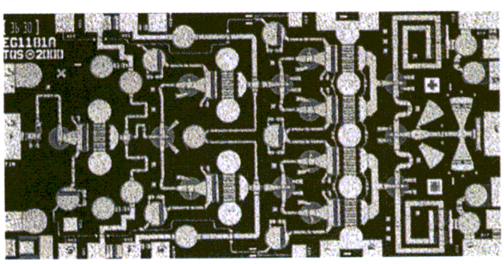
The Solano communications integrated circuit (IC) provides high-bandwidth communications paths for multiple processors and input/output (I/O) modules. The chip has four full-duplex, high-speed, low-voltage-differential-signaling (LVDS) links. The four links provide an aggregate bandwidth of more than 12.8 Gb/s per node. The manufacturer claims that a data network implementing this IC provides higher system throughput than conventional buses or serial-link communications. The chip is typically connected to the external memory-interface bus of a digital signal processor (DSP) or other signal-processing device. **Spectrum Signal Processing, Inc., One Spectrum Court, #200-2700 Production Way, Burnaby, BC V5A 4X1, Canada; (604) 421-5422, FAX: (604) 421-1764, Internet: http://www.spectrumsignal.com.**



For more information, visit www.mwrf.com

Millimeter-wave amplifier spans 27 to 32 GHz

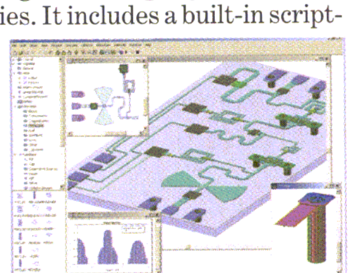
The model TGA1172 millimeter-wave amplifier operates from 27 to 32 GHz for wireless communication products such as point-to-point and point-to-multipoint radios, satellite earth stations, and spacecraft payloads. The pseudomorphic-high-electron-mobility transistor (PHEMT) gallium-arsenide (GaAs) three-stage amplifier provides 29 dBm (0.8 W) of output power at the 1-dB compression point and 18 dB of small-signal gain at 28 GHz. Typical input and output losses are 10 dB. The device draws 630 mA from a +5- to +7-VDC power supply, and requires a separate negative voltage supply for gate biasing. **TriQuint Semiconductor, Inc., 2300 NE Brookwood Pkwy., Hillsboro, OR 97124; (503) 615-9000, FAX: (503) 615-8900, Internet: http://www.triquint.com.**



For more information, visit www.mwrf.com

Software upgrade helps automate high-frequency design

Microwave Office 2000 Version 4.0, the latest release of this electronic-design-automation (EDA) software suite, integrates design synthesis with simulation and manufacturing methodologies. It includes a built-in scripting language that provides users with access to the software's underlying object model, enabling design synthesis and other design-automation features. It also includes nonlinear noise analysis and a harmonic-balance simulation engine, which the company says is orders of magnitude faster than previous versions. The layout editor has been enhanced to include interactive design-rule checking (DRC) and polygon-pushing capabilities for complex monolithic-microwave-integrated-circuit (MMIC) and RF IC layout. **Applied Wave Research, Inc., 1960 E. Grand Ave., Suite 500, El Segundo, CA; (310) 726-3000, FAX: (310) 726-3005, Internet: http://www.mwoffice.com.**



For more information, visit www.mwrf.com

Amplifier drives fiber-optic modulators

The model CMM3030 BD wideband gallium arsenide (GaAs) driver amplifier drives fiber-optic modulators to data-transmission rates of 13 Gb/s and beyond. The pseudomorphic-high-electron-mobility-transistor (PHEMT) monolithic microwave integrated circuit (MMIC) operates from 30 kHz to 30 GHz and has a gain of 1[illegible] dB and a maximum power output of +23 dBm. Typical output voltage is +7.5 VDC peak-to-

peak. The bias voltage can be adjusted to reduce the output voltage as needed. The amplifier boasts flat response and very-low internal jitter, which is said to make it especially well suited for high-speed digital data applications. **Celeritek, Inc., 3236 Scott Blvd., Santa Clara, CA 95054; (408) 986-5060, FAX: (408) 986-5095, Internet: http://www.celeritek.com.**

For more information, visit www.mwrf.com

Report Sparks Slide Of Comm ICs

An old saying that is striking a resonant chord with manufacturers of chips for the communications industry is "let the chips fall where they may." A report issued a few weeks ago by an analyst at investment house Merrill Lynch & Co. claims that manufacturers of telecommunications integrated circuits (ICs) will just cover the profit estimates of analysts over the next few quarters. For the preceding six quarters, those companies had told analysts to raise their estimates for future earnings. The report triggered a sharp response on Wall Street the following day, as the stocks of virtually all telecommunications-industry chip makers experienced substantial to moderate declines.

Leading the fall was Broadcom, a manufacturer of cable-modem and computer-network chips for infrastructure manufacturers such as Cisco Systems and Motorola, which dropped more than $25 a share to close at $144.50. PMC-Sierra gave up more than $18 to close at $113, while TranSwitch was off $7.19 to $38.06. Similar to Broadcom, both companies sell ICs heavily to telecommunications-infrastructure manufacturers. Even Integrated Device Technology (IDT), a company thought to be better positioned than the aforementioned three and a seller to Cisco Systems due to its new Internet-protocol (IP) coprocessors, dropped 2.4 percent in the wake of the Merrill Lynch report.

Underlying the softness in semiconductors are projected cutbacks in capital spending by the major telecommunications-equipment manufacturers. This is causing inventory buildups at these companies that will reflect back to the chipmakers in the form of smaller orders for ICs over the next few months. Cisco Systems, for example, the leader in networking equipment, said inventories of raw material had risen, and that could result in fewer orders for ICs down the road.

Infrastructure suppliers are feeling the pinch because larger telecommunications companies are putting more capacity online than customer orders would dictate. On the same day that the Merrill Lynch report was issued, BellSouth, the telecommunications giant serving nine southeastern states, announced that it would limit buying next year to cutback on network expansion. The company plans to reduce expenditures by $500 million, but it will still spend between $5.5 and $6 billion. BellSouth's retrenchment is another in a list of smaller capital investments by the large telecommunications companies. AT&T expects spending to level off, while WorldCom will cut back. These reductions dampen the prospects of the equipment manufacturers—Cisco, Lucent Technologies, Nortel Networks, etc.—and that, in turn, sends the IC markets into a tailspin. ••

Application Profile

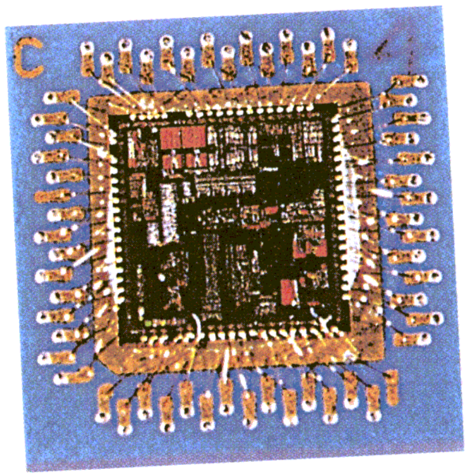
How to make Cell Phones Smaller and Lighter? BGA with Integrated Components using DuPont Green Tape™.

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

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

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

OEM designers are now learning that integrating IC and package design to take advantage of the



unique properties of Low Temperature Co-fired Ceramic (LTCC) technology can yield decreased size and improved performance in wireless devices.

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

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

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

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

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

DUPONT®

GREEN TAPE™ FODEL® BIROX® DIFFUSION PATTERNING™ LUXPRINT®

Contracts

M/A-COM SIGINT Products—Has been awarded a contract by the Naval Surface Warfare Center (NSWC) at Virginia Beach, VA to supply a large quantity of collection microwave receivers (Rxs) over a five-year period.

ITT Industries' Avionics Division—Was selected by The Boeing Co. to provide the integrated survivability system for the US Army's Comanche helicopter. Under this Engineering & Manufacturing Development (EMD) contract , ITT Industries will provide 14 aircraft survivability systems comprised of a radar-warning receiver (RWR), laser-warning receiver (LWR), and point chemical detector (PCD).

Motorola, Inc.—Has signed a third-generation (3G) contract with ALLTEL, the first 3G contract signed by either company in the US. The contract is for 3G code-division-multiple-access (CDMA) 2000 1x standards-based hardware and software, which are scheduled for installation in New Orleans and Baton Rouge, LA in 2001.

Andrew Corp.—Has won the contract to supply RF communications infrastructure for Chicago's Midway Airport Terminal Development Program. The network will provide essential communications for fire, police, and emergency services, as well as for the Chicago Dept. of Aviation.

ADC Telecommunications, Inc.—Has signed a three-year contract to supply its complete range of hybrid-fiber-coax (HFC) network equipment and services to Everest Connections, a St. Louis, MO-based broadband cable-network builder and alternative services provider. The agreement is estimated to be worth approximately $300 million over the next three years.

RF Micro Devices, Inc.—Has received production orders to supply power amplifiers (PAs) for Sanyo's latest dual-band code-division-multiple-access (CDMA) personal-communications-services (PCS) handset. Sanyo's customers include Sprint PCS. Volume shipments have begun and will rise to a multimillion-dollar level by the year's end.

Fresh Starts

BMI, Inc.—Announced its achievement of ISO-9001 certification across all manufacturing facilities in Palatine and Schaumburg, IL, as well as in Berlin, Germany. The standard is recognized internationally for assessing quality-management systems including product design, development, production, installation, and service procedures. ISO-9001 is the most comprehensive level of certification among the ISO-9000 family of international standards.

Hybrid Networks, Inc.—Announced that it will be the first to integrate Intel Corp.'s 3804 demodulator chip into its head-end equipment that will enable it to provide customers with near/non line-of-sight (LOS) Internet-access capabilities.

BAE Systems—Completed the sale of its Hazeltine commercial PHAZAR antenna product line to Antenna Products, Inc. of Mineral Wells, TX. The sale includes the planar-single-beam (PSB) passive antenna and the intelligent-antenna-system (IAS) lines.

Intersil Corp.—Signed a binding letter of intent (LOI) to acquire Scottsdale, AZ-based SiCOM, Inc. for approximately 3.7 shares of Class A common stock.

Agilent Technologies, Inc.—Announced that IBM Corp. has qualified Agilent's 2-Gb/s fiber-channel host-bus adapter (HBA) for use with its Ultrastar 36LZX hard drives. The qualification ensures customers of interoperability at higher speeds, a vital step in the storage-area-network (SAN) market's transition to 2-Gb/s fiber-channel solutions.

Discovery Semiconductors, Inc.—Announced that its 40-GHz positive-intrinsic-negative (PIN) photodiodes were used to establish a new record data-bit rate over a single optical fiber. Its model DSC20S modules received 128 channels of 40-Gb/s signals over the C and L wavelength bands, demonstrating transport of 5.12 Tb/s (5120 Gb/s) over 300 km. This is the first demonstration that 40-Gb/s electronic-time-division-multiplexing (ETDM) transmission is possible with the same number of channels as previously used with lower ETDM bit rates.

Motorola's Semiconductor Products Sector and Atmel—Announced a licensing agreement that will enable the companies to provide a reliable supply of RF bipolar complementary metal-oxide semiconductor (BiCMOS). The agreement allows Motorola to share its BiCMOS technology with Atmel. This will enable Atmel to immediately provide wireless original-equipment manufacturers (OEMs) with products that are designed in a process that is fully mask compatible with Motorola's 0.35-μm RF BiCMOS technology.

IFR Systems, Inc.—Has signed distribution agreements with LeCroy Corp. of Geneva, Switzerland for distribution of test products in Europe. IFR is involved in wireless test solutions. LeCroy is a supplier of digital oscilloscopes and test equipment.

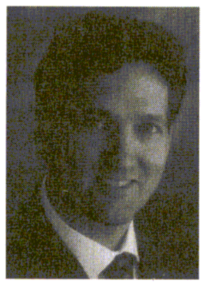
Honeywell and Rohde & Schwarz—Have agreed on a partnership in the field of military radio communications. The two companies will jointly market the Airborne Radio M3AR (Series 6000) from Rohde & Schwarz on the North American market. M3AR radio operates in the very-high-frequency (VHF)/ultra-high-frequency (UHF) band and features maximum transmission security and jam resistance.

Silicon Wave, Inc.—Completed its fourth round of financing with approximately $52 million infused into the company. The round includes new investments from 3Com Ventures, Access Technology, Alps Electric Co. Ltd., GTG Ventures, and Intersil Corp.

Radiant Networks and Motorola—Have signed an agreement under which the companies will jointly test and field trial Radiant Networks' Mesh technology. Mesh technology is a new generation of broadband-access technology that allows each subscriber to connect with its neighbors rather than a base station. Mesh architecture provides a high data-rate connection from the end operator's trunk network to the end customer's premises.

Ball Wireless Communications Products—Jim Potter to director; formerly vice president of strategic planning and program management for BI, Inc.

Advanced Hardware Architectures (AHA)—Jeff Presley to vice president of business development; formerly employed in business development with World Wide Packets.


PRESLEY


CAHLANDER

TriPoint Global's VertexRSI—Bernard Cahlander to vice president and general manager of the Santa Clara, CA facility; formerly vice president of TT&C systems.

Leitch Technology Corp.—John Margardo to regional sales manager for the New England and upstate New York territories; formerly Northeast sales manager at Sigma Electronics.

BMI, Inc.—Ronald Thompson to general manager of the BMI Metronics Shields division; formerly vice president of operations at Knowles Electronics, Inc. Also, Robert M. McCoy to logistics manager; formerly inventory manager with Total Control Products, Inc. In addition, Valerie L. O'Connor to vice president of people-centered services; formerly director of human resources for Dudek & Bock Spring Manufacturing Co.

CTS Corp.—Patrick J. Dennis to senior vice president of finance and chief financial officer (CFO); formerly vice president and corporate controller with Johnson Controls, Inc. Also, James A. Hart to vice president and general manager of the RF Crystal and Oscillator Products business unit; formerly worldwide operations manager at Ingersoll-Rand. In addition, Chang-Min Sohn to sales manager of the CTS Korea Branch Sales Office in Seoul; formerly manager of sales for Seoul at LSI Logic.

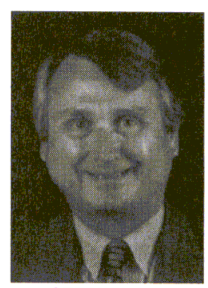
AirNet Communications Corp.—John C. Behrens to chief financial officer (CFO); formerly vice president at Glenayre. Also, Richard K. Beckley to vice president of international sales; formerly senior vice president of worldwide sales with Telular Corp.

TestMart—Michael Comstock to vice president of operations; formerly vice president of e-commerce and planning at DHL.

WIDCOMM, Inc.—Martin A. Caniff to vice president of engineering; formerly president of Doctor Design, Inc.

Cerprobe Corp.—Mike Sykes to vice president and chief information officer (CIO); formerly vice president of information services and CIO at On Command Corp.

CenturyTel—Mike Czerwinski to vice president of competitive local-exchange carrier (CLEC) and long distance; formerly president of EATEL.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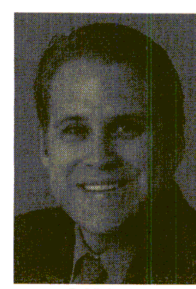
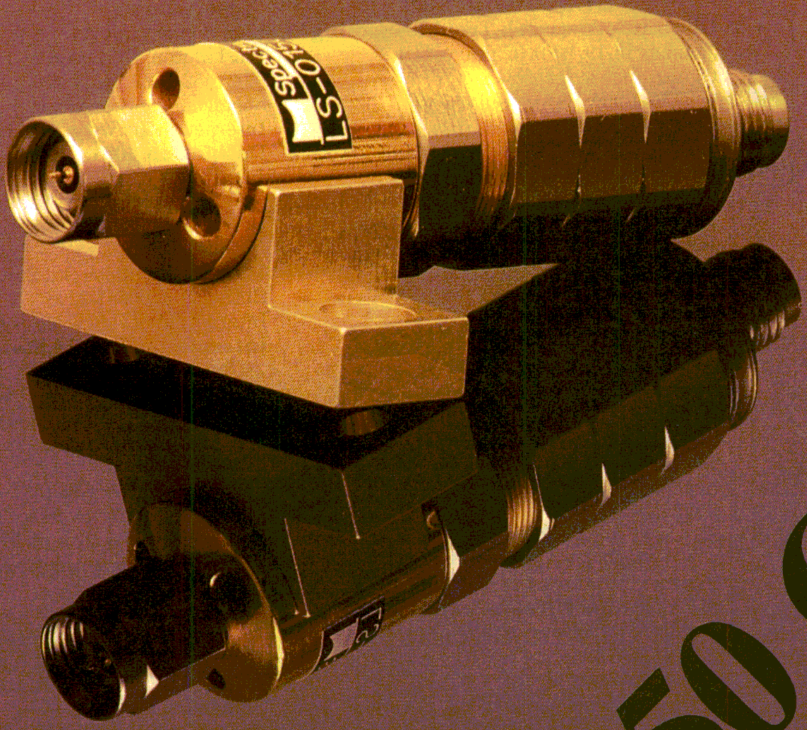

BARTLEY

Quad Systems Corp.—Russell Bartley to director of field service; formerly field-service manager for the central region of the US.

Scott Specialty Gases—Leanne Merz to director of e-business; formerly product manager.

Aegis Broadband, Inc.—Edward Triebell to Asia-Pacific managing director; formerly Asia-Pacific regional sales director for L-3 Communications' Commercial Products Group.

Bell Industries, Inc.—Ramon Martinez to operations manager of the J.W. Miller Division; formerly Lawson (ERP) business manager.



EDUCATIONAL MEETINGS

Short Courses

Cisco Internetwork Troubleshooting
January 15-19, 2001 (Chicago, IL)
Global Knowledge
9000 Regency Pkwy., Suite 500
Cary, NC 27511
(800) COURSES, FAX: (919) 461-8646
Internet: http://am.global knowledge.com/ciscocerts

RF and Microwave Receiver Design
January 22-24, 2001 (Orlando, FL)
R.A. Wood Associates
1001 Broad St., Suite 450
Utica, NY 13501
(315) 735-4217, FAX: (315) 735-4328
e-mail: rawood@rawood.com
Internet: http://www.rawood.com

Mobile Communications and Wireless Networks
January 23-26, 2001 (Washington, DC)
Learning Tree International
1805 Library St.
Reston, VA 20190-5630
(800) 843-8733, FAX: (800) 709-6405
Internet: http://www.learningtree.com

Short Range Wireless and Bluetooth
January 31-February 2, 2001 (Mountain View, CA)
Besser Associates
201 San Antonio Circle, Bldg. E
Mountain View, CA 94040
(650) 949-3300, FAX: (650) 949-4400
e-mail: info@bessercourse.com

Meetings

2001 Consumer Electronics Show (CES)
January 6-9, 2001 (Las Vegas, NV)
Consumer Electronics Association
2500 Wilson Blvd.
Arlington, VA 22201-3834
(703) 907-7605
Internet: http://www.CESweb.org.

SUPERnet 2001
January 14-17, 2001 (Santa Clara Convention Center, Santa Clara, CA)
Telecommunications Industry Association and SUPERCOMM
(312) 559-3866
Internet: http://www.supernet2001.com

Measurement Science Conference
January 15-19, 2001 (Disneyland Hotel, Anaheim, CA)
Measurement Science Conference
1280 Bison Ave., Suite B9-530
Newport Beach, CA 92660
John Bowman
(714) 847-7380
e-mail: john.bowman@fluke.com
Internet: http://www.msc-conf.com

RF & Hyper Europe 2001
January 16-18, 2001 (Paris, France)
17, avenue Ledru Rollin
BIRP/RF & Hyper Europe 2001
Paris 75012, France
+33 1 53 17 11 40, FAX: +33 1 53 17 11 45
e-mail: hyper@birp.fr

Wireless Communications Association (WCA) 7th Annual Technical Symposium
January 17-19, 2001 (Double Tree Hotel, San Jose, CA)
Wireless Communications Association International
1140 Connecticut Ave. NW, Suite 810
Washington, DC 20036
(202) 452-7823, FAX: (202) 452-0041
e-mail: megan@wcai.com
Internet: http://www.wcai.com

DesignCon 2001
January 29-February 1 (Santa Clara Convention Center, Santa Clara, CA)
DesignCon 2001 (International Engineering Consortium)
549 West Randolph St., Suite 600
Chicago, IL 60661-2208
Internet: http://www.iec.org

International Solid State Circuits Conference (ISSCC)
February 5-7, 2001 (San Francisco Marriott Hotel, San Francisco, CA)
The Solid State Circuits Society of the IEEE
Piscataway, NJ 08855-1331
Internet: http://www.isscc.org

Commercialization of Military and Space Electronics Conference & Exhibition
February 12-15, 2001 (Los Angeles Airport Marriott Hotel, Los Angeles, CA)
Components Technology Institute, Inc.
904 Bob Wallace Way, Suite 117
Huntsville, AL 35801
(256) 536-1304, FAX: (256) 539-8477
e-mail: dale@cti-us.com
Internet: http://www.cti-us.com

Wireless/Portable Symposium & Exhibition
February 12-16, 2001 (San Jose Convention Center, San Jose, CA)
Penton Media, Inc.
Wireless/Portable 2001
611 Route 46 West
Hasbrouck Heights, NJ 07604
FAX: (201) 393-6297
Internet: http://www.WirelessPortable.com

Call for Papers

IMAPS Advanced Technology Workshop on Thermal Management for High-Performance Computing and Wireless Applications
April 20-21, 2001 (Sheraton Palo Alto Hotel, Palo Alto, CA)
International Microelectonics and Packaging Society (IMAPS)
General Chair: Dave Saums
Power Devices, Inc.
Newburyport, MA
(978) 499-4990
e-mail: dsaums@msn.com
Deadline for abstracts: January 15, 2001

2001 Virginia Tech Symposium on Wireless Personal Communications
June 6-8, 2001 (Blacksburg, VA)
Virginia Polytechnic Institute and State University
Jenny Frank
Conference Coordinator
MPRG/Virginia Tech
432 NEB, Mail Code 0350
Blacksburg, VA 24061
(540) 231-2971
e-mail: mprg@vt.edu
Deadline for abstracts: December 15, 2000

Optical operation improves GaAs MESFET performance

When gallium-arsenide (GaAs) metal-semiconductor-field-effect transistors (MESFETs) are controlled by light rather than voltage, a significant change in their characteristics results. An analytic model for an optically controlled GaAs MESFET—an OPFET—was developed by Srikanta Bose, Mridula Gupta, and R.S. Gupta of the Semiconductor Devices Research Laboratory, University of Delhi South Campus (New Delhi, India) to show the change in performance under light control. The significant feature is that the cutoff frequency increases and there is a drastic reduction in optimum noise figure. Experiments show that the characteristics of a GaAs MESFET can be controlled by incident light radiation having photon energy equal to or greater than the bandgap energy of GaAs. This is analogous to controlling the device by varying its gate bias. The reason for the improvement in the frequency and noise parameters is a significant increase in transconductance from the application of light photons. See "Cutoff Frequency And Optimum Noise Figure of GaAs Optically Controlled FET," *Microwave and Optical Technology Letters*, September 5, 2000, Vol. 26, No. 5, p. 279.

What lies ahead for multimedia satellite technology?

Future broadband satellite-communications (SATCOM) systems will offer high-speed Internet access and multimedia information services such as multicasting and interactive video. So say John Farserotu of CSEM and Ramjee Prasad of Aalborg University (Denmark) in a study covering the types of systems, the trends and issues, and the kinds of technology needed to deploy global information networks to users on demand, anywhere, anytime. To be consistent with emerging third-generation (3G) wireless communications, the focus is on multimedia information services over the Internet protocol (IP) and IP/asynchronous transfer mode (ATM). The implementation of future IP/ATM over SATCOM networks will be either on a bent-pipe satellite relay or switch in the sky. The authors present the relative advantages and disadvantages of each architecture. See "A Survey of Future Broadband Multimedia Satellite Systems, Issues and Trends," *IEEE Communications Magazine*, June 2000, Vol. 38, No. 6, p. 128.

Novel circuit technique reduces MOSFET noise and power consumption

A circuit technique called switched biasing is proposed as a method for reducing the 1/f noise in metal-oxide-semiconductor-field-effect transistors (MOSFETs) by Eric A.M. Klumperink, Sander L.J. Gierkink, *et al.* of the MESA + Research Institute, University of Twente (The Netherlands). The authors claim that switched biasing is more effective than conventional techniques such as chopping and correlated double sampling. The latter only reduces the effect of 1/f noise, whereas switched biasing reduces the 1/f noise itself. Moreover, noise reduction techniques usually increase power consumption, but switched biasing reduces consumption. The authors use a sawtooth oscillator—in 0.8-μm complementary metal-oxide semiconductor (CMOS)—to demonstrate the effect of switched biasing, but they claim it is not limited to oscillators. That is because the technique tackles 1/f noise at its physical roots, and it works with high- and low-frequency circuits. See "Reducing MOSFET 1/f Noise and Power Consumption by Switched Biasing," *IEEE Journal of Solid-State Circuits*, July 2000, Vol. 35, No. 7, p. 994.

Smart antennas are not just for base stations

When smart antennas are used in a wireless network to improve reliability and increase capacity, most designers think of their application at a base station. Recent research, however, indicates that smart antennas offer similar improvements when installed in a user's handheld terminal. Reporting on experiments conducted at Virginia Tech University, Naftali (Tuli) Herscovici of Spike Technologies, Inc. (Nashua, NH) and Christos Christodoulou of the University of New Mexico (Albuquerque, NM) show that the technique of adaptive beamforming, used in base stations, can improve interference rejection when installed in a handset. And spatial diversity, a well-known performance enhancer in base stations, is just one of several diversity methods that improves base-station operation. Polarization- and angle-diversity are the other techniques that result in longer talk time for handsets, increased range, and greater reliability. The authors believe that while smart antennas have been used almost exclusively in receiving applications, smart transmitting antennas will be found in future equipment. See "Smart Antennas in Wireless Communications: Base-Station Diversity and Handset Beamforming," *IEEE Antennas and Propagation Magazine*, October 2000, Vol. 42, No. 5, p. 142.

Check Amplifier Dynamic Behavior With True Test Signals

This new measurement technique uses Fast Fourier transform (FFT) techniques and predistortion to analyze amplifier characteristics.

Martin Weiss

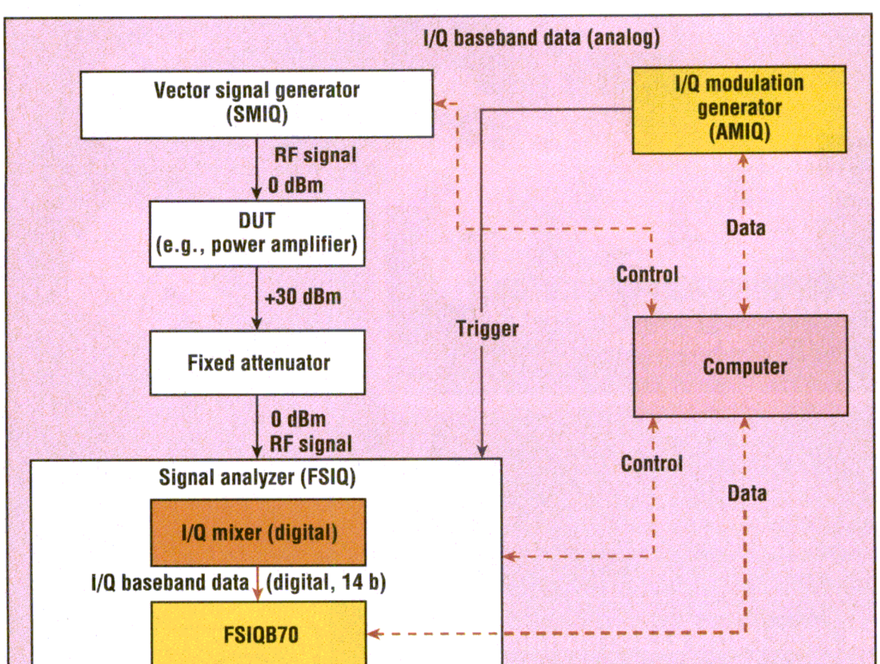
Applications Engineer

Rohde & Schwarz GmbH & Co. KG, Test and Measurement Div., Muehldorfstrasse 15, 81671 Munich, Germany; (49) 89 4129 11694, FAX: (49) 89 4129 12131, e-mail: Martin.Weiss@rsd.rohde-schwarz.com, Internet: http://www.rohde-schwarz.com.

AMPLIFIER quality is often evaluated with less-than-ideal test signals and measurement systems. Amplifiers for wireless communications systems, for example, are commonly tested with vector-network analyzers (VNAs) better suited for low-level linear-signal characterization. Due to a need to better understand the nonlinear behavior of large-signal RF amplifiers, a new method was developed for measuring amplifier nonlinear parameters. By predistorting the input signals to an amplifier under test, it was possible to decrease the level of adjacent-channel power (ACP) and thus more accurately evaluate amplifier amplitude-modulation/amplitude modulation (AM/AM) and amplitude-modulation/phase-modulation (AM/PM) performance.

In any wireless system, bandwidth is an expensive and limited resource. Service providers who have made large investments to license portions of available cellular and personal-communications-services (PCS) bands must recoup their investments by maximizing the number of subscribers served per cell and per channel. Because modern wireless communications systems are based on complex digital modulation schemes in order to increase the amount of information transmitted per bandwidth unit, increasing demands are placed on the transmit power amplifiers (PAs) to maintain a high degree of linearity even when boosting complex modulated signals. Excessive levels of ACP, for example, can disrupt the performance of nearby cells and prove costly to system operators in terms of lost coverage and subscribers. As a result, it is critical to accurately test the single-carrier and multicarrier PAs used in cellular and PCS systems.

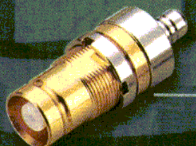
But testing these amplifiers is not trivial. As far as broadband signals are concerned, these tried-and-tested methods unfortunately involve a number of partly unsolved problems



1. This block diagram shows the test setup used to demonstrate amplifier AM/AM and AM/PM characteristics by using accurate test signals.

Focus US

To support the demanding needs of microwave and RF applications, capital reinvestment for machinery and tooling is a top priority.
The production capacity and capability of Chin Nan is second to none.



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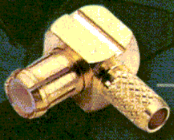
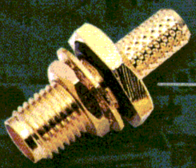
MMCX



MCX



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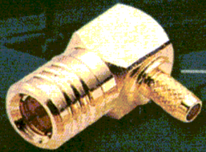

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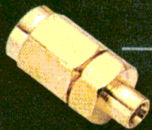

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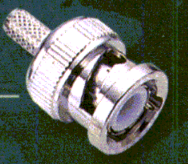

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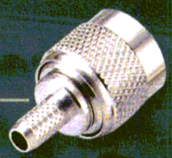

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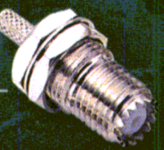

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such as:

• Feedforward control becomes more expensive with increasing bandwidth.

• Feedback control involves higher noise with increasing bandwidth.

• Measurement with a network analyzer does not show the characteristic expected when driving with broadband input signals. This is due to different characteristics of the amplifier, e.g., memory effects, temperature drift, etc.

Due to the limitations of traditional measurement methods in characterizing cellular/PCS amplifiers, it was necessary to develop a new characterization technique that would rely on using test signals that were truer representations of the actual signals used in a communication system. With this new method, it is possible to determine an amplifier's AM/AM and AM/PM characteristics by using realistic test signals (such as band-limited noise) to emulate actual communications channels.

Figure 1 shows a block diagram of the measurement setup. The measurement signal is generated under the control of measurement software running on an external computer. The software code is loaded into an arbitrary waveform generator, converted to RF signals by means of a high-resolution digital-to-analog converter (DAC), and applied to the device under test (DUT). The amplifier or DUT's output signals are downconverted to baseband signals and then sampled.

With this measurement setup, two sets of complex in-phase/quadrature (I/Q) data are created—the data generated by the measurement software and the data measured at the output of the DUT. The two sets of data have a time offset and generally show different levels, due to the AM/AM and AM/PM distortion.

The differences in levels between the two sets of signal data can be eliminated by a reference measurement. This is done by replacing the DUT with a direct connection and making the measurement, or by decreasing the signal level to a point where the DUT operates in a linear region, then making the measure-

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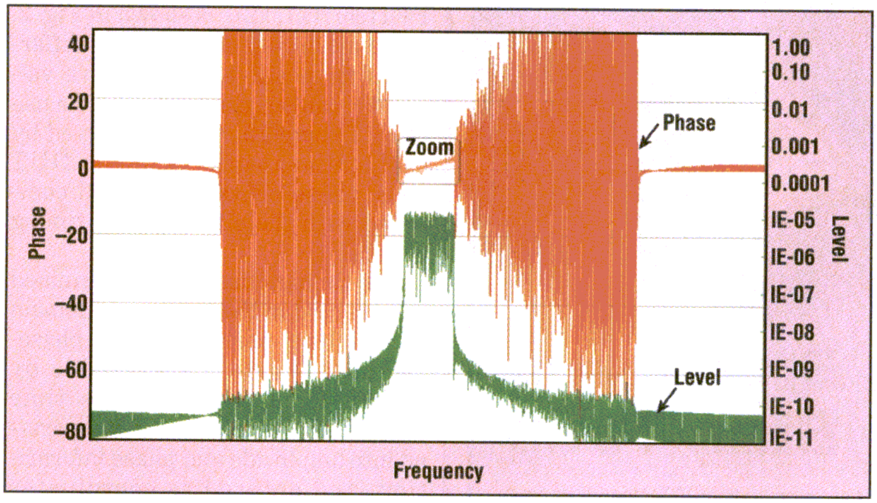


2. The FFT correlation, FFT[corr(x1, x2)], can be seen here for the phase and amplitude level of a sample amplifier.

ment at this point.

To eliminate the time offset (between the reference measurement and the measurement at the output of the amplifier DUT) both signals are processed by means of Fast Fourier transform (FFT). Phase differences are subtracted in the frequency domain and a regression calculation is carried out over the linear phase obtained by the time offset of the two measurements. If two measurements $x_1(t)$ and $x_2(t)$ show only differences in timing, so that:

$x_2(t) = x_1(t - \tau)$,

then the timing difference can be derived by means of:

$$x_1(t) \xrightarrow{FFT} x_1(f);$$

$$x_2(t) = x_1(t-\tau) \xrightarrow{FFT} x_2(f)$$

$$= x_1(f) \times e^{j2\pi f\tau};$$

$$corr\left[x_1(t),\ x_2(t)\right]$$

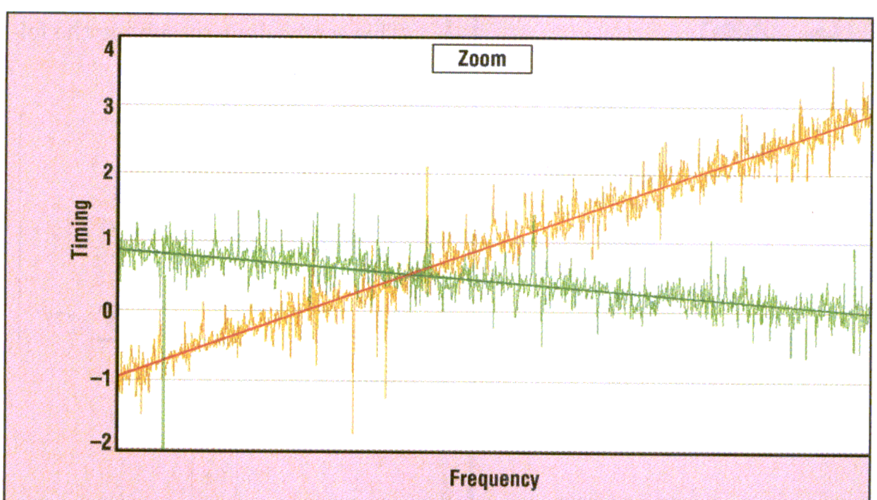
$$\xrightarrow{FFT} X_1(f)X_2^*(f) =$$

$$\left|x_1(f)\right|^2 \times e^{j2\pi f\tau};$$

$$\Rightarrow arg\left(FFT\left\{corr\begin{bmatrix}x_1(t),\\ x_2(t)\end{bmatrix}\right\}\right) =$$

$$2\pi f\tau \qquad (1)$$

The FFT correlation,



3. This closeup plot shows the timing differences for positive and negative values of τ.

FFT[corr(x1, x2)], is shown in Fig. 2, while a close-up of the timing differences for positive and negative values of τ can be seen in Fig. 3. The use of FFT correlation is not affected by the nonlinear effects of the DUT since these effects are small compared with the effects of the timing offsets.

The timing offset thus determined is corrected in the frequency domain so that level-normalized and phase-locked I/Q data are available by retransformation into the time domain. These data are then separated into amplitude and phase information, and entered as coordinates according to the definition of AM/AM and AM/PM compression. Then, a functional relationship, i.e., the numeric values for the amplifier's transfer characteristics, is obtained by regression. This calculation is performed with a few mathematical statements. For example, assuming xi as the reference signal (such as the signal amplitude that is fed to the input of the DUT) and yi as the measured signal (the DUT's output amplitude), the idea is to minimize the following statement:

$$S(a_0, a_1, ..., a_q) := \sum_{i=1}^{N} \left(y_i - p(x_i)\right)^{2^!} = min$$

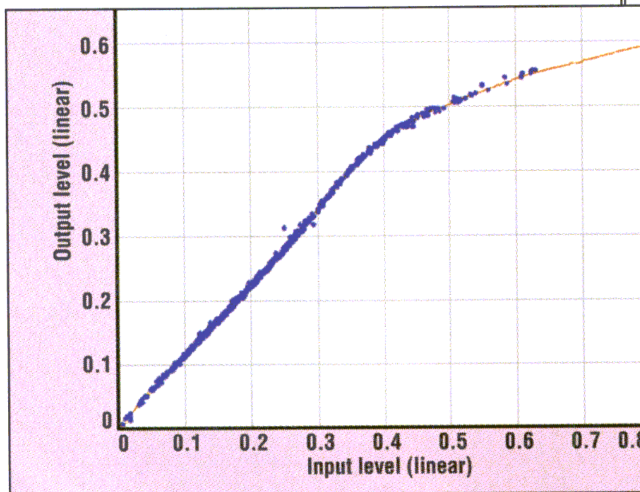
$$p(x) = \sum_{i=0}^{q} a_i \times x^i \qquad (2)$$

This can be done by solving the following expression:

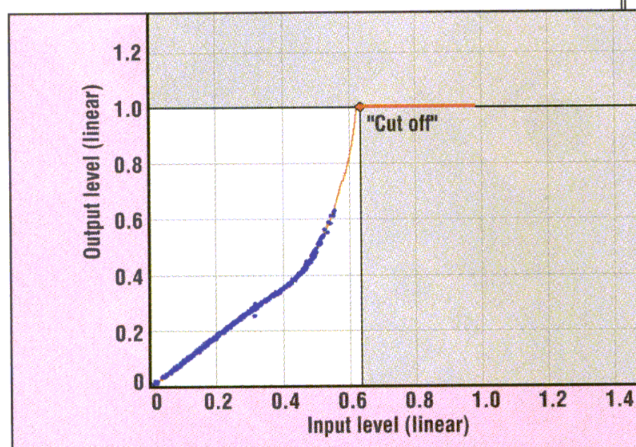
$$\begin{pmatrix} \sum x_i^0 & \sum x_i^1 & \sum x_i^2 & ... & \sum x_i^q \\ \sum x_i^1 & \sum x_i^2 & \sum x_i^3 & ... & \sum x_i^{q+1} \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & ... & \sum x_i^{q+2} \\ ... & ... & ... & ... & ... \\ \sum x_i^q & \sum x_i^{q+1} & \sum x_i^{q+2} & ... & \sum x_i^{q+q} \end{pmatrix} \times \begin{pmatrix} a_0 \\ a_1 \\ a_2 \\ ... \\ a_q \end{pmatrix}$$

$$= \begin{pmatrix} \sum y_i \times x_i^0 \\ \sum y_i \times x_i^1 \\ \sum y_i \times x_i^2 \\ \cdots \\ \sum y_i \times x_i^q \end{pmatrix} \quad (3)$$

The results of this calculation are the values of a_i; these are the coefficients of the polynomial which describe the DUT's characteristic transfer function. (It is also possible to use spline calculation or a combination of spline and polynomial regression for this purpose.) Figure 4 reveals the results of a timing-corrected measurement with a polynomial curve included for the amplifier's AM/AM characteristic curve.



4. This plot shows the results of an amplifier timing-corrected measurement for AM/AM characteristics.



5. The amplitude of the DUT used in the experiments is somewhat limited, although adequate for demonstrating the effectiveness of predistortion in RF measurements.

One way to prove that the initial data are really representative of the DUT's dynamic characteristics is to precorrect the I/Q data set generated by the measurement software using an inverse FFT characteristic. This can be used to perform an AM/AM and/or AM/PM characteristic measurement or to determine the improved ACP rejection in the frequency domain curve. However, due to the limited output power of the DUT, which cannot be improved by predistortion, it does not make sense to drive the DUT over its linearity cutoff point. Due to this, the amplitude of the DUT is somewhat limited in these measurements (Fig. 5).

By taking reference and measured I/Q data, estimating and eliminating the timing offset by FFT and inverse FFT operations, and calculating amplitude and phase through regression, the DUT's AM/AM and AM/PM characteristics can be measured. There are significant differences between the curves measured with a VNA and the curves measured with the new method. The new method provides reproducible results, compared to the results with the VNA, where careful calibrations must be performed and where much attention must be paid to the measurement setup (for example, to ensure that all coaxial connectors are properly torqued from measurement to measurement). When applied to other amplifiers, improvement in error-vector-magnitude (EVM) performance is possible. ••

Calculate The Effect Of RF Building Blocks On AM And PM Noise

This tutorial describes how basic RF subsystems operate on amplitude-modulation and phase-modulation noise.

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RF designers tend to analyze the propagation of noise from the master oscillator and ignore the noise effects from amplifiers and other uncorrelated noise sources. This type of analysis is sufficient for most designs. But as technology advances and master oscillators approach phase-modulation (PM) noise of –180 dBc/Hz, those seeking to produce optimal PM performance at Ka- and W-bands should not ignore the noise contribution from uncorrelated noise sources.

This article discusses amplitude-modulation (AM) and PM noise for specific RF components, including the amplifier, mixer, frequency multiplier, and frequency divider. Throughout the article, a sinusoidal signal is propagated through the basic RF building blocks to show how each block modifies the input signal's AM and PM noise. For simplicity, the author uses trigonometric sinusoidal signal expressions and avoids using complex signals, although the complex form can be used to reduce the number of derivation steps.

The generic expression of a sinusoidal-carrier input signal with noise is:

$$x(t) = A \times Sin(\omega_0 t) + n(t) \qquad (1)$$

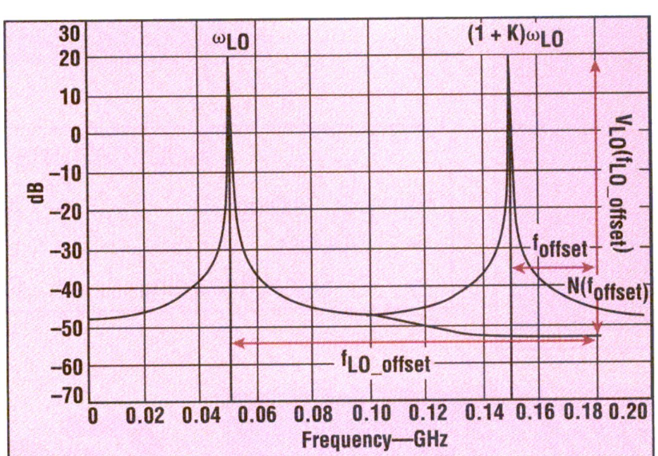
In most RF applications, the noise n(t) is constrained so that the input-noise amplitude is smaller than the carrier signal's amplitude, $|n(t) < A|$. The noise bandwidth is a small fraction of the carrier's frequency, $BW_n < \omega_0$, and n(t) is a zero-mean-random process.

With these constraints, the noise can be written in the following form:

$$n(t) = n_x(t) \times cos(\omega_0 t) + n_y(t) \times sin(\omega_0 t) \qquad (2)$$

This is the narrowband representation of a random process n(t), described in terms of the orthogonal components of the noise.

The spectral shape and the probability distribution of the noise and its orthogonal components are not constrained to white Gaussian noise and may have any band-limited spectral shape. The time-domain samples' probability distribution can be arbitrary.



1. This graph shows the output signal-power spectrum and noise of the LO and mixer.

Table 1: Practical AM and PM noise expressions

RF Block	AM noise	PM Noise
Amplifier	$\dfrac{N_y(f_{offset})+\left(\dfrac{NF*K*T}{2}\right)}{A^2}$	$\dfrac{N_x(f_{offset})+\left(\dfrac{NF*K*T}{2}\right)}{A^2}$
Attenuator	$\dfrac{N_y(f_{offset})+\left(\dfrac{K*T}{2*LOSS}\right)}{A^2}$	$\dfrac{N_y(f_{offset})+\left(\dfrac{K*T}{2*LOSS}\right)}{A^2}$
Mixer	$\dfrac{N_y(f_{offset})}{A^2}$	$(1\pm K)^2*\Theta_{LO}(f_{offset})+\dfrac{N_{xLO}(f_{offset})}{A_{LO}^2}+\dfrac{N_x(f_{offset})}{A^2}$ $+\left(\dfrac{L_{eak}}{G}\right)*\left(\left(\dfrac{A_{LO}^2}{A^2}\right)\Theta_{LO}(f_{LO\_offset})+\dfrac{N_{xLO}(f_{LO\_offset})}{A^2}\right)$
Frequency Multiplier	$\dfrac{N_y(f_{offset})}{A^2}$	$N^2*\dfrac{N_x(f_{offset})}{A^2}$
Frequency Divider	Signal is compressed	$\dfrac{N_x(f_{offset})}{N^2*A^2}+\theta_0(f_{offset})$

The noise power of n(t) is the sum of the power of its orthogonal components.

$$N(\omega) = N_x(\omega) + N_y(\omega) \qquad (3)$$

By inserting Eq. 2 into Eq. 1, rounding up the sine terms, applying the trigonometric identity for the sum of a sine and cosine signal and using the small angle approximations (see Fig. 3 for a detailed derivation), Eq. 1 can be rewritten as:

$$x(t) = A \times sin\left(\omega_0 t + \frac{n_x(t)}{A}\right)$$
$$+n_y(t) \times sin(\omega_0 t) \qquad (4)$$

In the context of this paper, Eq. 4 can be thought of as a piece-wise function so that:

In the region where the sine wave crosses zero:

$$x(t) \approx A \times sin\left(\frac{n_x(t)}{A}\right) \qquad (5)$$

In the region where the sine wave peaks:

$$x(t) \approx \left(A + n_y(t)\right) \times sin(\omega_0 t) \qquad (6)$$

Therefore, Eq. 4 can be rewritten as:

$$x(t) \approx A \times \left(1 + \frac{n_y(t)}{A}\right)$$
$$sin\left(\omega_0 t + \frac{n_x(t)}{A}\right) \qquad (7)$$

Eq. 7 is significant because it shows that the orthogonal components of the noise are responsible for the carrier's AM and PM noise and that these can be expressed as the following separable and independent functions.

$$a_n(t) = \frac{n_y(t)}{A} \quad (8)$$

$$\theta_n(t) = \frac{n_x(t)}{A} \quad (9)$$

Eqs. 8 and 9 are in the time domain. Due to the stochastic nature of the noise, it is useful to specify noise power in the frequency domain as noise power per Hertz.

$$AM_n\left(f_{offset}\right) = \frac{N_y\left(f_{offset}\right)}{A^2} \quad (10)$$

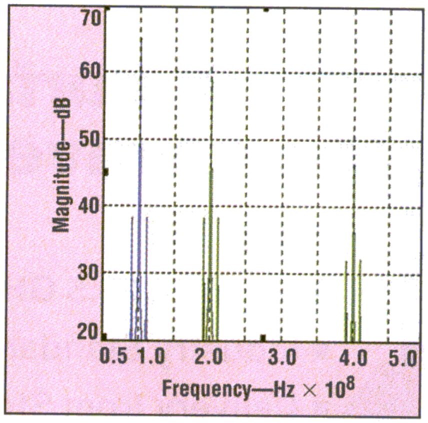
$$\Theta_n\left(f_{offset}\right) = \frac{N_x\left(f_{offset}\right)}{A^2} \quad (11)$$

where:
$N_x(f_{offset})$ and $N_y(f_{offset})$ = the spot-noise power at the carrier-offset frequency, respectively.

Throughout the rest of this article, the signal described by Eq. 4 or 7 is applied to the input of the basic RF building blocks. Closed-form expressions are derived for the output signals of the amplifier, mixer, frequency multiplier, and frequency divider.

THE AMPLIFIER

In the process of amplifying, an amplifier adds noise to the input signal. To a first-order approximation, the noise introduced by an amplifier is additive, bandlimited, thermal noise.



2. This graph shows a 100-MHz carrier with ± 10 MHz, –20-dBc FM offset spurs resulting from x(t) = Sin[2 π × 10⁶ 3 t] + 0.2 π × Sin[2 π × 10⁶ × t)] passing through a X2 and a X4 frequency multiplier. The spurs out of the multipliers grow by +6 dBc per frequency doubling.

The equation for the amplifier's output noise power is:

$$N_{ao}(\omega) = \sigma^2{}_{ao} = NF \times G \times K \times T \quad (12)$$

where:
N_{ao} = the amplifier output noise in Watts/Hz,
NF = the amplifier's noise figure,
G = the power gain,
K = Boltzman's constant, and
T = the amplifier's temperature.

Within the context of this article, Eq. 12 in the time domain is:

$$n_{ao}(t) = n_{ax}(t) \times cos(\omega_0 t) + n_{ay}(t) \times sin(\omega_0 t) \quad (13)$$

And the noise power that exists in the frequency domain within the bandlimited region is provided by Eq. 14.

$$N_{ax}\left(f_{offset}\right) = N_{ay}\left(f_{offset}\right) = \frac{NF \times G \times K \times T}{2} \quad (14)$$

Applying the signal of Eq. 4 to the amplifier, adding the noise of Eq. 14, and rewriting it in the form of Eq. 7 yields:

$$y_{amp}(t) \approx G^{0.5} \times A \times \left(1 + \frac{n_y(t) + n_{ya}(t)}{A}\right) \times sin\left(\omega_0 t + \frac{n_x(t) + n_{xa}(t)}{A}\right) \quad (15)$$

The frequency-domain expression for the AM and PM noise can be written as:

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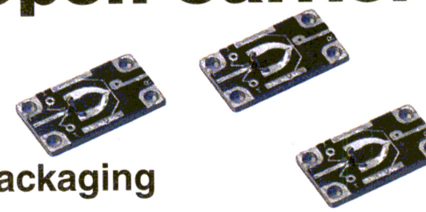

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CSM2-10	10 to 2,800 MHz	10 to 2,000 MHz	+10 dBm	30 dB	20 dBm	7.5 dB	Surface Mount
CSM2-13	10 to 2,800 MHz	10 to 2,000 MHz	+13 dBm	30 dB	22 dBm	7.5 dB	Surface Mount
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MC4110	2 to 10 GHz	DC to 2 GHz	+10 dBm	40 dB	14 dBm	6.0 dB	Open Carrier
MC4113	2 to 10 GHz	DC to 2 GHz	+13 dBm	40 dB	17 dBm	6.0 dB	Open Carrier
MC4120	2 to 10 GHz	DC to 2 GHz	+20 dBm	40 dB	23 dBm	6.5 dB	Open Carrier
MC4507	4 to 22 GHz	DC to 4 GHz	+7 dBm	32 dB	11 dBm	6.0 dB	Open Carrier
MC4510	4 to 22 GHz	DC to 4 GHz	+10 dBm	32 dB	14 dBm	6.0 dB	Open Carrier
MC4513	4 to 22 GHz	DC to 4 GHz	+13 dBm	32 dB	17 dBm	6.0 dB	Open Carrier
MC4520	4 to 22 GHz	DC to 4 GHz	+20 dBm	32 dB	23 dBm	6.5 dB	Open Carrier
MC4807	10 to 26.5 GHz	DC to 6 GHz	+7 dBm	28 dB	11 dBm	6.5 dB	Open Carrier
MC4810	10 to 26.5 GHz	DC to 6 GHz	+10 dBm	28 dB	14 dBm	6.5 dB	Open Carrier
MC4813	10 to 26.5 GHz	DC to 6 GHz	+13 dBm	28 dB	17 dBm	6.5 dB	Open Carrier
MC4820	10 to 26.5 GHz	DC to 6 GHz	+20 dBm	28 dB	23 dBm	6.5 dB	Open Carrier

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$$AM_n\left(f_{offset}\right) \approx \frac{N_y\left(f_{offset}\right) + \left(\frac{NF \times K \times T}{2}\right)}{A^2} \quad (16)$$

$$\Theta_n\left(f_{offset}\right) \approx \frac{N_x\left(f_{offset}\right) + \left(\frac{NF \times K \times T}{2}\right)}{A^2} \quad (17)$$

Before leaving this section, here is a list of observations that have practical use:

1. The amplifier added uncorrelated thermal noise to the carrier and degraded the AM and PM noise of the carrier.
2. The amplifier's power gain does not appear in Eqs. 16 and 17 because the noise is referenced to the amplifier's input signal.
3. If amplitude compression is applied to the signal of Eq. 15, the AM noise is reduced. This is advantageous when generating single tones for local-oscillator (LO) signals.
4. Eqs. 16 and 17 can be used to analyze the noise degradation through a chain of cascaded amplifiers. One must be careful not to double count the output terminator's thermal noise in the string of amplifiers, considering that, in an amplifier chain, each individual stage contributes (NF–1) of noise rather than NF.

AN AMPLIFIER ADDS NOISE TO THE INPUT SIGNAL. TO A FIRST-ORDER APPROXIMATION, THE NOISE INTRODUCED BY AN AMPIFIER IS ADDITIVE, BANDLIMITED, THERMAL NOISE

5. Eq. 14 shows that the thermal noise is divided equally between the AM and PM noise components, so the –174 dBm/Hz thermal-noise floor at room temperature is split to –177 dBm/Hz for each orthogonal noise component.
6. Eqs. 16 and 17 can be applied to the attenuator pad block, which is a special case of the amplifier. This is performed by setting G = attenuator loss and NF = 1/G.

THE MIXER

The mixer is a more complicated case than the amplifier because it requires two input signals to produce an output. The equations developed for the mixer can be used as the basis for deriving those for the frequency multiplier.

The inputs to the mixer's LO [LO(t)] and input signal [x(t)], are applied using the form of Eq. 7 :

$$LO(t) \approx A_{LO} \times \left(1 + \frac{n_{yLO}(t)}{A_{LO}}\right) \times \sin\left(\omega_{LO}t + \theta_{LO}(t) + \frac{n_{xLO}(t)}{A_{LO}}\right) \quad (18)$$

$$x(t) \approx A \times \left(1 + \frac{n_y(t)}{A}\right) \times \sin\left(K \times \omega_{LO}t + K \times \theta_{LO}(t) + \frac{n_x(t)}{A}\right) \quad (19)$$

In most RF circuits, the LO is coherent with the input signal, and therefore there is a correlated phase-noise component. Due to this correlation, it is convenient to express the input-signal frequency and the correlated phase noise as a multiple K of the LO frequency and phase noise.

The mixer output is the product of Eqs. 18 and 19. Multiplying, collecting the sine and cosine terms, discarding small quadratic products, and using small-angle approximation yields the following expressions for the mixer's output signal:

$$y_{mixer}(t) \approx G^{0.5} \times A \times \left[\left(1+\frac{n_y(t)}{A}\right) \times \cos \left((1 \pm K)\omega_{LO}(t) + (1 \pm K)\theta_{LO}(t) + \frac{n_{xLO}(t)}{A_{LO}} \pm \frac{n_x(t)}{A} \right) \right] \quad (20)$$

The n_{yLO}/A_{LO} AM term was dropped from Eq. 20 because the mixer compresses the LO signal, therefore the LO AM term becomes insignificant. Also, the $G^{0.5} \times A_{LO} \times A/2$ product was modified to $G_{0.5} \times A$ to define the mixer output as the power-conversion loss (or gain in active mixers) G, multiplied by the input-signal amplitude A. This is the way real-world mixers are specified.

Real-life mixers leak the LO signal onto the output.[1] This term should not be disregarded, since it can be a critical noise contributor when the input signal is very low, as with receivers (Rxs).

$$LO_{Leak}(t) \approx L_{eak}^{0.5} \times A_{LO} \sin \left(\omega_{LO}(t) + \theta_{LO}(t) + \frac{n_{xLO}(t)}{A_{LO}} \right) \quad (21)$$

where:
L_{eak} = the mixer's LO-to-output-port leakage factor.

The mixer's output signal is derived by disassembling Eqs. 20 and 21, writing it in the form of Eq. 4. This is followed by rounding up and combining the individual orthogonal-noise components and weighting them by their respective carrier amplitudes.

To cut down on the number of equations and get to a useful form, the time-domain equations for this step are bypassed, going directly to the frequency-domain noise power.

$$AM_n(f_{offset}) = \frac{N_y(f_{offset})}{A^2} \quad (22)$$

$$\Theta_n(f_{offset}) = (1 \pm K)^2 \times \Theta_{LO}(f_{offset}) + \frac{N_{xLO}(f_{offset})}{A^2{}_{LO}} + \frac{N_x(f_{offset})}{A^2} + \left(\frac{L_{eak}}{G}\right) \times \left(\left(\frac{A^2{}_{LO}}{A^2}\right) \Theta_{LO}(f_{LO\_offset}) + \frac{N_{xLO}(f_{LO\_offset})}{A^2} \right) \quad (23)$$

where:

f_{LO_offset} is the frequency offset from the LO rather than from the carrier (Fig. 1). This is performed to sample the noise spectrum in the region where the LO and the mixer's output frequency overlap.

In most practical cases, the noise spectrum from the LO has flattened out at the mixer's output frequency and what is left is the residual thermal noise of the LO. The coherent phase-noise component $\Theta_{LO}(f_{offset})$ is decorrelated from $\Theta_{LO}(f_{LO\_offset})$.

The uncorrelated PM noise-power terms are additive, but the coherent phase-noise components are correlated, and the phase-noise power will increase by $(1 + K)^2$ for an upconversion and decrease by $(1 - K)^2$ for downconversion.

THE FREQUENCY MULTIPLIER

The frequency multiplier can be considered a special case of the mixer. It can be treated as a mixer that mixes the input signal with frequency multiples of itself.

This section starts by deriving the output signal for the frequency doubler, using Eq. 20, which was derived for the mixer, and setting K = 1 with upconversion.

The assumption is that the input signal is relatively large and it is fed to the LO of the mixer, while the intermediate-frequency (IF) input of the mixer is an attenuated pick-off from the input signal. This configuration yields the following equation:

$$y_{doubler}(t) \approx G^{0.5} \times A \times \left[\left(1 + \frac{n_y(t)}{A}\right) \times \cos\left(\begin{array}{c} 2\omega_0(t) + \\ \dfrac{2n_x(t)}{A} \end{array}\right)\right] \quad (24)$$

where:

the input-AM noise is conserved, but the input-PM noise is doubled.

A heuristic argument can be used to derive the general case for K > 1 by assuming that frequency multiplication can be achieved by mixing the doubler output signal of Eq. 24 with an integer or fractional multiple of the input frequency ω_o.

Following the same steps used to derive Eqs. 22 and 23 for the mixer, the general equations for the AM and PM noise for an xN frequency multiplier are:

$$AM_n\left(f_{offset}\right) \approx \frac{N_y\left(f_{offset}\right)}{A^2} \quad (25)$$

$$\Theta_n\left(f_{offset}\right) \approx N^2 \times \frac{N_x\left(f_{offset}\right)}{A^2} \quad (26)$$

The PM noise power rises by the square of the multiplier factor N. This is because the phase-noise-multiplier factor N appears inside the argument of the sinusoidal time-domain signal. Since the phase noise in the frequency domain is described in terms of spectral noise power, the power associated with that noise is proportional to its magnitude squared, mathematically described as:

$$\sigma^2{}_{\Theta_n} = E\left[\left(\frac{Nn_x(t)}{A}\right)^2\right]$$

$$= N^2 \times \frac{\sigma^2{}_{n_x}}{A^2} = N^2 \times \sigma^2{}_{\theta} \quad (27)$$

where:

the symbol σ represents the variance or power of the subscripted signal, and Θ and θ are the input and output phase noise, respectively. Therefore, the output PM power is proportional to N^2 times the input-PM power.

Writing Eq. 27 in decibel yields 10 LOG($N^2 \times \Sigma^{2u}$), which is the well-known relation 20 × LOG(N) + input-phase-noise power.

Another consequence that can be inferred from Eq. 24 is that N also multiplies input FM spurs inside the argument of the sinusoidal as it did with the PM noise. Therefore, the power of the spurs also grows by 20 × LOG(N) + input-spur power, but their frequency offset relative to the carrier does not change.

This is illustrated by Fig. 2, where a 100-MHz carrier with 65-dB relative power, flanked by ±10-MHz offset, –26-dBc FM spurs, is passed through X2 and X4 multipliers. The results are a 200-MHz carrier with 59-dB relative power, flanked by ±10-MHz offset, –20-dBc FM spurs, and a 400-MHz carrier with 46-dB relative power, flanked by ±10-MHz offset, –14-dBc FM spurs, respectively. So, for every frequency doubling, the spurs rose +6 dBc relative to their respective carriers.

This relation holds for spurs that

(continued on p. 236)

Gunn Oscillator Attains W-Band Operation With GaAs Diode

The physical design of an integrated GaAs Gunn oscillator enables second-harmonic operation at higher-than-usual frequencies.

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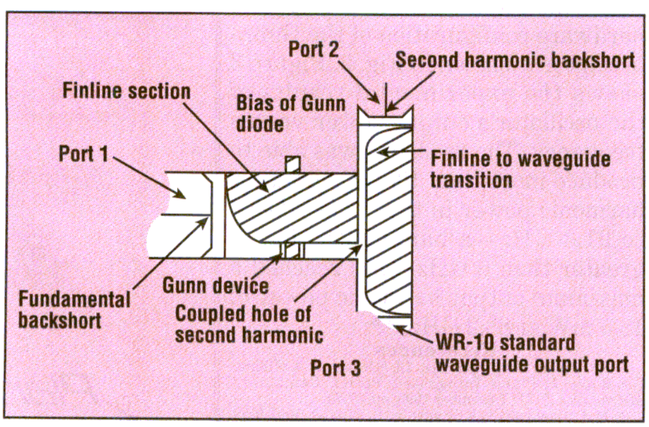
DUE to its low frequency-modulation (FM) noise and wide operating frequency range, the Gunn diode is used extensively as a local oscillator (LO). While the indium-phosphide (InP) Gunn diode has higher output power and upper frequency limits, the gallium-arsenide (GaAs) Gunn diode possesses qualities such as lower working voltage and current, reliable performances, and lower cost. An approach to achieving higher output power from GaAs Gunn diodes has been described.[1] This article presents the design of a novel finline second-harmonic W-band GaAs Gunn-oscillator that is suitable for millimeter-wave integrated front-end subsystems. At W-band (75 to 110 GHz), this integrated GaAs Gunn-oscillator can handle output power levels to 10 mW with a maximum power of 18.5 mW over a bandwidth of more than 6 GHz.

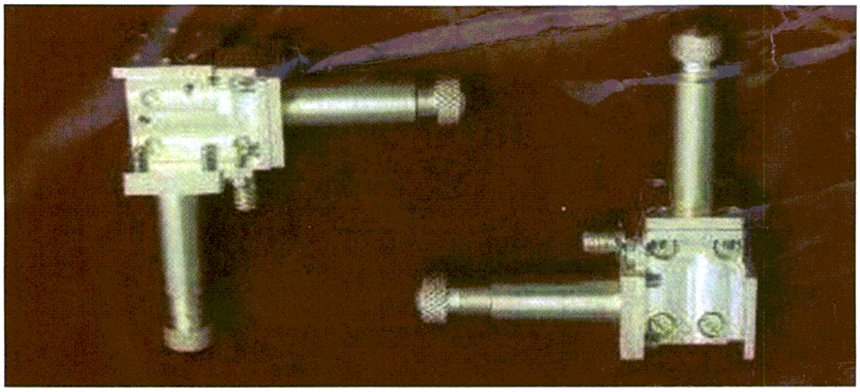
The GaAs Gunn oscillator is an important millimeter-wave device at Ka-band (26.5 to 40 GHz), but has difficulty in applications at W-band due to its lower upper-frequency limit. In order to generate RF power in the W-band range, it is desirable to identify the fundamental and harmonic frequency operation of the GaAs Gunn diode. To operate at the higher frequency, a second-harmonic extraction technology has been developed. In the past, the circuit structures of second harmonic W-band Gunn-oscillators were almost always waveguide and coaxial resonator cavities. But these designs are not practical for use in integrated subsystems because of their large physical dimensions.[2, 3]



1. The second-harmonic Gunn oscillator has a T-junction that defines the finline resonator cavity. The resonator cavity operates at the fundamental and second-harmonic frequencies.

Figure 1 shows the physical configuration of the finline second-harmonic W-band Gunn oscillator whose key structure is a T-junction. Port 1 of the T-junction is used to design the finline resonator cavity, which operates at the fundamental frequency f_0, and the second harmonic frequency, $2f_0$.

The Gunn chip is affixed to the mounting cube by a hot-pressure welding technique. The mounting cube is situated in the slot of an asymmetric unilateral finline, and the chip connects to the circuit through a gold (Au) strap which is ultrasonically bonded to the chip. The resonant frequency of the oscillator is mechani-

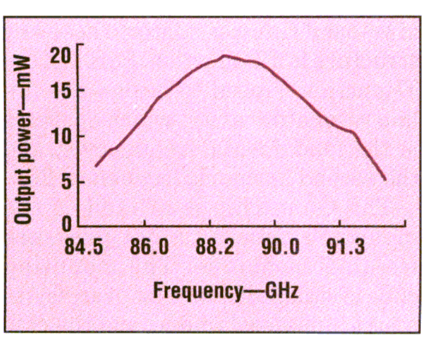


2. This photo shows the physical configuration of the second-harmonic W-band Gunn oscillator.

cally tuned by a fundamental-operation backshort (Fig. 1). At the arm, which is orthogonal to port 1 of T-junction, the finline must be specially designed for a cutoff frequency that is more the than maximum frequency of fundamental operation and less than the minimum frequency of second harmonic operation. Therefore, RF power at the fundamental frequency cannot be transmitted from the T-junction, but RF power at the second-harmonic frequency is easily coupled. And the coupled second-harmonic power can be optimized by finline to waveguide transition and by careful tuning of the second-harmonic backshort at port 2. The WR-10 standard waveguide acts as the second harmonic output port (i.e., port 3).

NOVEL STRUCTURE

This novel structure satisfies the steady-state oscillation condition in a certain range of W-band. It contains two individual circuits which belong to the fundamental and second-harmonic frequencies, and which can be tuned simultaneously.



3. A plot of output power versus frequency for the Gunn oscillator reveals a peak output of 18. 5 mW at a frequency of 88.2 GHz.

To optimize second-harmonic output power in W-band, a designer must carefully consider the slot width of the asymmetrical unilateral finline in three arms of the T-junction. And the mounting position of the Gunn chip must also be adjusted carefully to get the optimized dimensions. Finally, the characterization of transmission in finline, T-junction discontinuity, and mounting-cube discontinuity must be calculated exactly to achieve excellent circuit performance.

To demonstrate second-harmonic W-band Gunn-oscillator operation, a commercially available GaAs Gunn chip manufactured by Nanjing Electronic Devices Institute of China was used. It has a fundamental frequency of approximately 50 GHz. The circuit pattern was etched on a 5-mil (0.127-mm)-thick Duroid 5880 substrate with a dielectric constant of 2.22. The hardware configuration of the Gunn-oscillator is shown in Fig. 2. Figure 3 shows the experimental results of the oscillator's output power versus frequency. The oscillator was able to produce more than 10-mW of output harmonic power in the range of 85.1 to 91.3 GHz—a bandwidth that is greater than 6 GHz—and reached a maximum output harmonic power of 18.5 mW at 88.2 GHz. ••

References

1. Jun Xu, Yi Long, and Chao Li, "Construct A Millimeter-Wave E-Plane Integrated Power Combiner," *Microwaves & RF*, December 1999, pp. 67-70.
2. M.J. Lazarus, F.R. Pantoja, S. Novak, and M.G. Somekh, "Wideband Tunable mm-Wave Gunn Oscillator Design," *Electronic Letter*, Vol. 17, No. 20, October 1981, pp. 739-741.
3. J.E. Carlstrom, R.L. Plambeck, and D.D. Thornton, "A Continuously Tunable 65-115 GHz Gunn Oscillator," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-33, No. 7, July 1985, pp. 610-619.

Evaluate The Shielding Effectiveness Of Flexible Coaxial Cables

Several measurement methods are available for evaluating flexible coaxial cables, although optimum techniques provide adequate sensitivity under real-world conditions.

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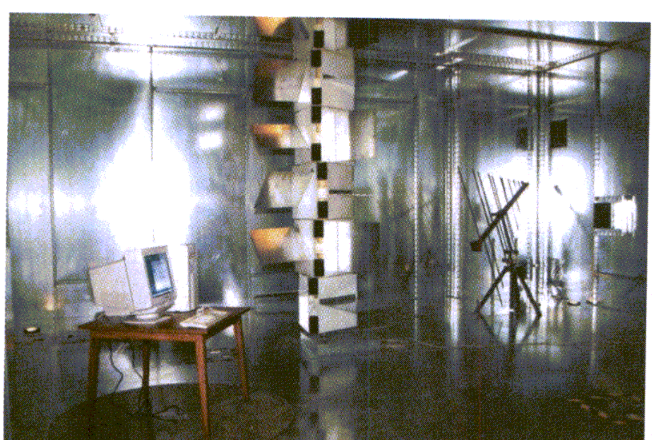
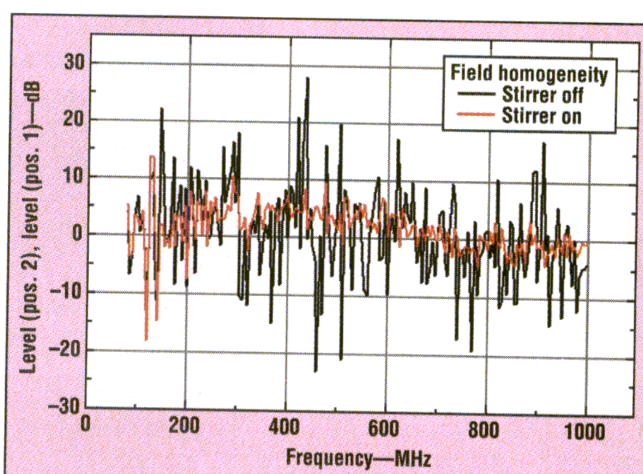
SHIELDING effectiveness (SE) is an important fundamental parameter to consider when specifying flexible coaxial cables. Equally important as cable attenuation, shielding effectiveness determines the amount of isolation between cables and equipment that may be in close proximity to one another. Signal characteristics such as fidelity and crosstalk interference are minimized by properly selecting flexible cables with proper SE. However, there are multiple methods which can be used to measure shielding effectiveness. Controversy exists as to what the best method is. By understanding the various means by which shielding effectiveness is measured, it is a simple matter to determine the best method to use for its measurement. This paper looks at these measurement systems and other methods and presents what is believed to be the most accurate in terms of simulating a random RF environment with very low spurious or resonant effects.

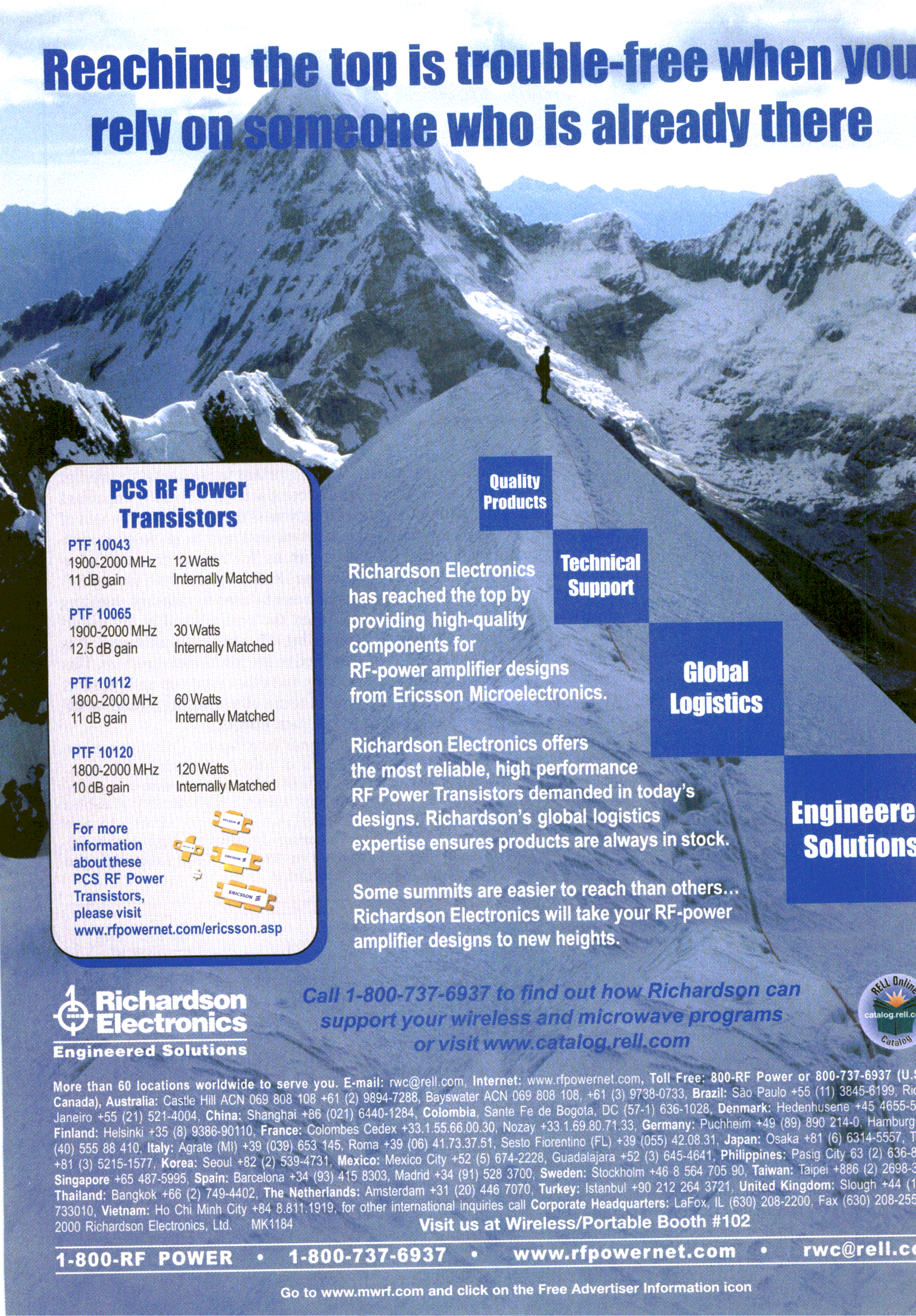
Small apertures present in the weave of the metal shield around the dielectric layer and over the cable's length allow RF energy to pass out into the environment surrounding the cable, an undesirable situation known as egress. Also undesirable is ingress, which is defined as external signal interference disrupting the flow of information along the coax. This becomes problematic in installations where a high density of cables exists in close proximity to one another. In addition, high-power signal environments will exacerbate the situation.



1. This mode-stirred chamber provides a tightly controlled environment for performing shielding-effectiveness measurements.



2. The differences in the E-field levels can be seen as two distinct positions, with the stirrer on and off.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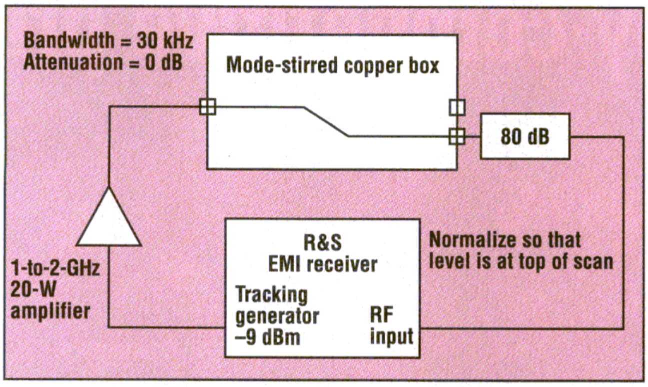
A flexible coaxial cable consists of a center conductor surrounded by a dielectric material. This "core" is wrapped with an outer shield and the entire structure is enclosed in a flexible jacket material. The geometric relationships between the inner and outer conductors, separated by the dielectric's electrical properties, determine the characteristic impedance of the cable. The amount of RF energy that leaks out of the cable is determined by the structural design of the shield. A shield design consisting of a single woven layer of wires offers poor effective isolation at high frequencies. The design of a better shield can be realized by using a plated copper (Cu) flat braid encased with a plated Cu round braid. This approach can be improved by the addition of metallized tape wound between the flat braid and the round braid. This triple-shield approach offers high isolation, while still maintaining good cable flexibility. Braid coverage, expressed in percent, relates to the amount of outer surface covered by the braid wire. As an example, for 60-percent braid coverage, there is 40 percent of the surface area left open.



3. This mode-stirred measurement setup is arranged for precalibration purposes.

Shielding effectiveness is fundamentally measured as a radiated power level relative to the power going into the cable, over a reference length of cable (usually 1 ft.). The shielding effectiveness becomes better with increasing numbers of shields. For a single-layer shield design, the radiated power is approximately 40 dB below the input-power level at 1 GHz (measured in a 1-ft. length). By adding another shield layer, performance improves to approximately 80 dB below the input power, per foot of cable. For a triple-layer shield design, the improvement is better than 95 dB below the input power, per foot of cable at 1 GHz.

There are a number of methods available to measure shielding effectiveness. Each method has a specific merit that should be taken into account when considering testing for shielding effectiveness. Some of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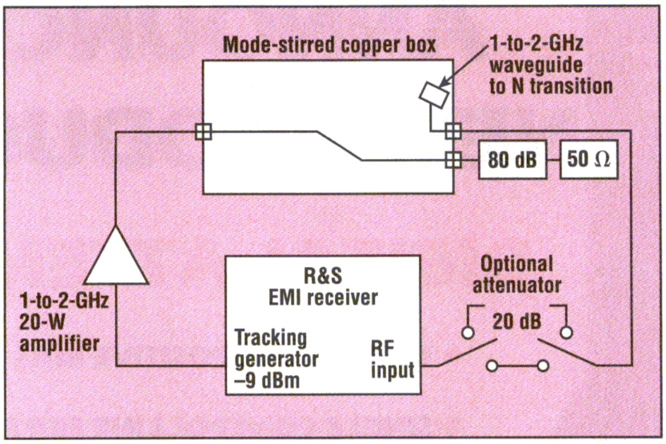
these measurements involve placing the cable into a large, screenroom-type of chamber. However, the size of these chambers creates various resonant anomalies that directly affect the accuracy of the measurements. Other measuring schemes involve RF pickup coils, which tend to lose sensitivity as the frequency of the measurement increases.



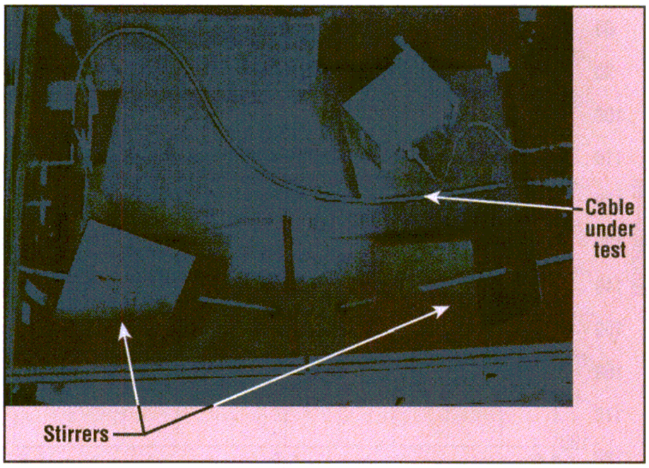
4. The mode-stirred measurement setup is now arranged with a waveguide to type-N adapter for evaluating the shielding effectiveness of coaxial cable assemblies.

According to Henry Pixley, product development engineer at General Instrument, Comm Scope Division, "In order to be able to accurately measure the cable's shielding effectiveness, an actual measurement of radiated electromagnetic fields must be made within an electrically controlled environment." Different approaches to achieving this electrically controlled environment have yielded a variety of measuring techniques, including the gigahertz transverse-electromagnetic cell method (GTEM), the mode-stirred chamber method, the absorbing clamp method, the transfer-impedance method, and the open-area-test-site (OATS) method.

The GTEM is recognized method to measure SE. The GTEM is a waveguide feedhorn design. The RF excitation energy is fed at the feedhorn input end and sets up a calibrated field intensity within the waveguide itself. The test performed in the GTEM is a measurement of the amount of field radiation that leaks into the center conductor of a cable through its shield. This requires that a sampling antenna be placed within the feedhorn waveguide to measure the field intensity being imposed onto the cable sample. The GTEM cell is useful to 5 GHz. It is a widely accepted method for measuring many kinds of equipment and complete systems due to the large area that is available within the feedhorn.

The mode-stirred chamber is another device to measure a cable's

shielding effectiveness. The mode-stirred chamber consists of a shielded enclosure with reflective paddles to effectively stir up the modes inside the chamber (Fig. 1). It eliminates the polarization condition found in an OATS measurement, resulting in better measurement accuracy. Due to the mode-stirring tuners, higher E- and H-field intensities can be produced using lower power than that of the OATS method. Thus, the mode stirred chamber produces an RF environment which simulates actual conditions of homogeneous field strengths more closely than single E- and H-fields, which have to be measured and mathematically averaged (Fig. 2). The physical size of the box determines its upper-frequency range, typically slightly above 2 GHz. In his report, "Mode Stirred Chambers for EMC Measurements," H.G. Krauthauser says that not only are mode-stirred chambers better than OATS or other chamber methods, but that "...tests in MSCs (mode-stirred chambers) are much cheaper compared to OATS or semianechoic chambers." These chamber sizes can range from table-top size up to full-sized rooms.



5. This photograph illustrates a test system based on the block diagram of Fig. 4.

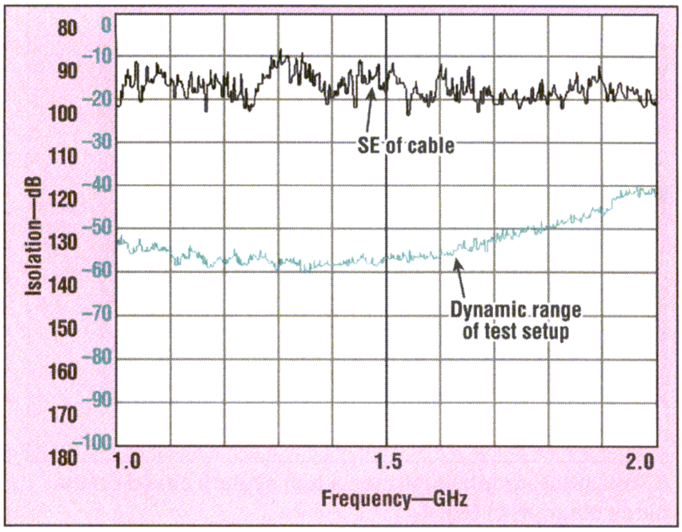
Semflex uses the mode-stirred chamber method to evaluate the shielding effectiveness of their cable products. The measurement system includes a precision electromagnetic-interference (EMI) receiver (Rx). The mode-stirred Cu box is first calibrated to determine the test system self-noise and dynamic range (Fig. 3). A waveguide-to-coaxial adapter is then used for the interface of the cable under test to the measurement system (Fig. 4).

MODE-STIRRED CHAMBER

The use of a mode-stirred chamber (Fig. 5) offers a low noise floor, typically better than 120 dB below signal-carrier level, offering a high dynamic range where to measure the SE. The mode-stirred chamber affords a small physical size suitable for the cable being tested so that measurements are not cumbersome or expensive when compared to OATS or similar methods. The reflective-paddle design does yield the closest simulation of a true RF environment with random reflections.

TEST RESULTS

A summary of the test results run on a new cable design shows shielding-effectiveness performance that generally exceeds 90 dB across a measurement range of 1 to 2 GHz (Fig. 6). Prior to taking the measurement, a precalibration run is performed to determine the dynamic range of the test environment. This is typically seen to be 120 dB at 2 GHz, adequate for the shielding-effectiveness measurements.



6. These measured results, using the mode-stirred measurement method, compare the shielding effectiveness of a model 2221-RT110-040 coaxial cable (upper trace) with the dynamic range of the test setup (lower trace).

Shielding effectiveness is an important parameter to the proper function of coaxial cables in today's modern RF and microwave applications. The test methods used to verify this parameter need to be sensitive enough to pick up the smallest amounts of RF energy, need to realistically model actual RF environments with their random E and H field distributions, and need to be cost effective. The mode-stirred chamber meets all of these fundamental parameters. This is the method Semflex uses to verify the shielding effectiveness of its coaxial-cable assemblies. ●●

For further reading

Henry D. Pixley, "Drop Cable Shielding," *Communications Technology Magazine.*

Roger Lique, "A Description of the Triaxial Test for Shielding Performance of CATV Drop Products," Trilogy Communications, Inc., May 1992.

Otto Breitenbach *et al.*, "Screening of Cables in the MHz to GHz Frequency Range-Extended Application of a Simple Measuring Method," *Influence of Mismatches*, May 1998.

H.G. Krauthauser, "Mode Stirred Chambers for EMC Measurements," http://www.unimagdeburg.de /iele_e.html.

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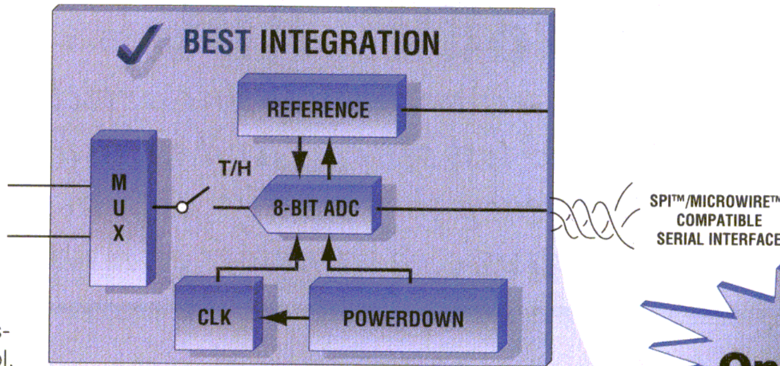

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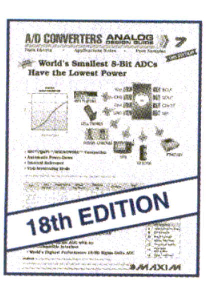

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Measuring And Evaluating Dynamic ADC Parameters

Dynamic ADC testing, Part 2

The second half of this article provides test systems and measurement software that can be used to test the dynamic parameters of ADCs.

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ANALOG-TO-DIGITAL converters (ADCs) represent the link between analog and digital worlds in receivers (Rxs), test equipment, and other electronic devices. As outlined last month in Part 1 of this article series, a number of key dynamic parameters provide a fairly accurate correlation of the performance to be expected from a particular ADC. In this concluding article installment, some of the test setups and measurement procedures for testing the dynamic parameters of high-speed ADCs will be presented. This installment will describe the required software tools, hardware configurations, and test instruments needed to evaluate a 10-b, +3-VDC converter-family example.

Table 1: Summarizing the key dynamic ADC parameters

Dynamic parameter	Description definition
Signal-to-noise ratio (SNR)	$SNR_{dB} = 6.02 \bullet N + 1.763$
Signal-to-noise plus distortion (SINAD)	$SINAD_{dB} = 20 \bullet \log_{10} (A_{SIGNAL}[rms]/A_{NOISE}[rms])$
Effective number of bits (ENOB)	$ENOB = (SINAD - 1.763)/6.02$
Total harmonic distortion (THD)	$THD_{dBc} = 20 \bullet \log_{10} (\sqrt{(V_{HD\_2}^2 + V_{HD\_3}^2 + ... + V_{HD\_N}^2)} / V[f_{IN}])$
Spurious-free dynamic range (SFDR)	SFDR is the ratio expressed in decibels of the RMS amplitude of the fundamental (maximum signal component) to the RMS value of the next largest spurious component, excluding DC offset.
Two-tone intermodulation distortion (TTIMD)	$TTIMD_{dB} = 20 \bullet \log_{10} \{\Sigma(A_{IMF\_SUM}[rms] + A_{IMF\_DIFF}[rms])/A_{FUNDAMENTAL}[rms]\}$ IMF_SUM and IMF_DIFF in a TTIMD setup containing 2 input tones only.
Multi-tone intermodulation distortion (MTIMD)	$MTIMD_{dB} = 20 \bullet \log_{10} \{\Sigma(A_{IMF\_SUM}[rms] + A_{IMF\_DIFF}[rms])/A_{FUNDAMENTAL}[rms]\}$ IMF_SUM and IMF_DIFF in and MTIMD setup containing more than 2 (usually up to 4) input tones.
Voltage standing-wave ratio (VSWR)	$VSWR = (1+\|\rho\|)/(1-\|\rho\|)$, where: ρ = the reflection coefficient.

A variety of approaches are available for capturing output data from general-purpose and high-speed ADCs, and for analyzing their dynamic performance. The methods in this article represent one proven approach; readers are encouraged to modify these methods as necessary for the application at hand.

In Part 1, numerous definitions and mathematical descriptions of important dynamic parameters for high-speed ADCs were presented (Table 1), including signal-to-noise ratio (SNR), signal-to-noise-plus-distortion (SINAD), effective number of bits (ENOB), total harmonic distortion (THD), and spurious-free dynamic range (SFDR).

To perform adequate dynamic tests on high-speed data converters, it is recommended to use a test or evaluation board supplied (assembled) by the manufacturer, or to follow the circuit-board layout recommendations provided on the ADC's data sheet. This article considers the layout requirements for dynamic testing before delving into the details of hardware and software. An evalu-

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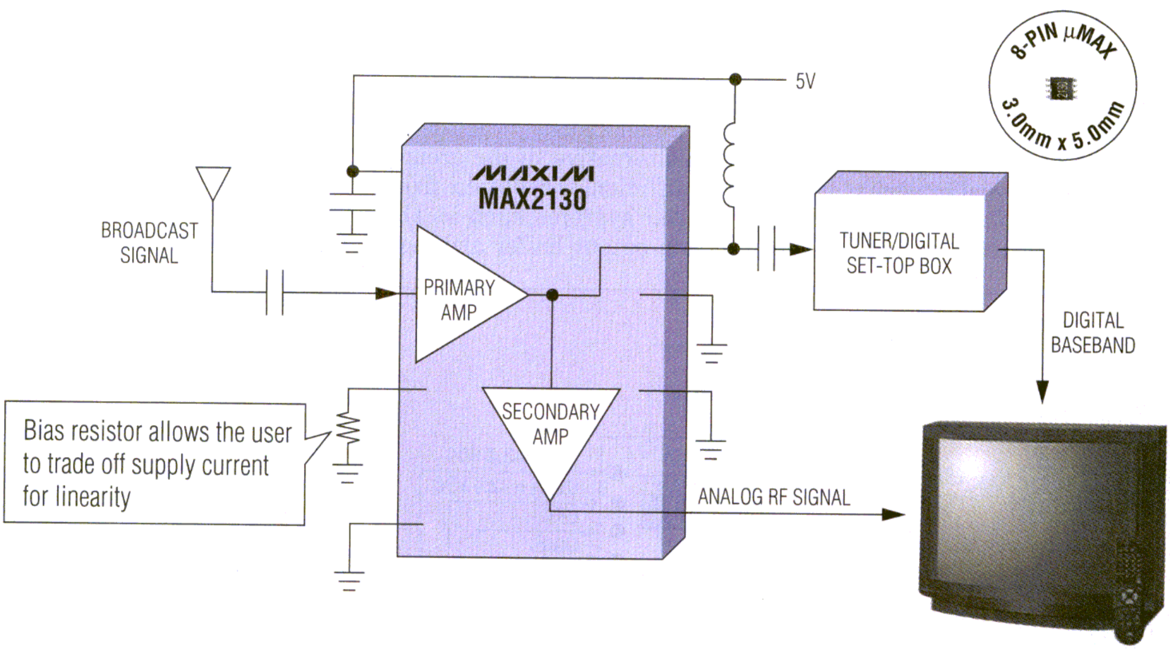

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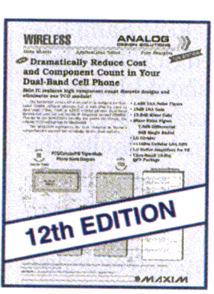

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ation or characterization board for fast data converters must incorporate high-speed layout techniques. The dynamic performance specified in an ADC's data sheet can usually be replicated by following the basic rules below:

- Locate all bypass capacitors as close to the device as possible, preferably on the same side as the ADC, using surface-mount components to achieve minimum trace length, inductance, and capacitance.
- Bypass analog and digital supplies, references, and common-mode inputs with two 0.1-μF ceramic capacitors in parallel and a 2.2-μF bipolar capacitor to ground.
- Multilayer boards with separate ground and power planes produce the highest level of signal integrity.
- Consider the use of a split ground plane arranged to match the physical location of analog and digital grounds on the ADC's package. The impedance of the two ground planes must be kept as low as possible, and to avoid possible damage or latchup, their AC- and DC-voltage differences (or both) must be less than +0.3 VDC. The two grounds should be joined at a single point, so that noisy digital ground currents do not interfere with the analog ground plane. The ideal location of this connection can be determined experimentally, as the point along the gap between the two ground planes that produces optimum results. This connection can be achieved with a low-value surface-mount resistor of 1 to 5 Ω, a ferrite bead, or a direct short.
- As an alternative [if the ground plane is sufficiently isolated from noisy digital systems such as the downstream output buffer and digital signal processor (DSP)], all ground pins can share the same ground plane.
- Route high-speed digital signal traces away from sensitive analog traces.
- Keep all signal lines short and free of 90-deg. turns.
- Always consider the clock input as an analog input. Route it away from actual analog inputs and other digital signal lines.

A proper test setup and the right test equipment is necessary to realize the performance specified for a given converter (Figs. 1a and 1b). The following hardware has proven to be efficient, and is therefore recommended for the test setup (although readers are invited to substitute equivalent equipment):

For the DC power supply, a model E3620A dual-supply unit from Agilent Technologies (Santa Clara, CA) [formerly Hewlett-Packard Co.] can provide voltages and currents of 0 to +25 VDC and 0 to 1 A, respectively. Separate supplies should be used for the analog and digital nodes. Each supply should provide at least 100 mA of output drive current.

For the clock-signal function generator, a model HP8662A signal generator from Agilent Technologies provides stable signals. The clock input for the device under test (DUT) accepts complementary-metal-oxide-semiconductor (CMOS)-compatible clock signals. This signal should have low phase noise and fast rise and fall times, because the high-speed ADC has a 10-stage pipeline, and its interstage conversion depends on the repeatability of the rising and falling edges of the external clock. Sampling occurs on the falling edge of the clock signal, so that edge should have the lowest possible jitter/phase noise. Significant aperture jitter limits the ADC's SNR performance as follows:

$$SNR_{dB} = 20\log_{10}(0.5\pi f_{IN} \times t_{AJ}),$$

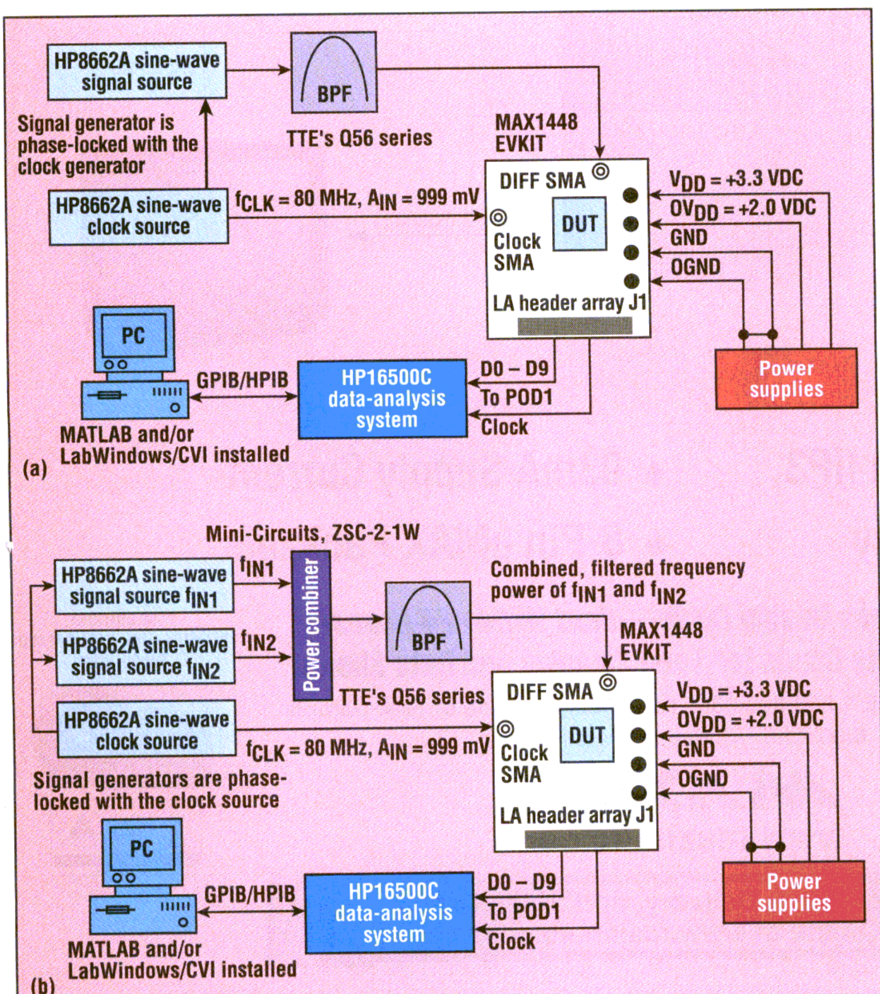
where:

f_{IN} = the analog input frequency, and

t_{AJ} = the time of the aperture jitter.

Clock jitter is especially critical for undersampling applications.

For the input-signal function generator, another model HP 8662A sig-



1. This test setup is suitable for evaluating SNR, SINAD, THD, and SFDR (a) while it can be modified for testing two-tone IMD performance (b).

nal generator from Agilent Technologies is recommended. For proper operation, this function generator should be phase-locked to the clock-signal generator.

For the logic analyzer, a model HP16500C from Agilent Technologies offers flexible and accurate measurement power. Depending on the number of points in the proposed Fast Fourier transform (FFT), it may be possible to capture the data using a logic analyzer with less memory depth than the HP16500C, such as the 4-kB data record available in the firm's model HP1663C/EP logic analyzer.

For the analog bandpass filter, the Q56 series elliptical function bandpass filters from TTE (Los Angeles, CA) provide high rejection with low insertion loss. The series is available with cutoff frequencies of 7.5, 20, 40, and 50 MHz.

Digital multimeters (DMMs) for the measurement system are available from a variety of sources, including Fluke Manufacturing Co. (Everett, WA), Keithley Instruments (Cleveland, OH), and Hewlett-Packard Co. (Palo Alto, CA), including the handheld model HP2373A and the AC-powered model HP34401A. The DMMs are used to check for proper reference voltages, supplies, and common-mode voltages.

EVALUATING THE DUT

To simplify evaluation of the DUT, it was measured with a performance-optimized, fully assembled and tested surface-mount EVKit evaluation board. Follow the steps below to configure the setup and operate this board. One should complete all the connections before turning on the power supplies or enabling the function generators.

- Apply a +3.0-VDC analog power supply to pins VAIN1 and VAIN2, and connect its ground terminal to pin AGND.
- Apply a +3.0-VDC digital power supply to pins VDIN1 and VDIN2, and connect its ground terminal to DGND.
- Verify that no shunts are installed for jumpers JU1 (shutdown disabled) and JU2 (digital outputs enabled).
- Connect the clock-function generator to the CLOCK-SMA connector.
- Connect the output of the analog-signal function generator to the input of one of the bandpass filters.
- To evaluate differential analog signals, verify that shunts are installed on pins 1 and 2 of jumpers JU3 and JU4. Connect the output of the bandpass filter to the DIFF-IN-SMA connector.
- To evaluate single-ended analog signals, verify that shunts are installed on pins 2 and 3 of jumpers JU3 and JU4, and connect the output of the bandpass filter to the SINGLE-IN-SMA connector.

• Connect one of the logic-analyzer interface cables (pods) to the square pin header J1.

• Turn on both power supplies, and verify with a voltmeter that a voltage of +1.20 VDC is present across test points TP4 and TP5. If necessary, adjust potentiometer R34 to obtain the required +1.20 VDC.

• Enable the function generators. Set the clock-function generator to its maximum output amplitude (999 mV for the suggested HP8662A signal generator) and a clock frequency of f_{CLK} = 80 MHz. Set the analog signal-function generator to the desired input tone, with any amplitude between 10 μV and 999 mV. Note that the input amplitude and frequency must be selected according to the bandpass filter's corner frequency. Bandpass filters used in evaluating high-speed data converters usually tolerate a narrow passband. To achieve optimum performance (depending on filter type and manufacturer), set the input tone to within 5 percent of the corner frequency. Since the filter attenuates the generator's output signal, set the generator's amplitude slightly higher to achieve the desired full-scale input specification.

• For proper operation, phase-lock the two function generators [or three function generators, if testing for two-tone intermodulation distortion (IMD)].

• Synchronize the logic analyzer with the external clock signal from the board, and set the logic analyzer to latch data on the clock's rising edge.

• Enable the logic analyzer and begin collecting data. Data can be stored on a floppy disk, on the logic analyzer's hard disk, or on a data-acquisition (DAQ) board communicating through the logic analyzer's general-purpose-interface-bus (GPIB) port.

Now that the necessary steps for test setup and hardware configuration have been completed and the system is ready to capture data from the DUT, it is time to select the software tools for data capture and analysis.

• LabWindows/CVI from National Instruments (Austin, TX) serves as the required data capture and communications link between the logic analyzer and the DAQ-controller board. (The C-language-based program routine used for this purpose will not be discussed in this article.)

• MATLAB from The MathWorks (Natick, MA) is a powerful tool that performs the FFT and dynamic analysis of the captured data.

To help understand how a MATLAB program routine analyzes and graphs the dynamic performance of a high-speed data converter, the next section reviews some of the FFT and power-spectrum basics.

The FFT and the power spectrum are adequate tools for measuring and analyzing signals from captured data records. They can capture time-domain signals, measure their frequency content, convert the results to convenient units, and display them. To perform FFT-based measurements, however, one must understand the issues and calculations involved. Basic functions of an FFT-based signal analysis are the FFT itself and the power spectrum. Both are extremely useful for measuring the

frequency content of stationary or transient signals. FFTs usually produce the average of a signal's frequency content over the time interval that the signal was acquired. Thus, FFTs are always recommended for stationary-signal analysis.

Among the most basic and important computations in signal analysis are the use of the FFT in converting from a two-sided to a single-sided power spectrum, adjusting the frequency resolution, and displaying the spectrum. A power spectrum usually returns a matrix containing the two-sided representation of the time-domain signal power in the frequency domain. The values in this matrix are proportional to the amplitude squared of each frequency component making up the time-domain signal.

A plot of the two-sided power spectrum usually contains negative and positive frequency components. Actual frequency-analysis tools, however, focus on the positive half of the frequency spectrum only, noting that the spectrum of a real signal is symmetrical around DC. Negative frequency information is therefore irrelevant. In a two-sided spectrum, half the energy resides in the positive frequencies and half in the negative frequencies. To convert from a two-sided spectrum to a single-sided spectrum, therefore, one must discard the second half of the matrix and multiply every point (except DC) by two.

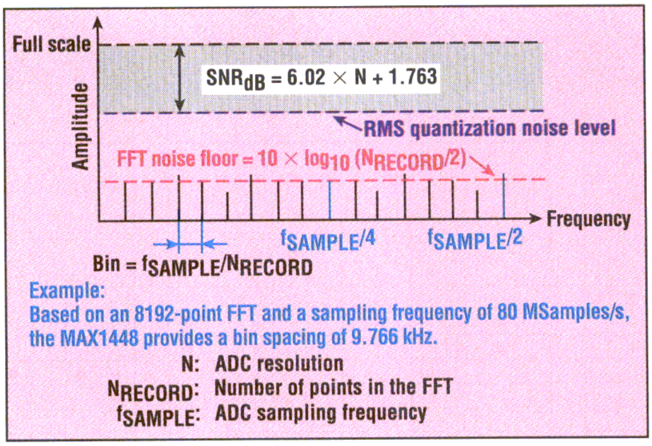
The frequency range and resolution on the x-axis of a spectrum plot depend on the sampling rate and the size of the data record (the number of acquisition points). The number of frequency points or lines in the power spectrum is N/2, where N is the number of signal points captured in the time domain. The first frequency line in the power spectrum always represents DC. The last frequency line can be found at $f_{SAMPLE}/2 - f_{SAMPLE}/N$. Frequency lines are spaced at even intervals of f_{SAMPLE}/N, commonly referred to as a frequency bin or FFT bin (Fig. 2). Bins can also be computed with reference to the ADC's sampling period:

$$\text{Bin} = f_{SAMPLE}/N = 1/N\Delta t_{SAMPLE}$$

where:

f_{SAMPLE} = the sampling frequency, and

Δt_{SAMPLE} = the sample time differential.



2. An FFT graph is composed of a number of separate frequency/FFT data bins.

For example, with a sampling frequency of f_{SAMPLE} = 82.345 MHz and a record length of 8,192 data points, the distance between each frequency line in the FFT plot is exactly 10.052 kHz. (See Fig. 1 of Part 1 of this article series, *Microwaves & RF*, November 2000, p. 75).

The calculations for the frequency axis (x-axis) are proof that the sampling frequency determines the range or bandwidth of the frequency spectrum. For a given sampling frequency, the number of points acquired in the time domain determines the resolution frequency. To increase the resolution for a given frequency range, the depth of the data record can be increased at the same frequency (see the sidebar for program-code extraction No. 1).

Window functions are common in FFT analysis, and their proper use is critical in FFT-based measurements. The following discussion of spectral leakage stresses the need to select an appropriate window function and scale it properly for a given application. To accurately determine spectral leakage, however, it may not be enough to use adequate signal-acquisition techniques, convert a two-sided power spectrum into a single-sided one, and rescale the result. To gain a better understanding of this term, one should perform an N-point FFT on a spectrally pure sinusoidal input.

Spectral leakage is the result of an assumption in the FFT algorithm that the time record is precisely repeated throughout all time, and that all signals contained in this time record are periodic at intervals corresponding to the length of the time record. However, a nonintegral number of cycles in the time record ($f_{IN}/f_{SAMPLE} \sim N_{WINDOW}/N_{RECORD}$) violates this condition and causes spectral leakage (Fig. 3) [See also the second sidebar in Part 1]. Only two cases can guarantee the acquisition of an integral number of cycles:

- Synchronous sampling with respect to the input tone.
- The capture of a transient signal that fits entirely into the time record.

Table 2: Characteristics of frequently used window functions (see also MATLAB program code)

Window type	−3-dB mainlobe width	−6-dB mainlobe width	Maximum sidelobe level	Sidelobe rolloff rate
No window (uniform)	0.89 bins	1.21 bins	−13 dB	20 dB/decade 6 dB/octave
Hanning	1.44 bins	2.00 bins	−32 dB	60 dB/decade 18 dB/octave
Hamming	1.30 bins	1.81 bins	−43 dB	20 dB/decade 6 dB/octave
Flat top	2.94 bins	3.56 bins	−44 dB	20 dB/decade 6 dB/octave

In most cases, however, the application deals with an unknown stationary input. (A stationary signal is one that is present before, during, and after the data capture.) This means that there is no guarantee of sampling an integral number of cycles. Spectral leakage distorts the measurement by spreading the energy of a particular frequency component over the adjacent frequency lines or bins. Selecting an appropriate window function can minimize the effects of this spectral leakage.

To fully understand how a particular window function affects the frequency spectrum, one must take a closer look at the frequency characteristics of windows. Windowing of the input data is equivalent to convolving the spectrum of the original signal with the spectrum of the window. Even for coherent sampling, the signal is convolved with a rectangular-shaped window of uniform height. (Performing an FFT with no apparent window function selected is frequently referred to as performing the FFT with a "uniform" or "rectangular" window.) Such convolution shows a typical sine-function characteristic spectrum.

The real-frequency characteristic of a window is a continuous spectrum consisting of a main lobe and several side lobes. The main lobe is centered at each frequency component of the signal in the time domain. Side lobes approach zero at intervals on each side of the main lobe. An FFT, on the other hand, produces a discrete frequency spectrum. The continuous, periodic spectrum of a window is sampled by the FFT, just as an ADC would sample an input signal in the time domain. What appears in each frequency line of the FFT is the value of the continuous convolved spectrum at each FFT frequency line.

If the frequency components of the original signal match a frequency line exactly, as is the case when one acquires an integral number of cycles, one sees only the main lobe of the spectrum. Side lobes do not appear because the window spectrum approaches zero at bin-frequency intervals on either side of the main lobe. If a time record does not contain an integral number of cycles, the continuous spectrum of the window is shifted from the main lobe center at a fraction of the frequency bin that corresponds to the difference between the frequency component and the FFT frequency lines. This shift causes the sidelobes to appear in the spectrum. So, the window's sidelobe characteristics directly affect the extent to which adjacent frequency components "leak into" the neighboring frequency bins.

WINDOW CHARACTERISTICS

Before choosing an appropriate window, it is necessary to define the parameters and characteristics that enable users to compare windows. Such characteristics include the –3-

dB main lobe width, the –6-dB main lobe width, the maximum sidelobe level, and the sidelobe rolloff rate (Table 1).

Sidelobes of the window are characterized by the maximum sidelobe level, defined as the maximum sidelobe level in decibels with respect to the main lobe's peak gain, and the sidelobe rolloff, which is defined as the asymptotic decay rate (in decibels/decade or decibels/octave of frequency) of the sidelobe peaks (Table 2).

Different windows suit different applications, and to choose the right spectral window, one has to guess the signal-frequency content. If the signal contains strong interfering frequency components distant from the frequency of interest, one should choose a window whose side lobes have a high rolloff rate. If strong interfering signals are close to the frequency of interest, a window with low maximum levels of side lobe is more suitable.

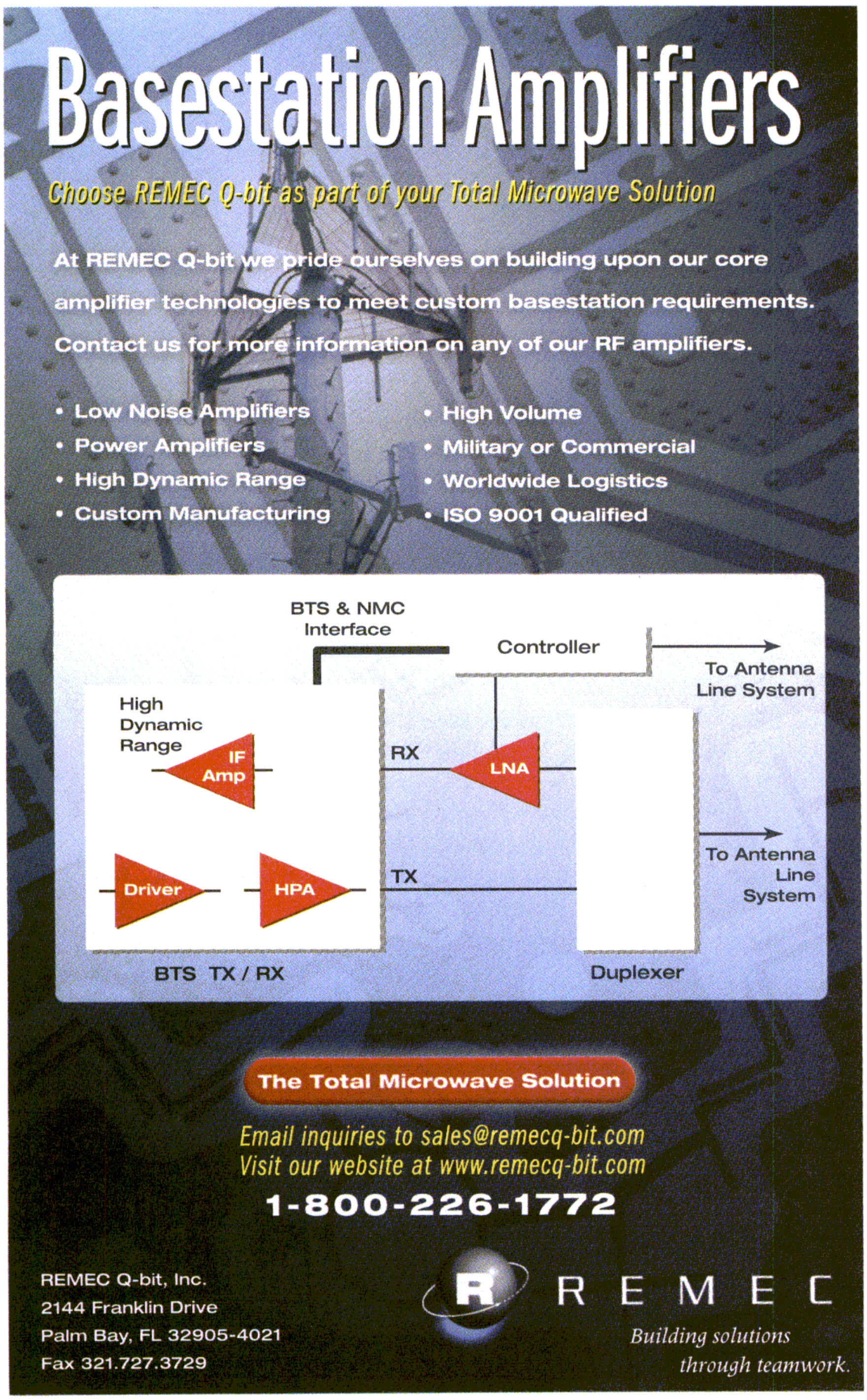
If the frequency band of interest contains two or more signals close to each other, spectral resolution becomes important. In that case, a window with a narrow main lobe is better. For a single-frequency component in which the focus is on amplitude accuracy rather than its precise location in the frequency bin, a window with a broad main lobe is recommended. Finally, coherent sampling (instead of a window) is recommended for a flat or broadband frequency spectrum (see the sidebar for program-code extraction No. 2).

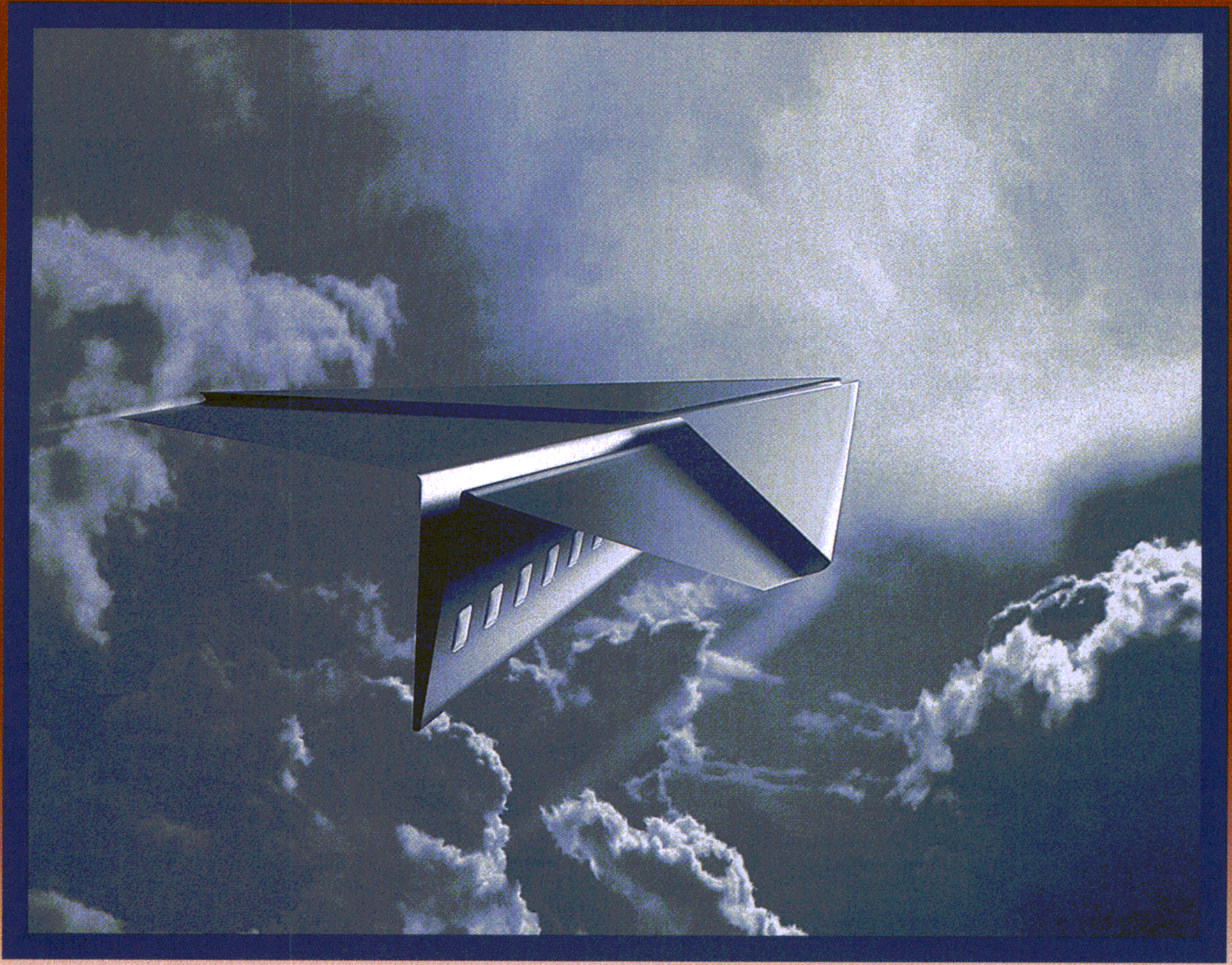
The Hanning window function, which provides good frequency resolution and reduced spectral leakage, offers satisfactory results in most applications. The flat-top window has good amplitude accuracy, but its wide main lobe provides poor frequency resolution and more spectral leakage. The flat-top window has a lower maximum sidelobe level than the Hanning window, but the Hanning window has a faster rolloff rate.

An application of only transient signals should have no spectral windows at all, because they tend to attenuate important information at the beginning of the sample block. With a transient signal, a nonspectral window such as a force or exponential window should be chosen.

Selecting an appropriate window is not easy, but if the signal content is unknown, one can start with the Hanning characteristic. It is also an excellent idea to compare the performance of multiple window functions to find the one most suitable for a particular application (Table 3).

With the knowledge gained in preceding sections of this article, the following program-code extraction should be easy to understand. Based on the FFT, power spectrum, and attention to spectral leakage and window functions, the specifications SNR, SINAD, THD, and SFDR are calculated as follows, using MAT-





LAB:

$SNR = 10\log_{10}(P_s/P_n)$

$SINAD = 10\log_{10}[P_s/(P_n + P_d)]$

$THD = 10\log_{10}(P_d/Ph_{(1)})$

$SFDR = 10\log_{10}[P_{h(1)}/\max(P_{h(2:10)})]$

where:

P_s = the signal power,

P_n = the signal noise,

P_d = the distortion power caused by second-through-fifth-order harmonics,

$P_{h(1)}$ = the fundamental harmonic power, and

$P_{h(2:10)}$ = the harmonic power of the second through ninth harmonics (see the sidebar for program-extraction code No. 3 for computing the power-spectrum level).

Based on MATLAB source code, a high-speed ADC from Maxim Integrated Products (Sunnyvale, CA), the MAX1448, was tested not only for its data-sheet specifications, but also for many other over- and under-sampling input frequencies as well. It achieved excellent dynamic performance for all conditions.

Two-tone IMD can be a tricky measurement, since the additional equipment required—a power combiner that combines two input frequencies—can contribute unwanted IM products that falsify the ADC's IMD. The following conditions must be carefully observed to optimize IMD performance, although they make the selection of proper input frequencies a tedious task.

First, the input tones must fall into the passband of the input filter. If these tones are close together (several tens or hundreds of kilohertz for a megahertz bandwidth), an appropriate window function must be chosen as well. Placing them too close together, however, may allow the power combiner to falsify the overall IMD readings by contributing unwanted second- and third-order IMD products (depending on the location of the input tones within the passband). Spacing the input tones too far apart may call for a different window type that has less frequency resolution.

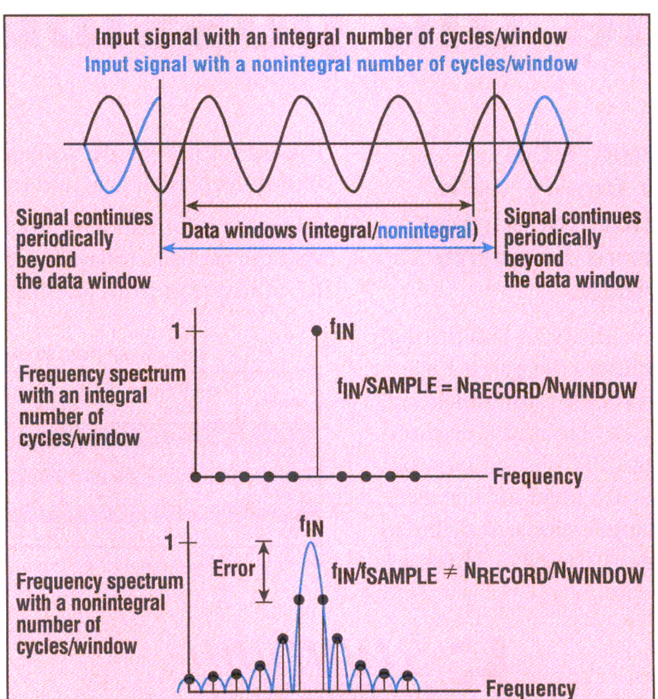
Table 3: Signal content versus window selection and advantages

Window type	Signal content	Window characteristics
No window (uniform)	Broadband random Closely spaced sine-wave signals	Narrow mainlobe Slow rolloff rate Poor frequency resolution
Hanning	Narrowband random signals Nature of content is unknown Sine wave or combination of sine-wave signals	High maximum sidelobe level Good frequency resolution Reduced leakage Faster rolloff rate
Hamming	Closely spaced sine-wave signals	Good spectral resolution Narrow mainlobe
Flat top	Sine wave with need for amplitude accuracy	Good amplitude accuracy Wide mainlobe Poor frequency resolution More spectral leakage

The setup also requires a minimum of three phase-locked signal generators. This requirement seldom poses a problem for test labs, but generators have differing capabilities for matching frequency and amplitude. Compensating such mismatches to achieve (for example) a –0.5-dB full-scale (FS) two-tone envelope and signal amplitudes of –6.5 dB full scale will increase the effort and test time required (see the sidebar for program-code extraction No. 4).

In short, besides the points covered above, many other issues confront an engineer trying to determine the dynamic range of a high-speed ADC by capturing its signals and analyzing them. Unfortunately, mistakes are easily made in spectral-measurement procedures. However, this task of DAQ and analysis is eased by an understanding of FFT-based measurement and related computations, the effect of spectral leakage and how to prevent it, and the necessary layout techniques and equipment.

A free copy of the MATLAB source code used in the evaluation of the MAX1448 high-speed ADC is available free upon request from the author at tanja_hofner@maximhq.com, or by sending an e-mail to jbrowne@penton.com and requesting a copy of the MATLAB code. ••



3. This plot shows the effects of data windows on spectral leakage.

For further reading

MAX1448 datasheet, Rev. 0, 10/00, Maxim Integrated Products, Sunnyvale, CA, 2000.

MAX1448EVKIT datasheet, Rev. 0, 0/00, Maxim Integrated Products, Sunnyvale, CA, 2000.

D. Johns and K. Martin, *Analog Integrated Circuit Design*, Wiley, New York, 1997.

E. Sanchez-Sinencio and A.G. Andreou, *Low-Voltage/Low-Power Integrated Circuits and Systems(Low-Voltage Mixed-Signal Circuits*, IEEE Press, Piscataway, NJ, 1999.

R. van de Plasche, *Integrated Analog-to-Digital and Digital-to-Analog Converters*, Kluwer Academic Publishers, Johanesburg, South Africa, 1994.

Engineering Staff of Analog Devices, *Analog-Digital Conversion Handbook*, PTR Prentice-Hall, Englewood Cliffs, NJ, 1986.

Engineering Staff of Analog Devices, *Mixed-Signal and DSP Design Techniques*, Analog Devices, Norwood, MA, 2000.

Simplified Method Eases The Design Of Bandpass Filters

A method to simplify the design of evanescent-mode waveguide bandpass filters is a new twist on previously established theory.

Dr. J. Howard and M. Lavey

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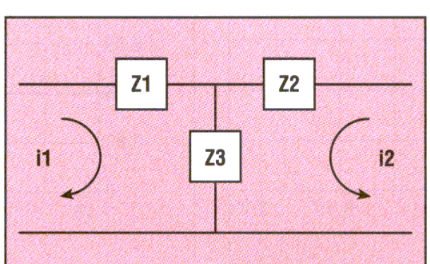
APPROXIMATELY thirty years ago, G. Craven and C. Mok presented their theory of evanescent dominant-mode waveguide bandpass filters.[1] The theory derives the equivalent ladder network from the lowpass prototype through an iterative technique, and is accurate for narrow-to-moderate bandwidths up to 20 percent. In 1989, J. Howard and W. Lin repeated Craven and Mok's work using the well-known "Q" technique where the individual resonator quality factors (Qs) are used in the design of evanescent waveguide-bandpass filters.[2] The advantage of this method is that the Q of the individual lumped-type filter resonators can be compared to their evanescent-mode counterparts. This permits further improvement of the evanescent-mode bandpass filter's performance. The techniques previously mentioned require an iterative method to arrive at the required evanescent-waveguide obstacle positions.

In 1977, R.V. Snyder presented a generalized evanescent-waveguide bandpass-filter theory employing an admittance-inverter-synthesis technique incorporating a frequency-variable turns ratio.[3] Snyder's generalized theory also requires an iterative approach to evaluate the correct positions of the evanescent-waveguide obstacles. However, this article offers a simple approximate evanescent waveguide-bandpass filter theory for narrow to moderate bandwidths that employs no iterative techniques. The advantage of the method is the ease of its implementation, since it requires no iteration and is in closed form.

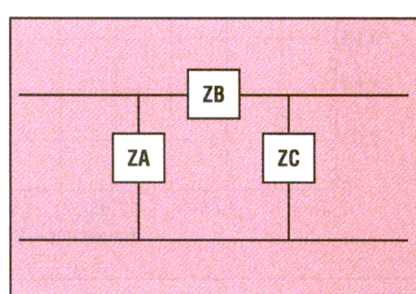
THE THEORY

The equations for a "T" coupled structure (Fig. 1) can be written as:

$$1a.\ Z_{11} = Z_1 + Z_3$$
$$1b.\ Z_{22} = Z_2 + Z_3$$
$$1c.\ Z_{13} = Z_{31} + Z_3 \quad (1)$$



1. The starting point for the theory of evanescent bandpass filters is the classical T-network.



2. This Π network is the equivalent of the T-network shown in Fig. 1.

where:

k is the coupling coefficient between the two sections.

A Π coupled structure is shown in Fig. 2, and using a Δ-Star transformation:

$$k = \frac{Z_{13}}{\sqrt{Z_{11}Z_{22}}} = \frac{Z_3}{\sqrt{(Z_1 + Z_3)(Z_2 + Z_3)}} \qquad (2)$$

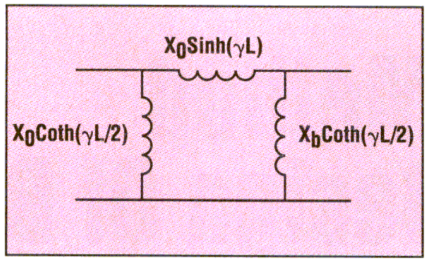
Therefore, substituting in Eq. 2,

$$3a \quad Z_1 = \frac{ZAZB}{ZA + ZB + ZC}$$

$$3b \quad Z_2 = \frac{ZBZC}{ZA + ZB + ZC}$$

$$3c \quad Z_3 = \frac{ZAZC}{ZA + ZB + ZC} \qquad (3)$$

Figure 3 shows the schematic of an evanescent-mode filter as a Π coupled structure. For two Π's in parallel:



3. The evanescent-waveguide equivalent circuit is represented by the Π circuit and components shown here.

$$k = \frac{ZAZC}{\sqrt{(ZAZC + ZAZB)(ZAZC + ZBZC)}} \qquad (4)$$

$$5a. \; ZA = \frac{X_0}{2} Coth\left(\frac{\gamma L}{2}\right)$$

$$5b. \; ZC = \frac{X_0}{2} Coth\left(\frac{\gamma L}{2}\right)$$

$$5c. \; ZB = X_0 \; Sinh(\gamma L) = 2X_0 Sinh\left(\frac{\gamma L}{2}\right) Cosh\left(\frac{\gamma L}{2}\right) \qquad (5)$$

These equations are correct for any of the internal resonators, while the end resonators are described by the following equations:

$$6a. \; ZA = X_0 Coth\left(\frac{\gamma L}{2}\right)$$

$$6b. \; ZC = \frac{X_0}{2} Coth\left(\frac{\gamma L}{2}\right)$$

$$6c. \; ZB = \frac{X_0}{2} Sinh(\gamma L) = 2X_0 Sinh\left(\frac{\gamma L}{2}\right) Cosh\left(\frac{\gamma L}{2}\right) \qquad (6)$$

From the paper, "Direct Coupled Resonator Filters," by Seymour Cohn[4],

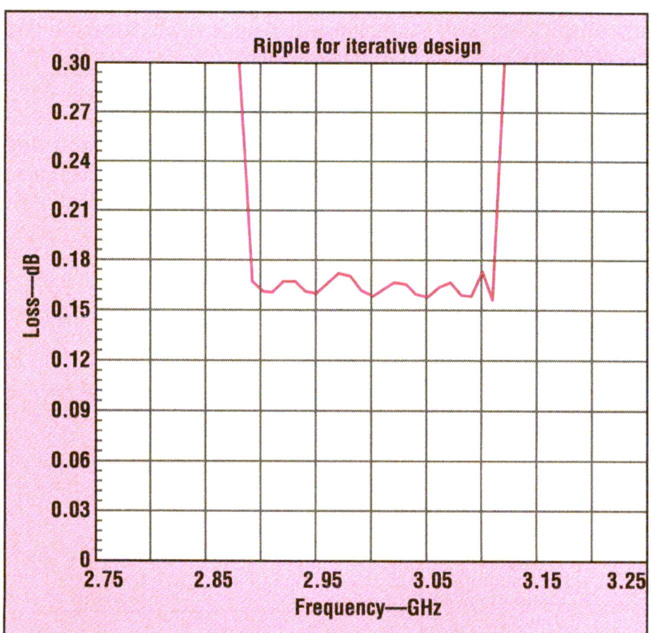
$$k_{i,i+1} = \frac{1}{\omega_1 \sqrt{g_i g_{i+1}}} \left(\frac{f_2 - f_1}{f_0}\right) \qquad (7)$$

where:

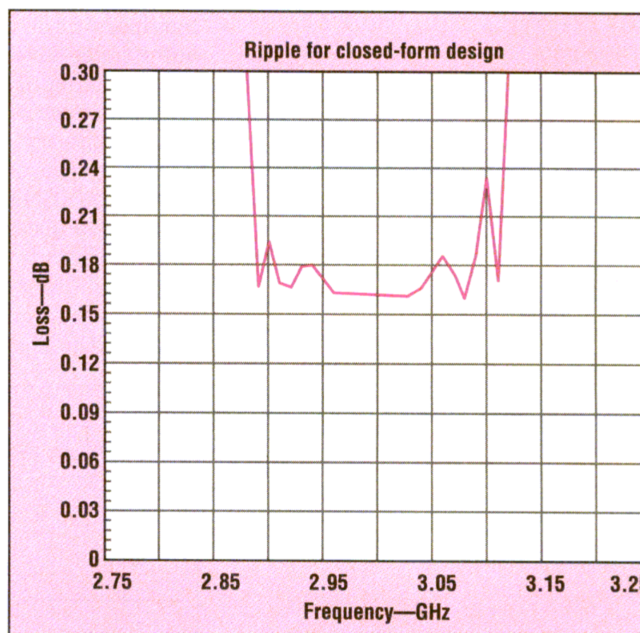
$\omega = 1 = 2\pi f$ = the cutoff frequency of the lowpass prototype, and g, the lowpass prototype normalizes elements, and $k_{i,i+1}$ is the coupling coefficient for sections i, i + 1.

For the evanescent waveguide:

(continued on p. 230)

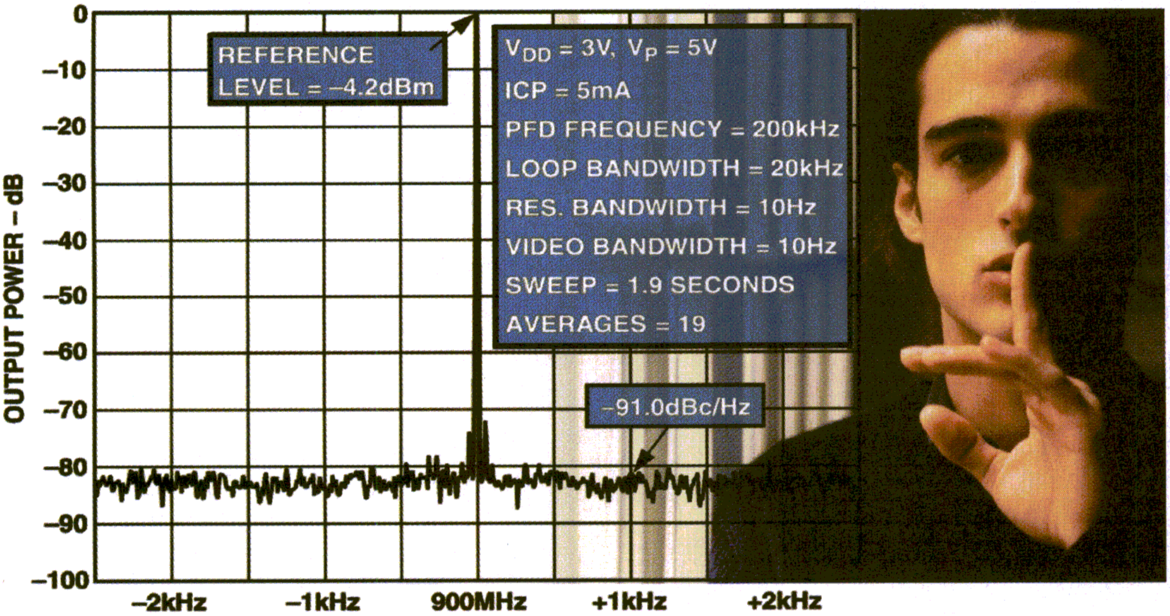


4. This plot represents the ripple response of an evanescent-bandpass filter designed using the iterative technique developed years ago.



5. This plot is similar to that of Fig. 4, except that it shows the ripple response of the filter using the closed-form design technique developed by the authors.

Shhh!



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Measurement Technology

Perform Precise Microwave Measurements

This article discusses several techniques for performing precise measurements on microwave and RF devices and circuits.

Oleksandr Gorbachov
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Gatax Technology Co., Taipei, Taiwan, ROC; FAX: +886-2-87920768, e-mail: alex_gor40@hotmail.com or alexgor40@yahoo.co.uk.

All coaxial cables, microstrip lines, and other transmission lines have inherent losses. But how do these losses impact the parameters measured, and how does one correctly choose the best line? This article presents several matching networks for RF/microwave measurements. These networks may be useful for developing various devices and circuits such as transistors, monolithic microwave integrated circuits (MMICs), hybrid modules, etc. The article presents some basic electromagnetic (EM) theory to solve simple problems that may emerge. Graphical data, equations, approaches, and suggestions are also presented to make RF/microwave-measurement procedures accessible and easier to interpret.

Consider the losses in a uniform transmission line between a well-matched line generator and a reflective load. These losses are defined as:[1,2]

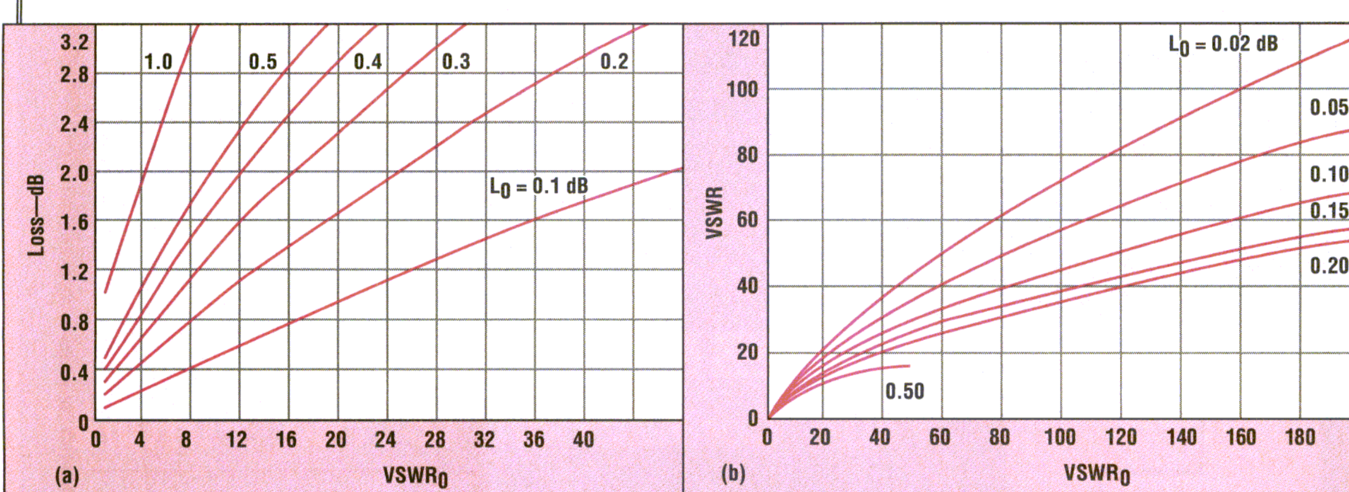
$$L = 10\log\left(1 - |\Gamma_L|^2 e^{-4\beta l}\right) / \left[e^{-2\beta l}\left(1 - |\Gamma_L|^2\right)\right] \quad [dB] \qquad (1a)$$

where:

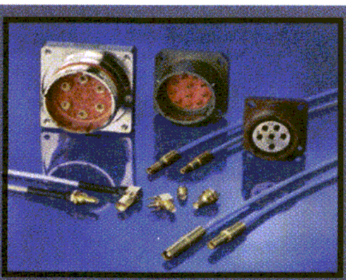
l = the length of the line between the generator and load,

β = the attenuation factor of a line for the wave mode considered, and

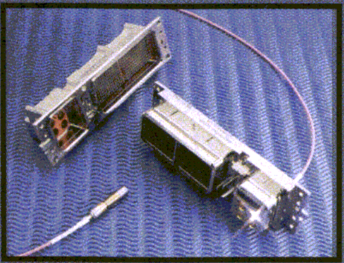
Γ_L = the reflection coefficient of the load.



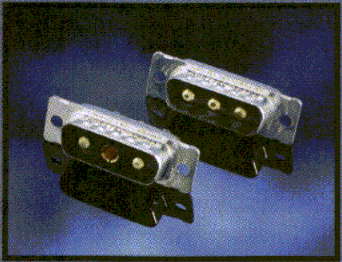
1. This graph illustrates the total losses in a line with standing waves (a), while the resulting VSWR through the line can also be seen (b).



Triaxial Connectors & Contacts



Fiber Optic Avionic Connectors



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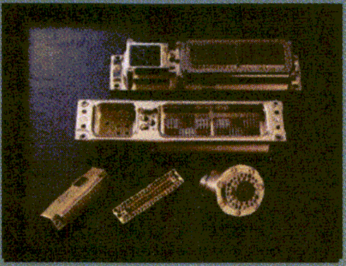
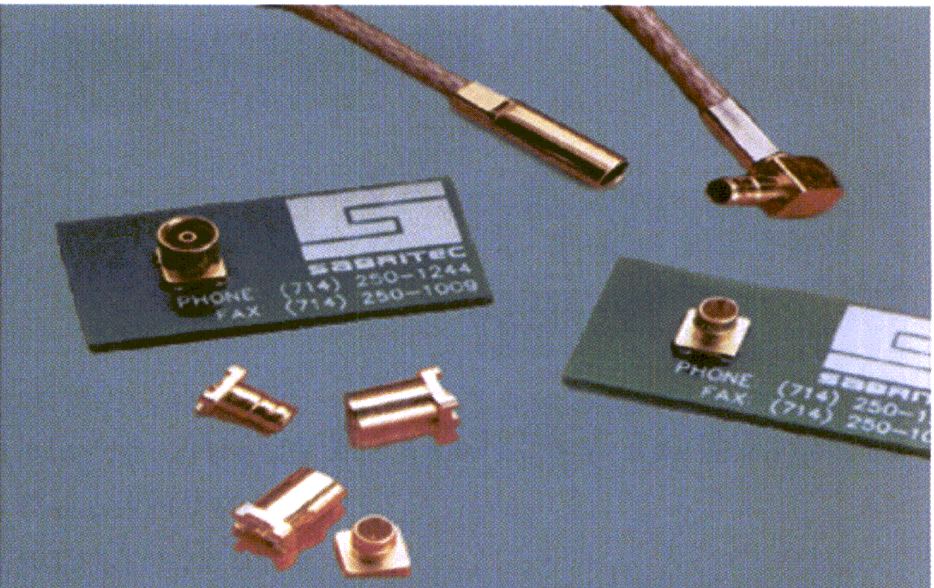


EMI/EMP Filtered Connectors



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The value $L_0 = e^{\beta l}$ represents the generalized loss for a line with travelling-wave conditions, and Eq. 1a shows the contribution of standing waves to the total losses. Figure 1a represents total calculated losses, which depend on the VSWR

$$VSWR_0 = \left(1 + |\Gamma_L|\right) / \left(1 - |\Gamma_L|\right) \quad (1b)$$

It shows that the total losses in a line increase significantly with increasing VSWR, especially for high initial-loss values. Thus, one must carefully consider the VSWR of connected lines to avoid erroneous measurements. For example, consider a line with a high VSWR at one point within the line. Observing it through a short, low-loss transmission line that is similar to a connector, one sees a lower VSWR (Fig. 1b).

TRANSFORMERS

All transformers have inherent losses, and they are connected to the load through the remaining parts of a regular-loss transmission line. If these circumstances are considered, the optimum resistance of a transformer line R^{opt}_L will differ from the known equation:

$$R_t = \sqrt{R_g R_L} \quad (1c)$$

where:
R_g = the "generator" resistance, and
R_L = the "load" resistance.

For simplicity, Figs. 2a and 2b shows the losses in a matching line with a transformer required to match the 50-Ω resistance of a "generator" with four different active "load" resistances at different initial-loss values. (It is assumed that L_0 is comprised of equal parts of inherent transformer losses and the remaining part of the 50-Ω line.) The losses for the fixed "load" resistance R^{opt}_t, represented by the solid line in Fig. 3a, are minimal and practically independent of the initial loss. The dashed line in Fig. 3a shows the theoretical value without losses. By ignoring these losses and selecting a theoretical resistance, one can sufficiently approximate the high values of the required transformation and the significant inherent losses encountered. At the same time, the use of a transformer considerably improves the total loss value (Fig. 3b). So distributing the high VSWR in a matching line significantly decreases power loss, even for nonoptimal conditions.

Tuners have different types of inherent losses. Some of these can be attributed to transmission-line losses. Sometimes the original loss value is indicated by the manufacturer[3] and the total losses can be evaluated by the method noted previously, knowing the real VSWR produced. Other losses include resistive and radiation losses that can be attributed to the stubs and surrounding areas. These are not mentioned in data books, and are only vaguely alluded to in some application notes. Resistive losses can be evaluated, but radiation losses are difficult to calculate and predict.

Consider an air coaxial line with inner-conductor radius R_1 and outer-conductor radius R_2. For a transverse-EM (TEM) wave with resistance Z_0, one can write down the following known equations:

$$Z_0 = 60 \ ln \frac{R_2}{R_1},$$

$$E_r = \frac{V_r}{r \ ln \frac{R_2}{R_1}},$$

$$H\varphi = \frac{E_r}{\sqrt{\mu / \varepsilon}} \qquad (2a)$$

where:

E_r and V_r = the radial components of the electrical field and voltage, respectively, H_ϕ = a tangent component of the magnetic field, and μ and ϵ = the relative permeability and dielectric constant of a coaxial line (μ = 1 and ϵ = 1 for air). Knowing that the power transferred is

$$P_0 = \frac{V^2}{2Z_0} \qquad (2b)$$

and that the current along the coaxial length l is proportional to:

$$I_z \sim H_\varphi \qquad (2c)$$

one can calculate the total resistive losses P_Σ attributed to the inner and outer conductors:

$$\frac{P_\Sigma}{P_0} \sim k_\Sigma \frac{1}{ln \frac{R_2}{R_1}} \left(\frac{\sqrt{\rho_1}}{R_1{}^3} + \frac{\sqrt{\rho_2}}{R_2{}^3} \right),$$

$$k_\Sigma = \frac{30\sqrt{\pi f \mu_0}}{\mu / \varepsilon} 1 \qquad (3a)$$

where:

$$\mu_0 = 4\pi \times 10^{-7} H / m \qquad (3b)$$

is the permeability of free space
f = the frequency, and
$\{\rho_1\}$ and $\{\rho_2\}$ = the relative resistance of the inner and outer conductors of a coaxial line.

The transformation coefficient and associated VSWR of the length l of a transmission line with a resistance Z_t are maximal at l = λ/ 4,
where:

λ = the wavelength of a line.

In this case, the transformation of resistance Z_1 from one port of a transformer to Z_2 at another port is described as $Z_1Z_2 = Z^2_t$. Using these equations, one can determine the relative variation of losses for different geometrical dimensions of a line. The dashed line in Fig. 4a shows the results of these calculations in terms of a maximal $VSWR_{max}$ achieved for a quarter-wave transformer. It is assumed that the inner and outer conductors are made from the same material. Analogous results are shown in Fig. 4b for different values of initial losses that may be known for an undisturbed line. (An undisturbed line is one where the stubs are sufficiently distant from the inner conductor that they have no electrical

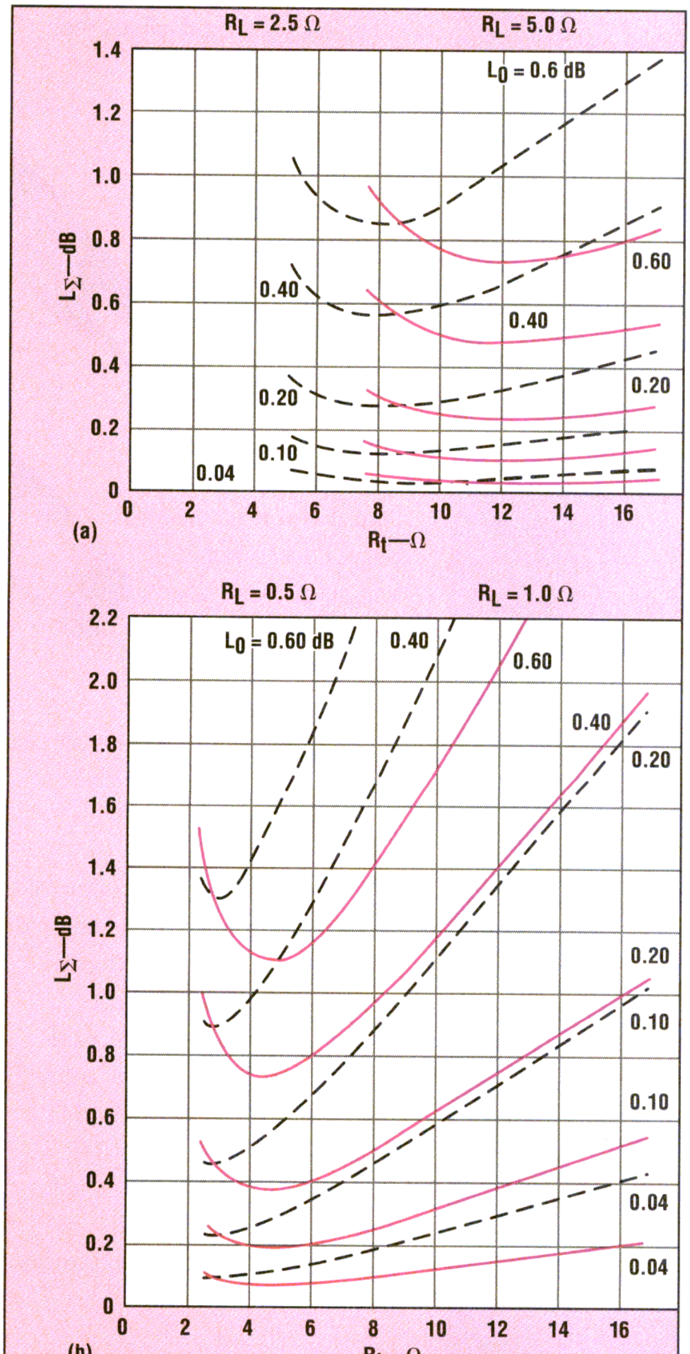
effect on it.) Increasing the desired $VSWR_{max}$ results in an abrupt increase in losses.

Initial losses increase by a cubic exponent as the diameter of the inner conductor decreases. So it is best to use a tuner whose central conductor has a large diameter.

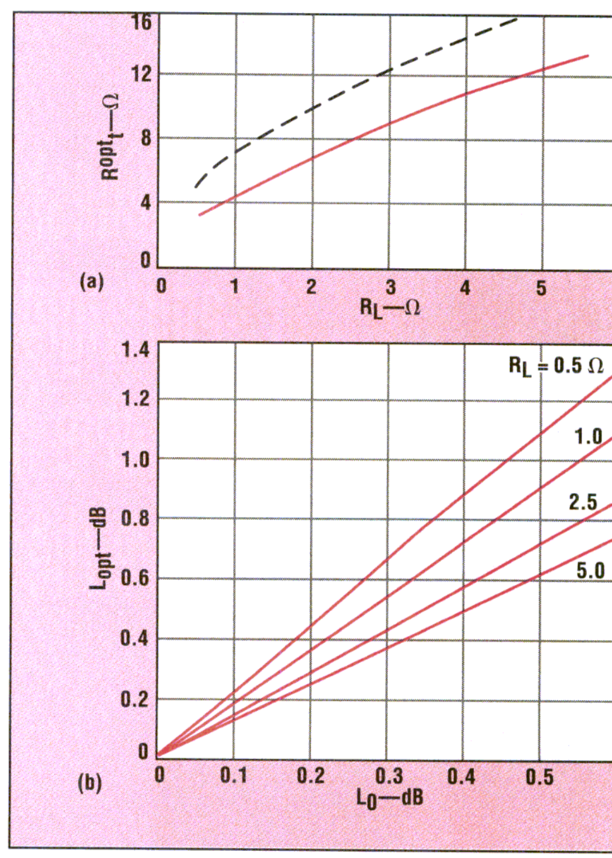
With the same coaxial length l, the initial losses are also proportional to the square root of the frequency. But the slope of the curves in Figs. 4a and 4b are more abrupt due to the decreasing transformation coefficient when $l \neq \lambda/4$. Then, with the same coaxial-line resistance, a quarter-wave transformer decreases initial losses inversely proportionally to the square root of the frequency. So the length of the tuner's transforming stub should be as close as possible to one quarter of a wavelength.

Losses in a tuner depend on the conduction of the materials used. The solid line in Fig. 4a shows the portion of the transformer's total losses attributed to the stub itself. The figure illustrates that the conduction of a stub must be as high as possible or it should be plated by an additional conduction layer with a thickness at least two to three times the skin depth. This applies to the central conductor as well. As a reference, brass possesses ρ = from 4 to 6 × 10^{-8} Ω × m, aluminum (Al) possesses –2.69 × 10^{-8}, gold (Au) –2.44 × 10^{-8}, copper (Cu) –1.72 × 10^{-8}, and silver (Ag) –1.62 × 10^{-8}. Using Ag plating for these applications may be the best way to minimize losses. Despite the unsightly appearance this kind of plating can acquire due to tarnishing, it yields good results even at millimeter-wave frequencies for highly stabilized waveguide-cavity resonators.

The results considered here are valid for travelling waves in a transformer or, described simply, for well-matched conditions between the



2. This graph depicts the total losses in the quarter-wave transformer (a), while the total losses in the 50-Ω line are also shown (b).



3. This graph illustrates the optimum resistance of the transformer (a), while the total losses in the quarter-wave transformer and the 50-Ω line at the optimum resistance are also depicted (b).

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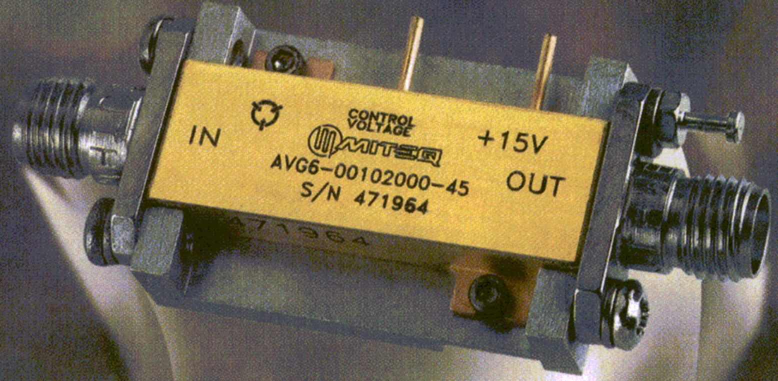

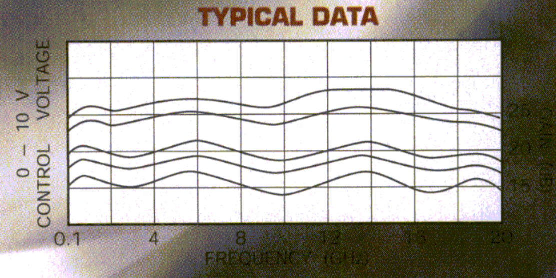

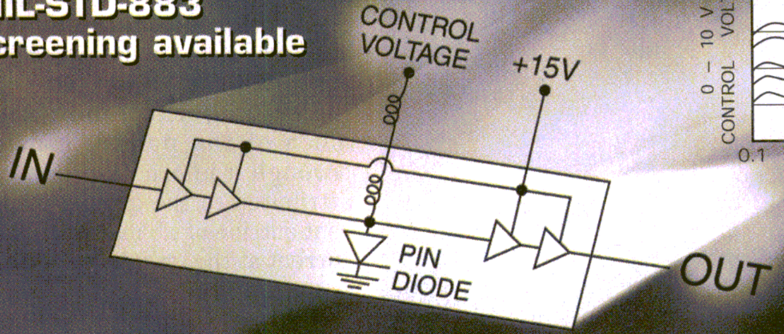

3 YEAR WARRANTY

MODEL NUMBER	FREQUENCY RANGE (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (dB, Max.)	NOISE FIGURE (dB, Max.)	VSWR IN/OUT (Max.)	OUTPUT POWER @ 1 dB Comp. (dBm, Min.)	NOM. DC POWER (+15 V, mA)
AVG4-00100400-14	.1–4	28	±1.00	1.4	2.0:1	+10	150
AVG4-00100600-15	.1–6	28	±1.00	1.5	2.0:1	+10	150
AVG4-00100800-18	.1–8	26	±1.50	1.8	2.0:1	+10	175
AVG4-02000800-20	2–8	32	±1.25	2.0	2.0:1	+10	175
AVG5-04000800-12	4–8	30	±1.00	1.2	2.0:1	+10	150
AVG5-00101800-35	.1–18	24	±2.50	3.5*	2.5:1	+10	175
AVG6-00102000-45	.1–20	24	±2.50	4.5*	2.5:1	+10	250
AVG4-06001200-19	6–12	24	±1.50	1.9	2.0:1	+10	175
AVG4-06001800-25	6–18	22	±2.00	2.5	2.3:1	+10	185
AVG6-02001800-40	2–18	25	±2.25	4.0	2.5:1	+10	250

* Noise figure increases below 500 MHz.

Note: All above specifications are with 0 dB attenuation.

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"generator" and "load" provided by the tuner. If any standing waves exist in the stub-transformer line, one must evaluate the losses as described at the beginning of this article. In this case, the resulting losses in Fig. 4b represent the original losses for Fig. 1.

Certainly, an approach was considered for an idealized structure. But, due to energy considerations and the use of parameters common to transmission lines such as VSWR, the results are valid for different shaped stubs used in real coaxial-like tuners.

Another important task performed by microwave measurements is the clear presentation of RF-current distribution in an entire system. For example, Fig. 5 represents RF currents for the TEM-mode regular microstrip line. It can be seen that the main part of the total current is concentrated on the metal surfaces inside the dielectric. Thus, it is often excessive to Au plate an entire microstrip line, especially its bottom grounding surface, where RF current is zero. It is more important to select an appropriate width for the entire substrate. Such discrepancy of dimensions can be frequently observed in commercial transistor-test fixtures. By limiting the substrate width, the initial current at ±b margins can be evaluated by the equation:[6]

$$I_z = I_{zo} / \left(1 + (x/h)^2\right) \qquad (4)$$

Changing the boundary conditions at ±b shifts the field structure, which causes a variation of all the main parameters of a microstrip line, such as its resistance, wavelength, etc. Moreover, an appreciable part of the energy is radiated to the surrounding space and is lost in the soldering mass at the margins as well. One can use the following method to evaluate how much of the power transferred through a microstrip line can be attributed to the ground-plane current outside of ±b margins. The total current at the ground plane is:

$$I_{z\Sigma} = \int_{-\infty}^{\infty} I_z(x)\,dx = 2\int_0^{\infty} I_z(x)\,dx$$

$$= 2\int_0^{\infty} \frac{I_{z0}}{1 + (x/h)^2}\,dx$$

$$= 2hI_{z0}\tan^{-1}\frac{x}{h}\Big|_0^{\infty} = \pi h I_{z0} \qquad (5)$$

The power is proportional to:

$$P_{z\Sigma} \sim I_{z\Sigma}^2 = (\pi h I_{z0})^2 \qquad (6)$$

But the same amount of current flows through the upper-side metal strip of a microstrip line in a reverse direction, so the total power is:

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VSWR (max.)	1.15:1	1.3:1	1.4:1	1.5:1
Switching Time (max.)	10 ms			
Operating Mode	TTL Latching with Self Cut-Off & Indicating Circuitry			
Dimension (W*D*H)	34.0*13.4*40.0mm			
I/O Port Connector	SMA (F) / SMA(F)			

4P5T

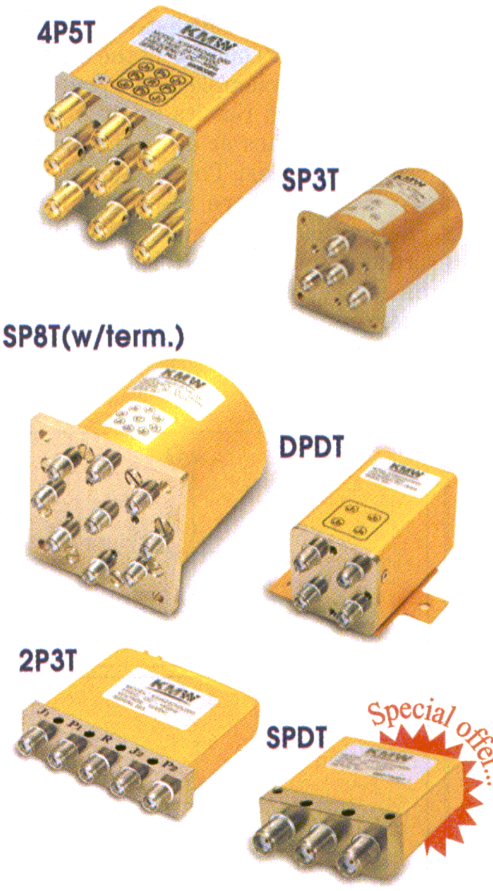
SP3T

SP8T(w/term.)

DPDT

2P3T

SPDT



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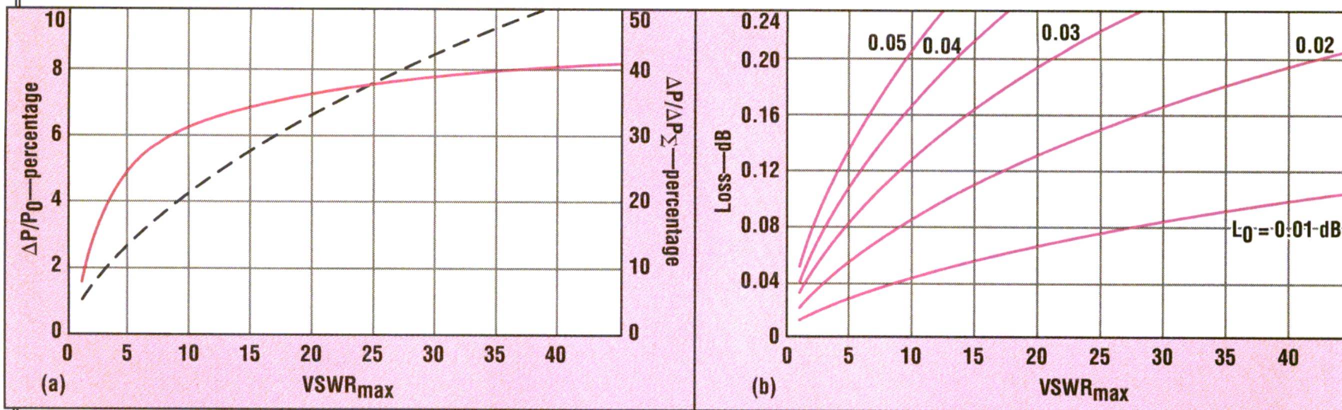
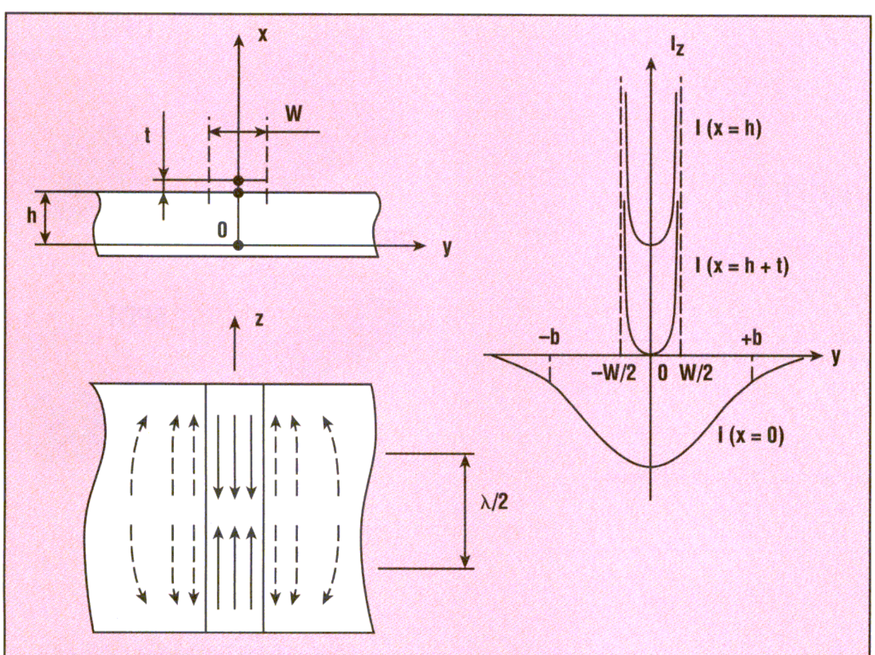


4. The dashed line in this graph shows the relative losses for the quarter-wave coaxial stub tuner, while the solid line shows the portion of the relative losses attributed to the stub (a), and the total losses in the stub of a tuner for different initial losses are illustrated (b).

$$P_0 = 2P_{z\Sigma} \sim 2(\pi h I_{z0})^2 \qquad (7)$$

Replacing the integral limits by ±b in Eq. 5, one can calculate the power inside and (ΔP) outside of the margin noted. As an example, Fig. 6 presents the calculated results for two 50-Ω microstrip lines at different dielectric substrates. The marks at the word "losses" are the part of the energy that shares in a field-varying process. It is observed that such losses can reach fairly high values for "narrow" substrates. Their consequences may differ depending on other surrounding conditions. Also, when using metal adhesive (which usually has lower conductivity) for the interim layers for ceramics, one must remember their influence on current flow, especially at high frequencies.

Parasitic stubs at contacts can confuse microwave measurements, especially at the grounding planes of printed-circuit-board substrates that are pressed (unsoldered) to the grounding metal plate (where contact points cannot easily be seen). When a vector-network analyzer (VNA) is used to test the S-parameters, it attributes these stubs to the device under test (DUT) itself, providing erroneous data at some unknown frequencies. For that reason, many cut-and-try steps are sometimes required during the design process. Often these stubs cause parasitic oscillations in the circuit tested. So one must carefully provide an appropriate contact.



5. These diagrams show the TEM-mode-wave current distribution in a microstrip line.

All test fixtures and evaluation boards require bias circuitry provided by wires from an external power supply. If one allows RF currents to reach these wires, it can cause increased signal leakage and other surprising consequences, particularly for low-noise, high-sensitivity, and multifunction devices. Remember that a single metal wire with a finite conductor represents a waveguide line, along which slow surface waves can propagate. The field of these waves is concentrated near the wire's surface. The more shallow the skin depth (higher conduction) is, the lower the wave concentration will be. An effective radius of a field R_{ef} at which the field diminishes 2.7 times is:[5]

$$k_{i,i+1} = \frac{1}{\Delta\omega_1\sqrt{g_i g_{i+1}}} \left(\frac{f_2 - f_1}{f_0}\right) \qquad (8)$$

and the damping of a field along the wire is:

$$h'' \approx 2k_0\delta / d \qquad (9a)$$

where:

$$k_0 = 2\pi / \lambda_0 \qquad (9b)$$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= the propagation constant of free space,
d = the wire diameter, and
δ = the skin-depth of the wire.

By reducing the skin depth, the damping declines more quickly than the effective radius increases. For example, for a Cu wire

$$\delta \approx 1.12\ \mu m \qquad (9c)$$

with 0.2-mm diameter,

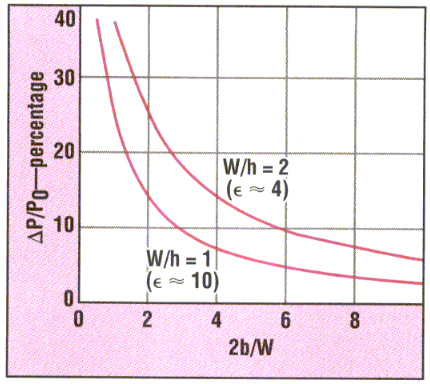
$$R_{ef} \approx 129\ mm \qquad (9d)$$

at 3.5 GHz and

$$h'' \approx 0.35\ dB \qquad (9e)$$

for 10-cm wire length. So, if RF currents are not sufficiently blocked and reach the wire, a high reciprocity between wires can be expected. Additional absorption material can be used to coat the wire and decrease their interconnection.

One should also consider waveguide waves at the relatively low frequencies of mobile-communication bands. By providing screens and packages to shield devices and circuits from a "hostile" RF environment, one can change the boundary conditions and cause variations of operating parameters. This is most evident when the circuit is covered by a metal shield and acts as a waveguide-transmission line. Consider an MMIC package with dimensions 4.45 × 4.45 × 0.76 mm. The cutoff wavelength for the "lowest" waveguide mode H_{10} is:



6. This graph shows the losses on the margins of the micro-strip line.

$$\lambda_c^{H_{10}} = 2a\sqrt{k\varepsilon} \approx 2 \times 4.45\sqrt{0.4 \times 10} = 17.76\ mm \qquad (9f)$$

where:
k = the coefficient characterizing a dielectric inside the entire cavity, which is approximately equal to the ratio of the dielectric volume and the total package volume. The cutoff frequency

$$f_c^{H_{10}} = c / \lambda_c^{H_{10}} \approx 16.89\ \text{GHz} \qquad (9g)$$

is far from the operating frequencies. But if one can excite the wave H_{10} with a power P_0 at the input of this waveguide, the power distribution along the waveguide length l will be:

$$P_0 = P_0 e^{-2\beta l} \qquad (10)$$

where:
β = the attenuation factor.
For an H_{10} wave, it equals:

$$\beta = \frac{2\pi}{\lambda_c}\sqrt{1-\left(\frac{\lambda_c}{\lambda}\right)^2} \qquad (11a)$$

where:
λ = the wavelength in free space.

Note that in this case, the power transmission from the input to the output occurs without any phase shift, in contrast to the conventional mode, where $\lambda < \lambda_c$.

For an empty package with l = 4.45 mm,

$$P / P_0 \approx -13.45\ \text{dB} \qquad (11b)$$

at 3 GHz, and

$$P / P_0 \quad 11.57 \qquad (11c)$$

at 9 GHz. These values are low and can cause trouble. Of course, an excitation condition depends mainly on the circuit inside. Even if no problems occur at operating frequencies, harmonics may play a crucial role in the entire system. ●●

References

1. I.V. Lebedev, *EHF Technology and Devices*, Vol. 1, Moscow, 1961.
2. O. Gorbachov, "Predict Total Losses in Amplifier Matching Networks," *Microwaves & RF*, Vol. 39, No. 5, May 2000, p. 130.
3. Maury Microwave Corp., Catalog, 1998.
4. Focus Microwaves, Inc., "Precision Microwave Measurements for the 21st Century," Catalog, 1998.
5. C. Tsironis, "Prematching Tuners Advance Load-Pull Testing," *Microwaves & RF*, Vol. 39, No. 3, March 2000, pp. 139-150.
6. M.B. Vinogradova, O.V. Rudenko, and A.P. Sukhorukova, *The Theory of Waves*, Moscow, 1990.
7. V.I. Gvozdev and E.I. Nefedov, *Extended Integrated Circuits for EHF*, Moscow, 1985.

Choosing Terrestrial Microwave Antennas For Extreme Environments

Antennas for terrestrial microwave radio links must often stand up to high winds and corrosion as a result of sea salt.

Donald Gardner

Product Line Manager for Terrestrial Microwave Antennas

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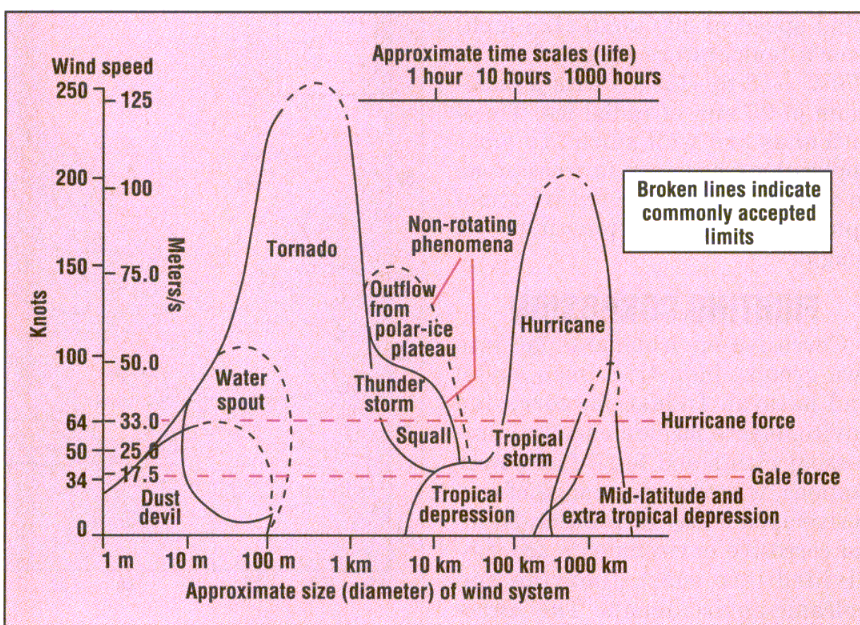
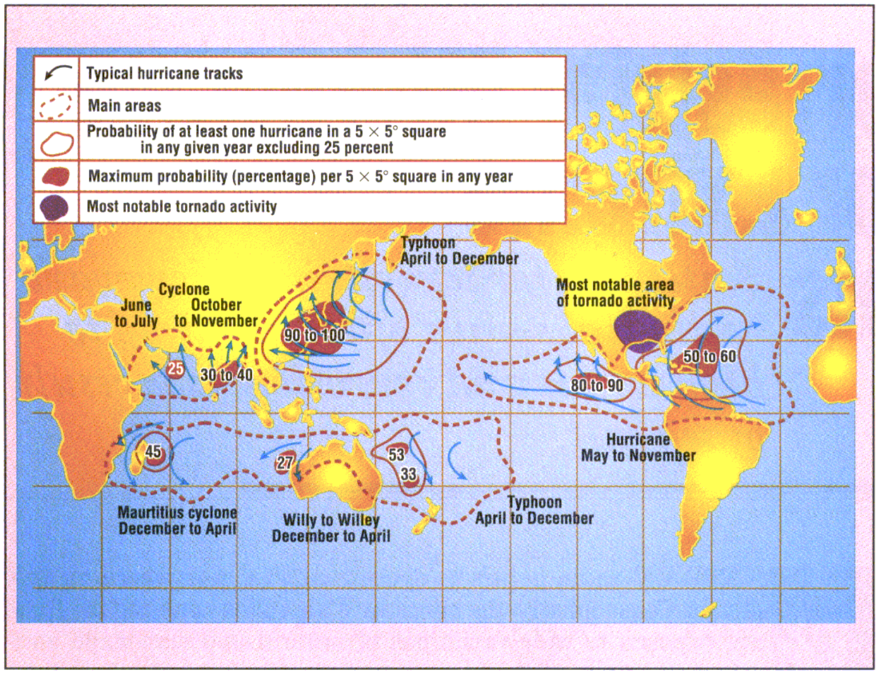
MICROWAVE radio networks operate almost everywhere on this planet. Consequently, the microwave antennas enabling the links are exposed to wide variations of natural and man-made environments. Some of these environments are extremely hostile in terms of wind speeds and corrosion, or a combination of the two, yet an antenna is expected to perform to specification for many years with minimal maintenance. Special antenna designs are often required to provide a reliable, durable solution.

Terrestrial microwave (TMW) antennas are typically designed to meet or exceed the requirements of the American National Standards Institute (ANSI) and Electronic Industries Association (EIA) standard ANSI/EIA-195 for operational and survival wind speeds. Survival wind speed is the maximum wind speed at which there is no permanent deformation of the antenna or any of its components. Operational wind speed is more complex to define. It is the angular deflection that causes the



1. The location of an antenna on a tower can make a difference in wind speed, since the mean wind speed tends to increase with height above the ground.



2. Wind speeds around the world vary greatly in strength and in the size of the area affected.

signal strength to drop by one-half (i.e., 3 dB). This, in turn, is tied in to the antenna type, diameter, and operating frequency.

To fall well inside the maximum limits laid down in EIA195, antennas are normally designed with a maximum angular deflection of 0.1 degrees at an operational wind speed of 110 km/h (70 mph) and a survival wind speed of 200 km/h (125 mph) over a temperature range of –50 to +70°C (–58 to –158°F) with a maximum of 25 mm of radial ice. These antennas are well suited to most applications; however, in areas prone to high winds and/or corrosive atmospheres, other solutions must be sought.

FIGHTING CORROSION

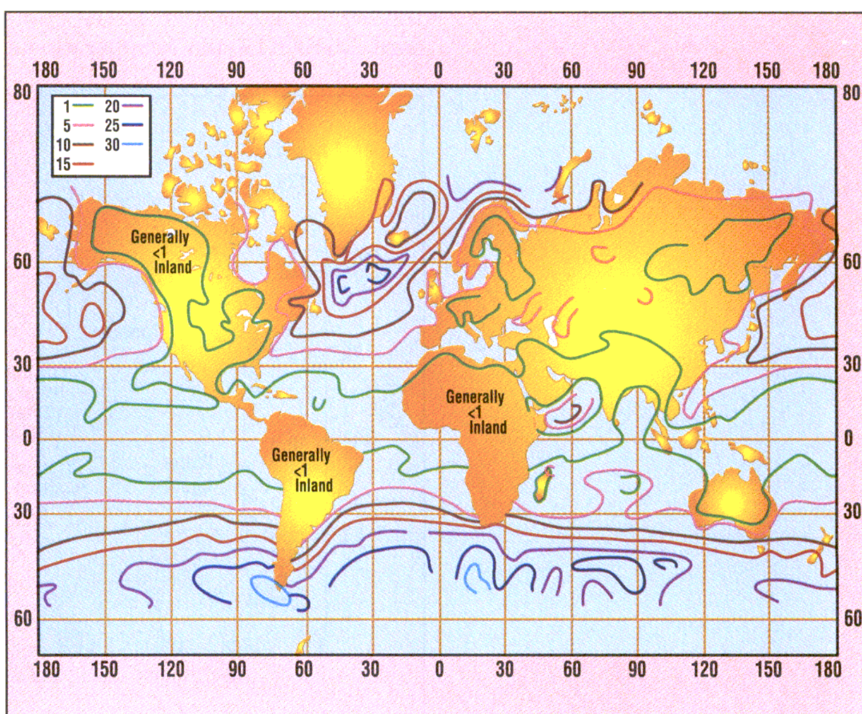
Corrosive environments fall into two groups: industrial (man made) and natural. Industrial corrosive environments include chemical-processing plants and fossil-fuel power stations, where a wide range of corrosive agents may be present. Natural corrosive environments are subdivided into coastal/marine and volcanic environments. The corrosive agents found in volcanic areas are broadly similar to those in industrial areas.

The main corrosive agent in the marine environment is sodium chloride (NaCl). It is present in sea water in a typical concentration of 3.4 percent, although this varies by geographical location and climatic factors. Saline atmospheres result from salt water becoming suspended in air through wind and wave action and can be measured by the rate of salt deposition over a specified area. Deposition rates vary throughout the world; local records are maintained by government climatic agencies.

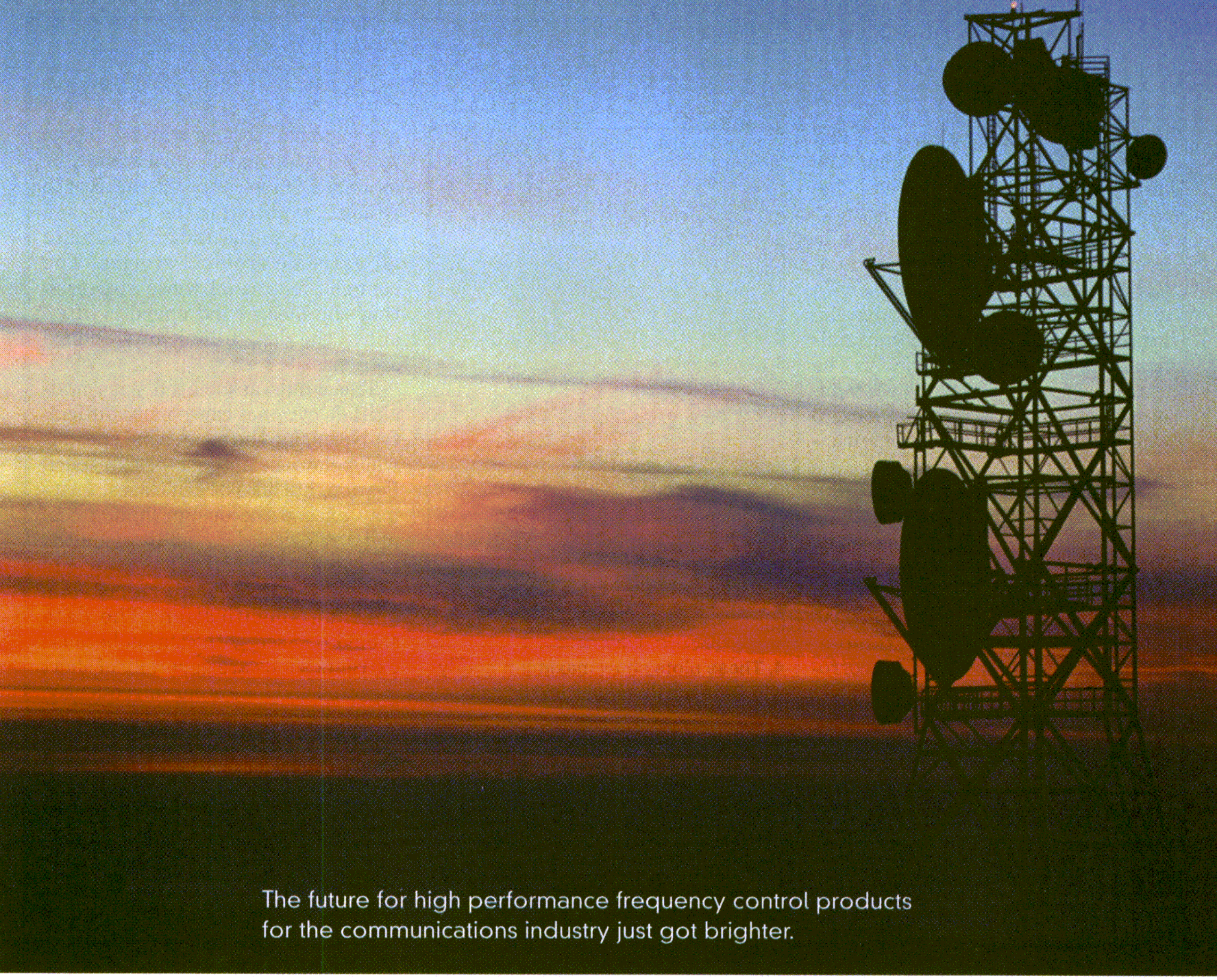
In assessing a specific locality, factors including sea and air temperature, prevailing wind direction, local topography, and relative humidity need to be considered. A prevailing offshore wind will mean that salt deposition rates will drop rapidly as the distance from the coast increases. Conversely, with a prevailing onshore wind, high rates of salt deposition may be found a considerable distance inland. The results can be surprising; for example, some beaches along the British coast have higher salinity than similar areas in India.

Another extreme example is on the Atlantic coast of Namibia in southwest Africa, where a combination of a cold ocean current and a hot coastal desert create local coastal salt fogs that rapidly corrode any unprotected structures.

A wide range of corrosive agents,



3. These plots show the percentage of mean wind speeds exceeding 14 m/s each year.



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including oxides of sulphur (S) and nitrogen (N), may contaminate the atmosphere in industrial areas. The concentration of contaminants is normally considerably lower than salt in a marine environment, but the potential for corrosion may be higher. In addition, the area affected may be localized, since corrosive contaminants usually disperse quickly. The concentration of permitted contaminants also varies from country to country according to local environmental-control regulations.

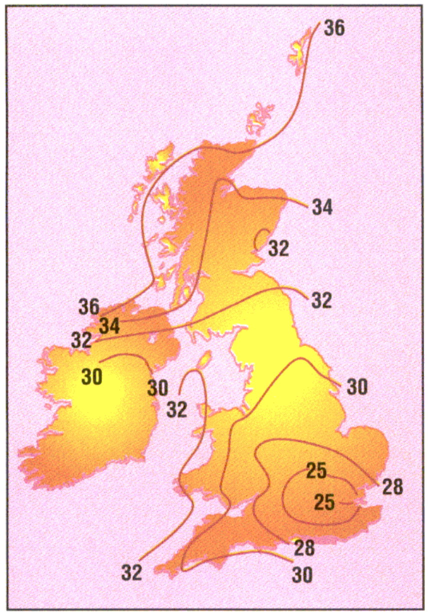
Although each site is unique and must be considered on an individual basis, some general guidelines can be provided:

1. Antennas sited off seashores (on oil rigs, long jetties, or on bridges spanning estuaries, for example) should always be specified for corrosive environment.
2. Antennas that are sited onshore in areas with a sea-salt concentration of more than 80 mg/(m^2-day) should be specified for corrosive environment. Depending on local climatic factors, these conditions can prevail for a considerable distance inland.
3. Antennas that are situated in close proximity to smelting facilities, chemical works, or fossil-fuel power stations (particularly those that burn brown coal) should always be specified for corrosive environment.
4. Areas of high general pollution caused by traffic and industry may require antennas for a corrosive environment depending on the levels of pollution and the life required from the antenna.

In addition to published data, valuable insights can also be gained from talking to other network operators in the area. In selecting an antenna for use in corrosive environments, some of the following features should be considered:

1. Fully epoxy-painted aluminum (Al) reflector and shields.
2. Epoxy-painted galvanized steel mount.
3. Epoxy-painted feed assembly.
4. Stainless-steel assembly and adjusting hardware.
5. Corrosion-inhibiting compounds and sealants applied during the installation process.

The wind loading on an antenna does not increase linearly with wind speed. Instead, the load increases with the speed squared. This means that a doubling of wind speed increases the loading by a factor of 4. Obviously, this has to be taken into effect by antenna and tower designers.



4. These plots show maximum hourly wind speeds (in m/s).

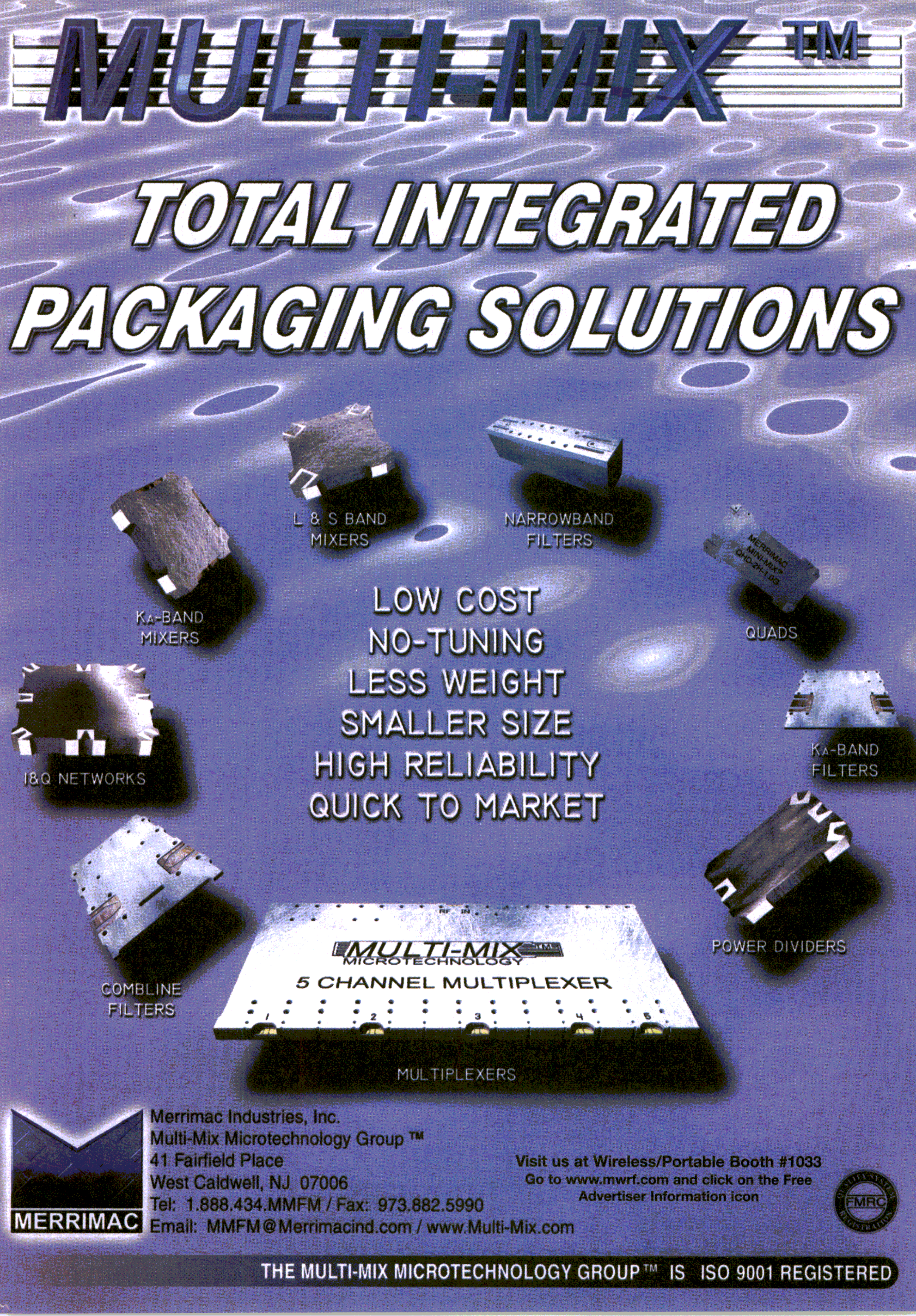
Standard antennas are designed for a survival wind speed of 200 km/h (125 mph). This is sufficient for the majority of antenna sites, but those that are subjected to high-wind conditions such as hurricanes, typhoons, or cyclones require a more robust antenna. In determining the wind speed experienced by the antenna, not only should the basic maximum ground speed be examined, but also factors unique to the antenna site. Such factors include geographic location, position of the antenna on the tower, local topography, and the probability of wind gusts. These factors work in combination and generally will give rise to a wind speed higher than that seen at ground level (Fig. 1).

Wind speeds vary widely over the planet in strength and the size of the area affected. Figure 2 illustrates the relative strength and scale of the major meteorological wind systems. Some wind systems are confined to limited geographical areas; the tornado belt of the American Midwest is one example. Others may be known by different names worldwide. For example, hurricanes in the North Atlantic, typhoons in the Pacific, and willy-willys in the Indian Ocean are all extreme tropical storms. The common feature of these storms is that the mean wind speed is often above the design limit of standard antennas.

The winds associated with mid-altitude cyclones cause more difficulty. Normally, the mean wind speed is well below the antenna-design specification, but in extreme cases, gusts may exceed the design limit. Local meteorological data will provide the probability of such extreme events and allow a decision to be made on antenna specification. The data should be used with caution because extreme winds are generally of short duration and may occur infrequently. In such cases, a subjective decision must be made on the purchase of a special antenna for high winds. Figure 3 shows the percentage frequency in the average year when the mean wind speed (measured over an interval of 5 to 10 min.) equals or exceeds 14 m/s.

Scientific evidence would strongly indicate that the planet is getting warmer. One consequence of this is that weather events are becoming increasingly extreme. Hurricane Mitch (1998) in Central America or the storm that passed through northern France over Christmas 1999 are two examples of this. The implication is that more areas of the world are likely to experience higher wind speeds than recorded climate data would suggest. This needs to be taken into account when specifying antennas.

In general, mean wind speed increases with height above ground. This variation corresponds to the relationship $V_H/V_{10} = (H/_{10})^A$, where V_H and V_{10} are the mean wind speed at H and 10 m (32.8 ft.) above ground, respectively. The factor A varies from approximately 0.1 to 0.4 according to the terrain. A value of 0.17 is usually adopted, but strictly speaking, this applies to undulating country with few trees or obstructions. As an example, a wind speed of 100 km/hr (62 mph) at a height of 10 m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would equate to 120 km/hr (75 mph) at 30 m (98 ft.).

Earth topography can create special situations where an antenna for high winds may be advisable. Where a steep-sided valley narrows, for example, a funneling effect may generate extreme wind speeds in a localized area. Similar effects occur in mountainous areas close to the sea that experience rapid changes in air temperature.

When hills rise sharply from level country, the wind speeds at the hilltop bear little difference from those upwind at the same level in free air. In other words, the hill can be imagined as a tower of the same height. With gentle slopes, the difference between the base and the top of the hill will be less marked. Topography causes localized effects. As a result, as much information should be gathered about each specific site as possible before an antenna is selected.

Wind gusts result mainly from the roughness of the earth's surface; they are accentuated when the air flows over buildings and other obstacles. It may also be caused by temperature convection currents. The data for extreme wind speed in gusts is normally measured over a minimum period of three seconds, and it should be noted that for brief intervals, the maximum speed may be higher. Although the mean wind speed may be relatively low, the maximum wind speed in a gust will be considerably higher—typically 50 percent higher for a 5-s gust in open country. One 5-s wind gust can damage an antenna. Height or topographical factors may further amplify wind gusts. Figures 4 and 5 illustrate this point by showing the maximum hourly mean wind speed (m/s) occurring once in 50 years and the maximum gust speed (m/s) occurring once in 50 years. An antenna should be selected for the maximum gusts it will be subjected to, not the mean.

Antennas are available that will survive wind speeds of 250 km/h (155 mph) and 320 km/h (200 mph). A 250-km/h wind speed rating is available on an antenna configuration that is designed for environments with low mean wind speeds punctuated by occasional periods of extreme conditions. These antennas are designed to attach to a standard 115-mm diameter pipe.

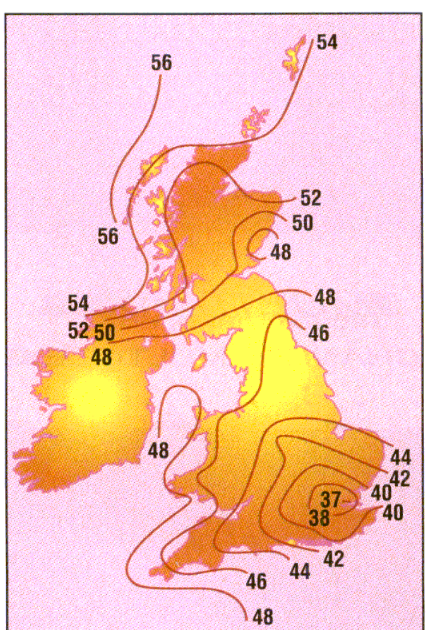
A second configuration of the 250-km/h-rated antenna will withstand continuous buffeting of relatively high mean wind speeds with additional periods of extreme conditions. These antennas attach to the tower with a special interface.

An antenna that has a 320-km/h (200-mph) wind-speed survival rating withstands continuous buffeting of high mean wind speeds with additional periods of extreme conditions. These antennas also attach to the tower interface with a special interface.

HIGH-WIND SELECTIONS

The following guidelines can be used when specifying a terrestrial microwave antenna for use in high-wind conditions:

1. Identify the maximum mean hourly wind speed at the antenna site from local meteorological data.
2. Make suitable allowances for local terrain and the height of the antenna on the tower.
3. Determine the wind profile of the area. Is it generally calm with occasional windy periods, or is it a windy area with periods of extreme conditions?
4. Is the antenna to be sited in a marine or corrosive environment? If so, consideration should be given to specifying an antenna to withstand a corrosive environment in addition to high winds.



5. These plots illustrate the maximum gust speeds around the world (in m/s).

FABRIC RADOME

All antenna designs tolerate no permanent deformation of the structure at any loading below the survival wind speed. It should, however, be noted that due to the high probability of wind-borne debris at extreme wind speeds, no guarantee can be made regarding the survival of a fabric radome.

The decision to install an antenna with particular specifications is primarily economic. Although this is a premium for an antenna that withstands extreme wind speeds or corrosive environments, that cost almost always becomes insignificant when it is considered in terms of the total life-cycle cost of the system, particularly if the antenna is part of a trunk network. It is estimated that the total cost of a new antenna installation may be in excess of $400,000 (US). The premium for a special environmental antenna is typically less than 1 percent of that. Should the antenna fail, not only is the rest of the investment not generating revenue, but also considerable expenditure may be required in order to reach a remote site in adverse conditions to carry out repairs or replacement.

For governmental networks, there is also a social dimension. In areas prone to extreme weather, good communications following a major storm are vital in the recovery process. It is therefore imperative that the antennas and towers are designed to cope with the potential for extreme conditions. ●●

For further reading

ANSI/EIA-195—"Electrical and Mechanical Characteristics for Terrestrial Microwave Relay System Antennas and Passive Reflectors."
ANSI/EIA/TIA-222—"Structural Standards for Steel Antenna Towers and Antenna Supporting Structures."
DEF STAN 00-35 (Part 4)—"Natural Environments."

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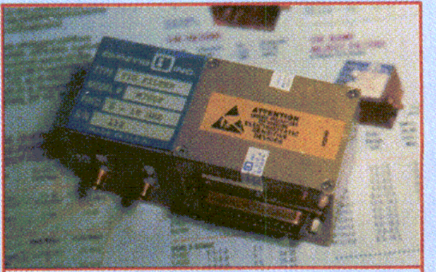

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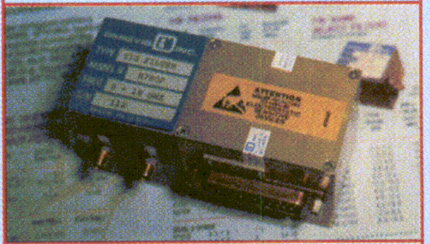
L106RX	1.0 – 2.0	1.5	10
C105RX	2.0 – 8.0	1.5	10
X106RX	8.0 – 12.4	1.5	20
Ku106RX	12.0 – 18.0	1.8	20
M102RX	4.0 – 12.4	1.5	8
M103RX	4.0 – 12.4	1.5	10
M104RX	4.0 – 18.0	1.5	10–60



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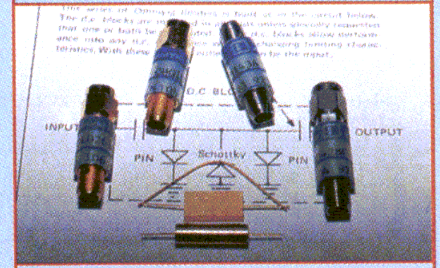

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YOM1518	1.0 – 4.0	20–60	16
YOM1514	4.0 – 12.0	10	15
YOM1513	4.0 – 10.0	10	15
YOM83	2.0 – 6.0	20	12
YOM1948	3.5 – 10.5	15	12
YOM1317	2.0 – 8.0	20	12
YOM818	8.0 – 18.0	20	12
YOM1516	6.0 – 18.0	20	10
YOM2320	2.0 – 10.0	13	11
YOM2321	5.0 – 18.0	13	9

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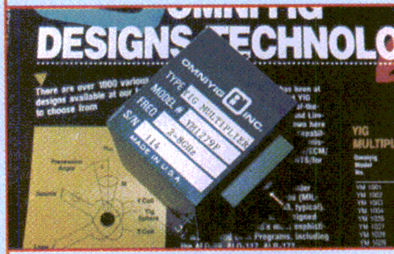

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Omniyig Model No.	Input Freq.	Output (GHz)	Outp Pwr (dBm
YM 1001	1–2 GHz	2 – 13	6
YM 1002	100 MHz	1 – 12	–3
YM 1003	200 MHz	1 – 12	–2
YM 1004	500 MHz	1 – 12	–1
YM 1026	1–2 GHz	2 – 18	2
YM 1027	100 MHz	1 – 18	–4
YM 1028	200 MHz	1 – 18	–3
YM 1029	500 MHz	1 – 18	–2
YM 1087	.1–.2 GHz	1 – 12	–2

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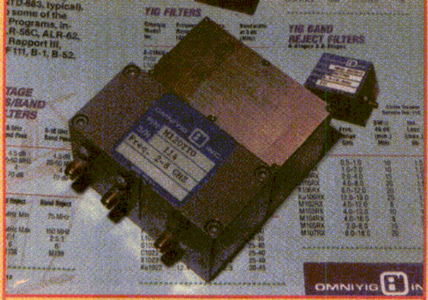

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L106	1.0 – 2.0	5.5	20–35
S106	2.0 – 4.0	5.0	20–40
C106	4.0 – 8.0	4.5	25–40
X106	8.0 – 12.4	4.5	25–40
Ku106	12.4 – 18.0	4.5	28–45
3-STAGE			
P103	0.5 – 1.0	5.0	14–25
L103	1.0 – 2.0	3.5	20–35
S103	2.0 – 4.0	3.0	20–35
C103	4.0 – 8.0	3.0	25–40
X103	8.0 – 12.4	3.0	25–40
Ku103	12.4 – 18.0	3.5	30–45
4-STAGE			
P104	0.5 – 1.0	6.0	12–23
L104	1.0 – 2.0	4.5	20–35
S104	2.0 – 4.0	4.0	20–35
C104	4.0 – 8.0	4.0	25–40
X104	8.0 – 12.4	4.0	25–40
Ku104	12.4 – 18.0	4.0	28–45
DUAL 2-STAGE			
P1022	0.5 – 1.0	3.5	17–30
L1022	1.0 – 2.0	3.0	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
MULTIOCTAVE BANDS			
M1611/2	1.0 – 18.0	5.5	25–65
M1612/4	2.0 – 18.0	6.5	25–75
M102/2^5	1.0 – 12.4	5.0	25–60
M1613/2	1.0 – 12.4	5.5	25–60
M1048/4	4.0 – 18.0	6.0	25–60
M203/4^5	1.0 – 18.0	6.5	25–70

Other Multioctave YIG Filters are available. Analog and 12-bit digital drivers are available for all YIG devices.

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ZERO BIAS SCHOTTKY DETECTORS

Omniyig Model No.	Freq. Range (GHz)	k Factor (mv/mw)	TSS (dBm)
Zero Bias			
ODZ0004A	0.1 – 18	1200	-51
ODZ0510A	0.5 – 4	1750	-53
ODZ0518A	1.0 – 12	1250	-52
ODZ0527A	2.0 – 12	1250	-52
ODZ0328A	2.0 – 18	1250	-52
Tunnel Planar			
ODT0004A	0.1 – 18	750	-50
ODT0510A	0.5 – 4	800	-50
ODT0527A	2.0 – 12	800	-50
ODT0328A	2.0 – 18	700	-50
ODT0240A	6.0 – 18	700	-50

COMB GENERATORS

Omniyig Model No.	Input Freq. (MHz)	Output Freq. Range (GHz)	Output Pwr. (dBm)
OHG10140	100	0.1 – 4	-10
OHG10118	100	0.1 – 18	-40
OHG20218	200	0.2 – 18	-34
OHG30318	250	0.25 – 18	-29
OHG51027	500	0.5 – 18	-20
OHG61027	1000	0.1 – 18	-33
OHG72027	2000	2.0 – 18	-10
OHG61026	1000	1.0 – 26	-35
OHG71026	2000	2.0 – 26	-20

TRACKING YIG FILTERS/ YIG OSCILLATORS

Omniyig Model No.	Freq. Range (GHz)	Filter IL (dB)	Tracking (MHz)
M129YTO	0.5 – 2	5.5	5
M120YTO	2 – 8	5.0	7
M121YTO	8 – 18	5.0	8

Oscillator RF power output +13 dBm. Integrated with Analog or 12-bit TTL drivers.

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LIMITERS

Omniyig Model No.	Freq. Range (GHz)	Max. Ins. Loss (dB)	Max. Lkg. Pwr. (dBm)*
PIN Diode			
OLP2801A	0.1 – 0.5	0.5	+20
OLP2817A	1.0 – 4.0	0.5	+19
OLP2726A	2.0 – 8.0	1.2	+19
OLP2640A	6.0 – 18.0	2.0	+18
OLP2650A	2.0 – 18.0	2.5	+18
Schottky			
OLD2802A	0.1 – 1.0	0.5	+15
OLD2709A	0.5 – 2.0	0.5	+15
OLD2762A	2.0 – 8.0	1.0	+14
OLD2635A	4.0 – 18.0	2.5	+14
OLD2650A	2.0 – 18.0	2.5	+13

*Measured at 1 Watt CW Power

COMB GENERATORS with INTEGRATED INPUT RF AMPLIFIER

Omniyig Model No.	Input Freq. (MHz)	Output Freq. Range (GHz)	Output Pwr. (dBm)
CG252A	100–200	0.1 – 12	-24
CG253A	100	1.0 – 18	-38
CG256A	200	1.0 – 18	-35
CG259A	250	1.0 – 18	-30
CG262A	500	1.0 – 18	-18
CG265A	1000	1.0 – 18	-15
CG266A	1000	2.0 – 26	-33
CG268A	2000	2.0 – 18	-20
CG269A	2000	2.0 – 26	-35

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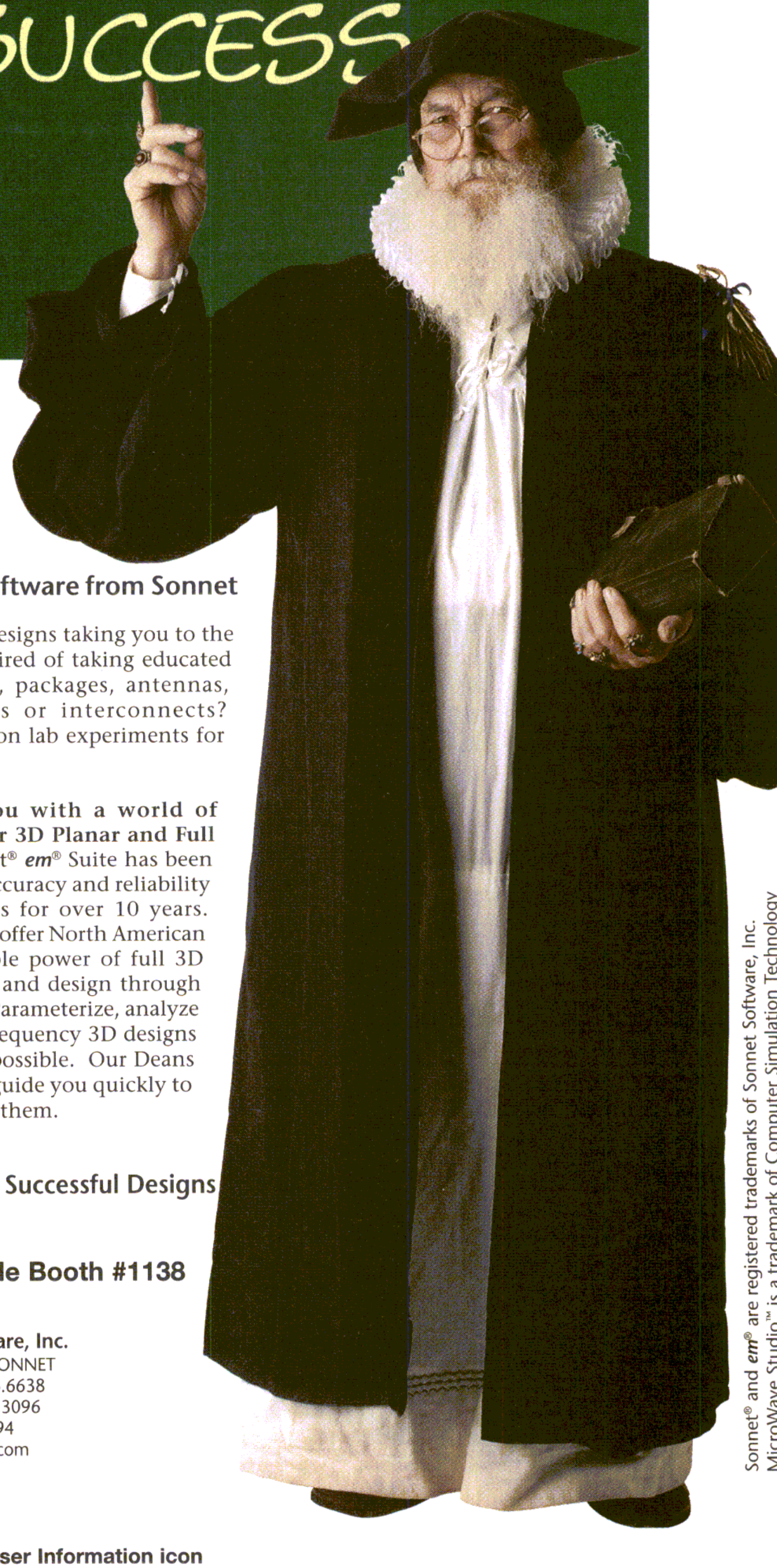

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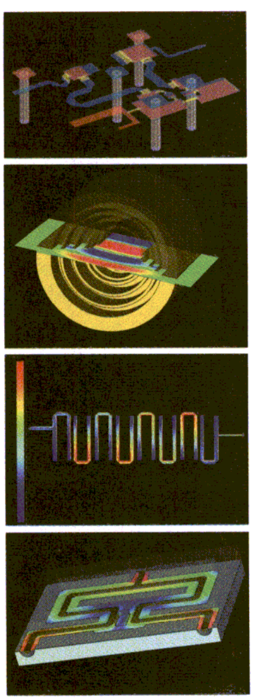

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Wireless Portable Symposium & Exhibition

Educational Choices Abound At Ninth Wireless Symposium

From antennas to wireless e-commerce, this year's expanded technical program delivers the practical know-how that designers need for the next generation of digital communication products.

GENE HEFTMAN
Senior Editor
DON KELLER
Senior Editor

ONE year ago, at th[illegible] Wireless Symposium, the hot technologies—*Bluetooth*, [illegible]band code-division multiple access (*WCDMA*), wireless l[illegible]-area networks (WLANs), and a few others—were still in a talking, rather than doing, stage. When the Ninth Wireless Symposium kicks off at the San Jose Convention Center (San Jose, CA, February 12-16, 2001) those technologies will be coming to the forefront as the marketplace forces wireless designers to turn theory into reality. And with theory constantly changing and expanding, keeping abreast of the technology is not only necessary, but also mandatory in order to succeed in the competitive markets just over the horizon. Recognizing the need to keep engineers up to speed on a dynamic industry, the Symposium's organizers broadened and refined last year's technical program to keep pace with advances in wireless communications. In addition to the serious business of the technical program, the Symposium will again offer a number of special events for the entertainment, social and business interests of the attendees (see sidebar on p. 134).

At last year's Symposium, there were 19 session tracks—the different subdivisions into which the technical program is divided—while this year there are 21. To keep pace with the expansion of technical knowledge in wireless communications, two tracks, for example, are devoted to antennas, compared to last year's single track. One is the antenna track, which covers subject matter similar to last year's program, and the newcomer is indoor propagation, a look at how signals travel when the environment contains various obstructions (walls, doors, windows, etc.), and how to design antennas for such situations.

New to this year's program is the Wireless e-Commerce track, which will examine the convergence of wireless and the Internet, and how companies and individuals will use this mobile technology to do business. Associated with the e-commerce track is another newcomer called Wireless Internet Technology. This track is more detail oriented with regard to the wireless Internet, and its mini-tutorials and technical sessions will address the mobile Internet market environment, the role of messaging services to reach remote workforces (M-commerce), and

Workshops at a glance—9:00 AM to 4:30 PM

Monday, Feb. 12	Thursday, Feb. 15	Friday, Feb. 16
3G Made Simple	Oscillators	3G Wideband CDMA
Balanced Circuit Design and Measurement for Wireless Applications	CDMA Fundamentals	Introduction to Bluetooth
Antennas & Propagation for Wireless Communications	RF & Wireless Made Simple, Part I	RF & Wireless Made Simple, Part II
Behavioral Modeling	RF Fundamentals, Part I	RF Fundamentals, Part II
Wireless Internet Made Simple	DSP Made Simple for Engineers, Part I	DSP Made Simple for Engineers, Part II
PLL Design	Amplifier Linearization	Practical Filter Design
RF System Fundamentals		
Fundamentals of Short-Range Wireless		

Wireless Portable Symposium & Exhibition

a look at one of the most critical subjects for the future success of any kind of Internet commerce—security concerns.

The 2000 show did not have a separate track devoted to the software radio, but it is available this time around. Led by track chair Mehul Udani, customer applications manager at Sychip (Warren, NJ), the three sessions will delve into current issues involved with software-radio design, how high-speed analog-to-digital converters (ADCs) are designed in, laid out, tested and debugged, and the implementation of synthesizer technology using direct modulation. Along the same lines is a panel session in the Wireless integrated-circuit (IC)/RF IC track. Known as "Is The Super-Heterodyne Radio Dead?," and led by track Chair Mark McDonald, design manager at Linear Technology Corp. (Milpitas, CA), attendees and a panel of experts will discuss the fate of the venerable superheterodyne radio. Contenders for its throne are the software radio, direct conversion, and a new technology known as super regeneration. Audience participation is encouraged.

Wireless network operators face the problem of expanding their networks in an increasingly crowded air space, so a track on Wireless Capacity is includ[illegible]d in this year's technical progra[illegible]tended as a panel forum led [illegible]ph Jesson, wireless practic[illegible]er, GE Capital Services (Sta[illegible]rd, CT), the discussion will focus more along business than technical lines. The goal is to get the most bang from the capital-spending buck, so various approaches to the problem will be presented. These include the introduction of smart antennas, a build-out of towers, or increasing data rates. Many other concerns of network operators will be put on the table, such as testing the facilities under load conditions, scaling, and other matters that will enable network expansion in a cost-effective manner.

WIRELESS IN DEPTH

For those who need a detailed explanation of many of the key technologies that underlie today's wireless communications, the Symposium once again provides its in-depth Wireless/Portable workshops (see table on p. 125). These tutorial sessions are either one- or two-day workshops that range from introductory to advanced subject matter. Some of the most popular introductory courses are taught by instructors from the well-respected Besser Associates (Mountain View, CA), a longtime leader in technical education for practicing engineers and managers.

A ______

B ______

C ______

Wireless Portable Symposium & Exhibition

Registration Form

Register by 12/31 for Early Bird Savings, 1/19 for Advance Savings

To register for the Exhibits *(FREE before January 31st)* COMPLETE SECTIONS 1 - 4

To register for the Conference and Exhibits COMPLETE SECTIONS 1 - 6

Please be sure to check the sessions you wish to attend. Space is limited. The most popular sessions will sell out, so be sure to register early!

Wireless Portable Symposium & Exhibition

Conference: February 12-16, 2001
Exhibits: February 13-15, 2001
San Jose Convention Center
San Jose, CA

1. PRIORITY CODE

Please enter your code found in the shaded box near your address. Only those with a code will receive a very special commemorative gift!

2. PRIMARY INFORMATION

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If, like many of our customers, you wish to be contacted via e-mail, please check Yes below for the reasons we may contact you:

❑ Yes ❑ No Future Electronics Group events, including Wireless/Portable Symposium & Exhibition

❑ Yes ❑ No Electronics industry publications, including Wireless Systems Design, Microwaves & RF, and others

❑ Yes ❑ No Other information from Penton Media, Inc.

❑ Yes ❑ No Relevant information from third party electronics businesses/organizations

3. SHORT QUESTIONNAIRE

A. What Is Your PRINCIPAL Job Function? *Enter one code from below*

Company Management
00 Executive & Operating Management
01 Mfg. /Production Management *(Non-Engineering)*

Engineering Management
02 Design & Development Management
03 Engineering Services Management *(Evaluations, QC, Reliability, Standards, Test)*
04 Mfg./Production Management
05 Research & Development Management

Engineering
06 Design & Development Engineering
07 Engineering Services Engineering *(Evaluation, QC, Reliability, Standards, Test)*
08 Research & Development

Other
09 Engineering Services Management
10 Purchasing and Procurement
11 Sales & Marketing
12 Other ____________

B. What Is the PRIMARY End-Product or Service at This Location? *Enter one code from below*

Communications Products & Services
21 Cellular Systems & Equipment
22 Telecom Systems & Services
23 Wireless Data Transmission
24 Satellite Communications, Telemetry *(Including GPS)*
26 Communications System End User *(Telco, Service Provider)*
27 Other Communications Products/Services

Computer Products & Services
30 PCs, Workstations, Servers
31 Laptops, Notebooks, Handhelds, PDAs, Other Mobile Computers
33 Networking Products or Software
34 Computer Peripherals
35 Software Development, Mfg, Sales
36 Computer Systems Integration
37 Other Computer Products & Services

Electronic Products & Services
41 Consumer Electronics & Appliances
42 Automotive, Other Ground Vehicles
43 CATV, Broadcast Systems
44 Avionics, Marine, Space & Military Electronics
45 Security/Identification
46 Medical Electronics
47 CAE/CAD/CAM Systems
48 Industrial Controls, Systems, Equipment & Robotics

Component, Mfg., Test Products & Services
50 ICs & Semiconductors
51 Electronic Sub-Assemblies *(Boards, Modules, Hybrids and Power Supplies)*
52 Electronic Instruments, ATE Systems, Design/Test Equipment
53 Components, Materials, Hardware & Supplies
54 Other Electronic Products & Services

Other Allied Organizations
60 Government & Military
61 Supplier to the Electronics Industry
62 Association, Press or Publisher
63 Other ____________

4. CHOOSE YOUR REGISTRATION OPTION

Exhibits & Networking Functions ❑ FREE *before 1/26/01* ❑ $35 *after 1/26/01*

or

Conference, Exhibits, and Networking Functions*

	Early Bird *before 12/29/00*	Advance Discount *before 1/26/01*	On-Site *after 1/26/01*
VIP 5-Day Pass	❑ $1220	❑ $1356	❑ $1695 ***BEST VALUE!***
Four Day Pass	❑ $1112	❑ $1236	❑ $1545
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Two Day Pass	❑ $583	❑ $648	❑ $810
One Day Pass	❑ $342	❑ $380	❑ $475

5. SELECT YOUR SESSIONS

Please check sessions only for the amount of days you selected in #4. See pg. 12-13.

MONDAY, FEBRUARY 12

9:00 am. – 4:30 pm
❑ WKS01 ❑ WKS02 ❑ WKS03 ❑ WKS04 ❑ WKS05 ❑ WKS06 ❑ WKS07 ❑ WKS08

TUESDAY, FEBRUARY 13

10:30 am. – 12:00 noon
❑ IP02 ❑ FL02 ❑ UL02 ❑ DC02 ❑ SR02 ❑ WI02 ❑ IR02

1:30 pm – 3:00 pm
❑ IP03 ❑ FL03 ❑ UL03 ❑ DC03 ❑ SR03 ❑ WI03 ❑ IR03

3:30 pm – 4:30 pm
❑ IP04 ❑ FL04 ❑ UL04 ❑ DC04 ❑ SR04 ❑ WI04 ❑ IR04

WEDNESDAY, FEBRUARY 14

9:00 am – 10:00 am
❑ BS05 ❑ WP05 ❑ BB05 ❑ WLA05 ❑ 3G05 ❑ WE05 ❑ PB05

11:00 am – 12:00 noon
❑ BS06 ❑ WP06 ❑ BB06 ❑ WLA06 ❑ 3G06 ❑ WE06 ❑ PB06

1:30 pm – 3:00 pm
❑ BS07 ❑ WP07 ❑ BB07 ❑ WLA07 ❑ 3G07 ❑ WE07 ❑ PB07

3:30 pm – 4:30 pm
❑ BS08 ❑ WP08 ❑ BB08 ❑ WLA08 ❑ 3G08 ❑ WE08 ❑ PB08

THURSDAY, FEBRUARY 15

9:00 am – 4:30 pm
❑ WKS09 ❑ WKS10 ❑ WKS11 ❑ WKS12 ❑ WKS13 ❑ WKS14

9:00 am – 10:00 am
❑ TM09 ❑ AN09 ❑ MT09 ❑ BT09 ❑ IC09 ❑ WC09 ❑ BP09

11:00 am – 12:00 noon
❑ TM10 ❑ AN10 ❑ MT10 ❑ BT10 ❑ IC10 ❑ WC10 ❑ BP10

1:30 pm – 3:00 pm
❑ TM11 ❑ AN11 ❑ MT11 ❑ BT11 ❑ IC11 ❑ WC11 ❑ BP11

3:30 pm – 4:30 pm
❑ TM12 ❑ AN12 ❑ MT12 ❑ BT12 ❑ IC12 ❑ WC12 ❑ BP12

FRIDAY, FEBRUARY 16

9:00 am – 4:30 pm
❑ WKS15 ❑ WKS16 ❑ WKS17 ❑ WKS18 ❑ WKS19 ❑ WKS20

6. PAYMENT INFORMATION

Payment in US funds must accompany your registration. US Government purchase orders will be accepted (Tax ID#36-2875386).

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Cardholder Signature

(I agree to pay the above amount in accordance with my cardholder agreement)

Wireless/Portable is a professional trade event open to members of the electronics industry affiliated associations. Identification may be required. Children under the age of 18 are not permitted.

Conference Policies: Badges are transferable with a written request from the primary registrant. Show Management reserves the right to change and/or cancel sessions. Requests for refunds must be received in writing with badges intact and a copy of payment receipt. Request must explain reason for request. All requests must be received by February 5, 2001. Requests that are incomplete or received after February 5th will not be processed.

Two perennial favorites in the introductory category are "RF & Wireless Made Simple" and "RF Fundamentals," both two-day workshops. The former is capably taught by longtime Besser instructor Al Scott, who presents the material in a practical and light-mathematical format which is suitable for marketing professionals and technical managers who do not need to deal with the heavy design concepts of RF/microwave technology. The presentation is broad based and provides students with a good overview of all aspects of wireless technology.

"RF Fundamentals," taught by Besser's Rick Fornes, is a design-oriented course suitable for engineers who are or will be involved in the design of wireless system hardware. All of the engineering concepts associated with RF design are included in this program: passive and active circuits, scattering (S) parameters, Smith charts, impedance matching, transmission lines, RF circuit layout to ensure optimum performance, and many others.

A workshop that occurs between the two aforementioned courses in technical difficulty and also under the tutelage of Besser Associates is "DSP Made Simple For Engineers." Presented by Rick Lyons, the two-day workshop must use some mathematics to explain the concepts of digital signal processing (DSP), but it is introduced sparingly and carefully. Topics covered include lowpass and bandpass sampling, the discrete Fourier transform (DFT), and finite-impulse-response (FIR) filters.

For the working design engineer, Eric Drucker, a consultant for PLL Consultants (Seattle, WA) returns once again with his one-day workshop on phase-locked-loop (PLL) design. Topics include an introduction to behavioral modeling, curve-fitting techniques, and how to predict the nonlinear behavior of transistors, amplifiers, and subsystems.

Another one-day workshop sure to arouse interest due to its high degree of relevance to today's wireless technology is WCDMA, cdma2000, and high data rate (HDR), taught by Darryl Schick, president of Linear Lightwave, Inc. (Lafayette Hill, PA). The focus of this course is to present a comprehensive review of third-generation (3G) and WCDMA technologies. Schick covers the air interfaces, interfaces to ANSI-41 and Global System for Mobile Communications/general-packet-radio-service (GSM/GPRS) networks and goes into a relatively new technology, HDR packet-data protocols. Those interested in this workshop should have a reasonably good understanding of CDMA and the IS-95 air-interface

standard, or they can take the prerequisite on the previous day, "Cellular CDMA Technology For 2G And 3G Systems," also taught by Darryl Schick.

One of the strongest technical and commercial trends in today's wireless universe is the convergence of wireless technolgy and the Internet. For those who need to get a handle on what has happened and where this technology is headed, the workshop "Wireless Internet Made Simple" should be a good starting point. The aim of the session is to provide an understanding of the technologies and market environment involved in bringing the Internet to the mobile user, but without delving deeply into the technical details. Concepts such as the controversial wireless applications protocol (WAP), the technology developed to provide users of mobile terminals with rapid and efficient access to the Internet, will be explained in the context of its application as part of the 3G wireless technology.

If wireless e-commerce and mobile commerce (m-commerce) are to have any chance of succeeding on the Internet, users (consumers and merchants) will have to be assured that any purchases, sales, or other business transactions are free from fraud, theft, and deception. As somewhat of a complement to the aforementioned Wireless Internet workshop, George Bechtel, director of wireless programs at Strategies Unlimited (Mountain View, CA), heads the Wireless Internet Technolgy track which includes the paper, "Security from the Wireless Customer to the Web." The session will cover security requirements such as encryption and smart cards. Also to be examined are network architecture, data formats, and the use of handheld information appliances in an e-business world.

Getting back to the nuts and bolts of design engineering, another popular one-day workshop that has been a mainstay at the Symposium for a number of years is "Antennas & Propagation For Wireless Communication," taught by Dr. Steven Best, president of antenna manufacturer Cushcraft Corp. (Manchester, NH).

SPECIAL EVENTS AT THE SHOW

In addition to the exhibits, workshops, and conferences, the Wireless/Portable Symposium will feature several special events.

On Monday, February 12, OEM Executive Summit invitees and invitation guests can enjoy Wireless/Portable's annual Golf Tournament and Awards Dinner from 9:00 a.m. to 5:00 p.m. VIP Super Passes and OEM Executive Summit invitations are required.

To open the show, Michael Karasick, chief technology officer (CTO) of IBM's Pervasive Computing Division, will deliver a keynote address on the role of wireless in the e-business revolution. The convergence of wireless and the Internet will put the Web's content and commerce in the hands of millions of people. Karasick will discuss how companies can start leveraging their investments in e-business today in order to create new wireless services that provide personalized, location-specific features to connect customers, employees, and partners anytime, anywhere. The address will take place on Tuesday, February 13 from 8:30 to 10:00 a.m. VIP Super Passes are required.

Also on Tuesday, the Wireless Communications Alliance (WCA), will meet in Room J1/4 to discuss what is hot and what is not in wireless engineering. A distinguished panel of investment bankers, venture capitalists, and analysts will review the year's hits and misses, identify attractive market segments, and fearlessly project trends and technologies that the industry would be well advised to consider. No pre-registration is required to attend. A $10 donation to the WCA will be collected at the door.

From Tuesday, February 13 through Thursday, February 15, Wireless/Portable will present the sexy side of wireless with its Hot & Happening Wireless Fashion Show on the Special Events Stage. This runway event will feature models showing off the latest wireless products and prototype designs.

On Tuesday afternoon from 4:00 to 5:00 p.m. on the Special Events Stage, WirelessWonders.com, an e-commerce wireless site, will sponsor the second-annual Seven Wireless Wonders of the Year 2000 Awards Ceremony. You can cast your vote for your favorite wireless product from January 1 to February 1, 2001, by visiting http://www.wirelesswonders.com. Be at the awards ceremony to see if your favorite product is a winner.

On Tuesday evening, Penton Media, Inc. will sponsor an opening-night reception on the show floor from 5:00 to 6:00 p.m. so that show attendees can enjoy cocktails and hors d'oeuvres while networking with peers and vendors.

On Wednesday, February 14, Wireless/Portable will hold two Birds-of-a-Feather sessions—one from 9:00 to 10:00 a.m. and one from 4:30 to 5:30 p.m. These informal round-table discussions will provide attendees with an opportunity to share insights and experiences while enjoying complimentary food and beverages.

On Thursday, February 15 at 1:00 p.m. on the show floor, Wireless/Portable will announce the winner of the Mercedes SLK230 16-valve convertible sportscoupe. All attendees are eligible to win this car. Just pick up an "Enter to Win" card at the registration counter.

Wireless Portable Symposium & Exhibition

This is a program for designers who want an engineering-level overview of antenna technology and its applications in wireless communications. All of the key concepts at the foundation of the technology are covered: VSWR, radiation patterns, directivity, polarization, axial ratio, and a host of others. Of particular interest to designers in light of the tremendous build out of base stations to accommodate the growth of wireless communications is the information on path loss, multipath fading diversity, and polarization distortion.

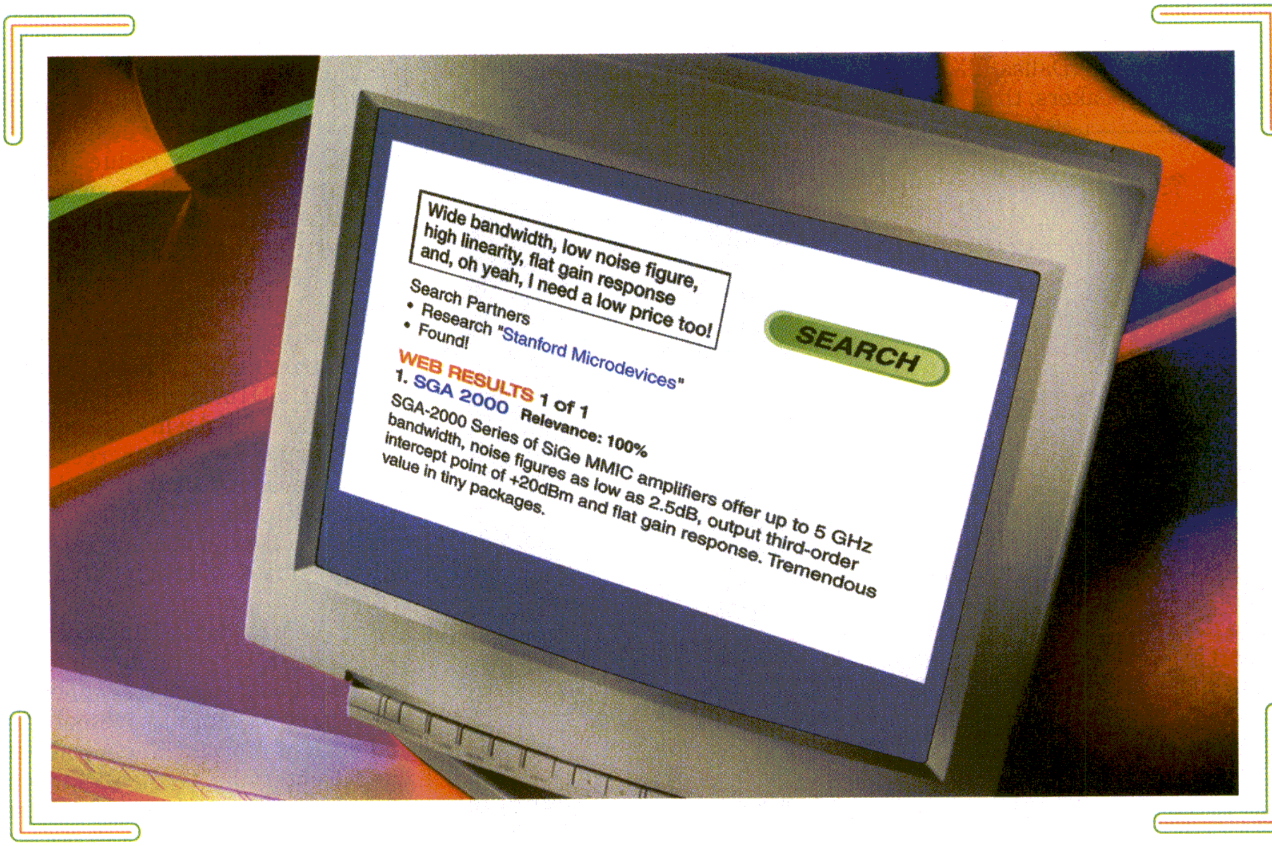
Going beyond the basic theory, Dr. Best will provide practical examples and demonstrations of antenna design using commercially available software.

Some of the less-glamorous, but vitally important technical areas in wireless design are getting a getting a new face at this year's technical sessions. Filters, for example, are being implemented with thin film-bulk-acoustic-resonator (FBAR) technology as well as more the traditional surface-acoustic-wave (SAW) process. This track, to be headed by Jeffrey Pawlan, the owner of Pawlan Communications (San Jose, CA), will explore new approaches to filter design made possible by advances in SAW and FBAR technologies. One session will delve into extending filter design methods to other passive devices such as the design of matching, coupling, and impedance-transforming circuits. In addition to this track, Randy Rhea of Eagleware Corp. (Stone Mountain, GA) is hosting a one-day workshop titled "Practical Filter Design." The course emphasizes applying filter theory to practical, real-world engineering problems. The subject matter is the design of lumped-element and distributed filters for a host of RF and microwave systems such as wireless, satellite, communications, and broadcast. Computer-aided-design (CAD) techniques are integrated into the presentation.

NEW TO THIS YEAR'S PROGRAM IS THE WIRELESS e-COMMERCE TRACK, WHICH WILL EXAMINE THE CONVERGENCE OF WIRELESS AND THE INTERNET.

Since virtually all electronic information appliances—cell phones, personal digital assistants (PDAs), laptops, and pagers—run on batteries, it is not surprising that two tracks are devoted to portability and battery

Still searching for the right amplifier for your latest design?



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SGA-2000 product family offers wideband operation of up to 5 GHz, high output linearity, flat gain response and low noise figure with very low power consumption. These devices are available in industry standard SOT-363 and 85mil plastic packages from stock to eight weeks.

SPECIFICATION MATRIX

	SGA-2163 SGA-2186	SGA-2263 SGA-2286	SGA-2363 SGA-2386	SGA-2463 SGA-2486
Frequency (GHz)	DC-5.0	DC-3.5	DC-2.8	DC-2.0
Gain (dB)	10.5	15.0	17.4	19.6
TOIP (dBm)	20.0	20.0	20.0	20.0
P1dB (dBm)	7.0	7.0	7.0	7.0
N.F. (dB)	4.1	3.2	2.9	2.5
Supply Voltage (Vdc)	2.2	2.2	2.7	2.7
Supply Current (mA)	20	20	20	20

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

SiGe HBT MMIC features include:

- Cascadable 50Ω
- Single voltage supply
- High output intercept
- Low current draw
- Low noise figure


86 package


SOT-363 package

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technology. In the Portable Products track is a mini-tutorial entitled, "Filterless Class-D Amplifiers For Wireless Phones," taught by Michael Score, systems engineer, and Donald Dapkus, systems engineer, both of Texas Instruments (Dallas, TX). According to the speakers, the Class-D amplifier extends battery life up to four times, lowers supply current, and reduces heat generation from the amplifier. Their paper will deal with four aspects of the amplifier: benefits, details of filterless Class-D modulation, why the modulation scheme supports Class-D operation, and system-level guidelines for filterless Class-D operation in wireless phones. Also in this track is a session titled "Enabling Low Cost Chargers for Portable Systems," presented by Jason Hansen and Jim Hill, both application engineers for ON Semiconductor (Phoenix, AZ). The thrust of their paper is how the design of an AC/DC adapter can reduce power dissipation in portable devices. The authors will provide examples of various battery charging schemes and how to design the charge-control scheme.

The Battery Power track is under the chairmanship of Barry Huret, president of Huret Associates, Inc. (Yardley, PA) and will explore technologies such as zinc-air, rechargeable and primary alkaline, and what is behind the SuperCapacitor. Other sessions will examine charger technology, smart-battery chips, and software.

For the past year, Bluetooth has held center stage in the wireless world and this year's track, headed by Robert K. Morrow, consultant and head of Morrow Technical Services (Centerville, IN), looks into one of the lesser-known but critically important aspects of Bluetooth, such as how it will coexist with other wireless protocols. The key question is how Bluetooth-enabled products will operate when in close proximity to their chief competitor, WLANs operating under IEEE 802.11. With so many portable devices—phones, laptops, computer peripherals, and consumer products—expected to be outfitted with Bluetooth in the next few years, some interaction between the two wireless systems is inevitable. Answers to how this will all play out will be provided by a session entitled "Bluetooth Coexistence With Other Protocols." The design of a Bluetooth-friendly RF IC to alleviate the problem will be presented. For more on the coexistence problem, see "Bluetooth Meets WLANs—Can They Live Together?," *Microwaves & RF*, August 2000, p. 31.

Another problem for Bluetooth could be the emergence of simpler,

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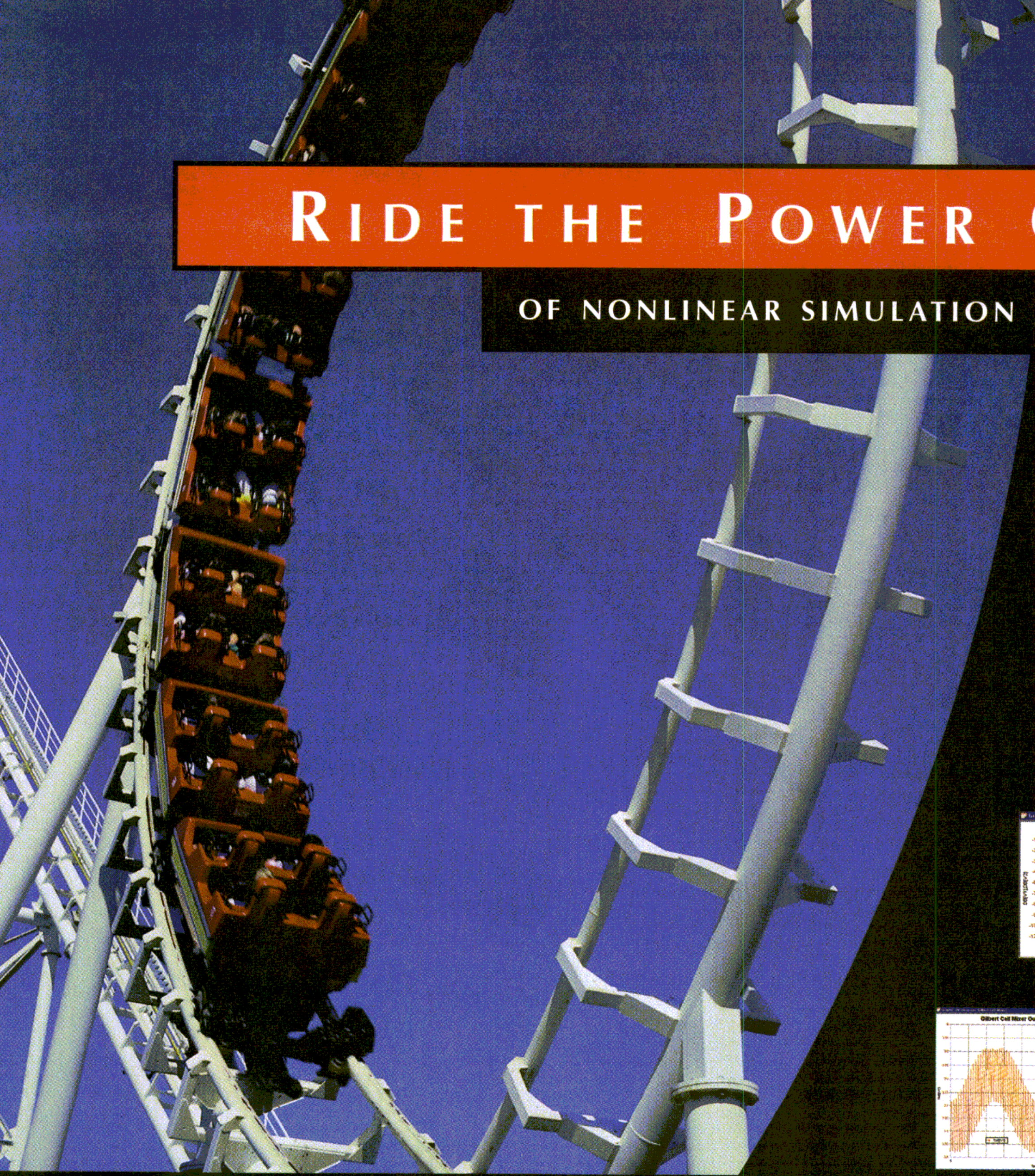

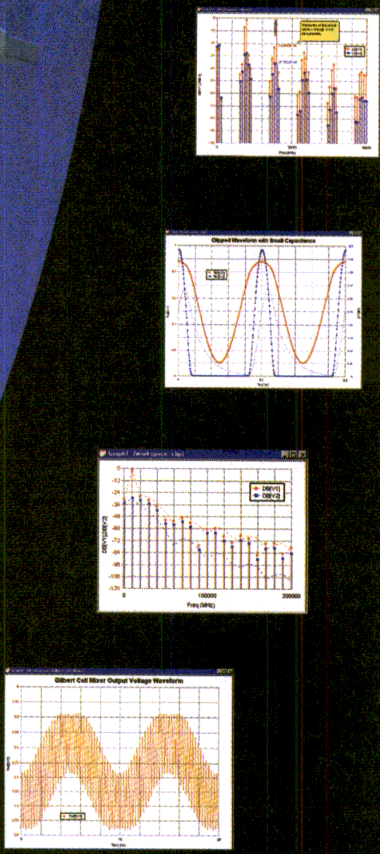

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less-expensive connectivity solutions for short-range wireless communications. This aspect of things will be presented in another paper that will examine Bluetooth's benefits and challenges.

While Bluetooth is more of a promise than reality at this time, WLANs have been around for a few years and are accorded their own technical track under the guidance of Tim Carey, director of marketing for Anritsu Co. (Morgan Hill, CA). One of the major developments in WLANs is the emergence of higher data rates under the IEEE 802.11a and b standards than under the original 802.11. A session on high-performance WLANs will describe these high data-rate specifications to enable designers to understand how they are applied in the different standards. Also on tap is a useful paper for those who need to survey the universe of wireless networks. Known as "Wireless Networking Fundamentals," attendees will learn the difference between circuit and packet switching, data-packet structure, network architectures, multiple-access techniques, and will obtain a good foundation on the building blocks of a wireless network.

Bluetooth's challenges extend to the test-equipment arena where instrument companies must figure out how to make the complex measurements of the new wireless technologies. Chaired by Symposium veteran Ben Zarlingo, product manager for Agilent Technologies (Everett, WA), the test and measurement track offers a session dedicated specifically to testing Bluetooth, WLANs, and other short-range wireless systems. These low-cost frequency-hopped and direct-sequence-spread-spectrum (DSSS) systems pose special test-and-measurement challenges. A more difficult problem may be the kind of testing required for 3G wireless that encompasses complex modulation schemes, so a session on 3G testing is on the agenda.

Although it is off to a slower-than-expected start, the ultra-wideband local-multipoint-distribution-system (LMDS) technology and other millimeter-wave applications present

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interesting possibilities for bringing huge amounts of information—data, voice, multimedia—into homes and businesses. The track on ultra-wideband, under the chairmanship of Doug Lockie, executive vice president and founder of Endgate Corp. (Sunnyvale, CA), starts with a market outlook on this sleeping giant and proceeds with a paper entitled "Radio Subsystems For Ultra-broadband," that deals with technological developments such as DSP, error correction, computer chips, and millimeter-wave components. The final paper, "Ultra-Broadband Network Radio Systems," looks at the radio options available to network designers in architectures such as asynchronous transfer mode (ATM), Synchronous Optical Network (SONET), and Ethernet. ••

Tuesday, February 13, 2001

8:30 AM – 10:00 AM	KEYNOTE BREAKFAST						
10:30 AM – NOON	IP02 pg 15 Indoor Propagation	FL02 pg 15 The Latest Developments in Filter Technology	UL02 pg 15 Ultra-broadband Market Outlook	DC02 pg 16 Modules and Components for Digital Communications	SR02 pg 16 Current Issues in Software Radio Design	WI02 pg 16 Enabling the Wireless Internet	IR02 pg 16 Irda, A New Era of Promised Wireless
NOON – 1:30 PM	EXHIBITS						
1:30 PM – 3:00 PM	IP03 pg 16 Propagation Models and Measurement Techniques	FL03 pg 16 Extending Filter Design Methods to Other Passive Devices	UL03 pg 16 Radio Subsystems for Ultra-broadband	DC03 pg 16 Digital Communication Hardware Measurement and Optimization	SR03 pg 17 Designing with High Speed ADC's	WI03 pg 17 M-Commerce: Reaching the Mobile Customer through the Wireless Internet	IR03 pg 17 Irda: The Smart Wireless
3:30 PM – 4:30 PM	IP04 pg 17 Antennas and RF Equipment for Indoor Coverage	FL04 pg 17 New Approaches to Filter Design	UL04 pg 17 Ultra-broadband Network Radio Systems	DC04 pg 17 Hardware Testing Routines	SR04 pg 18 Enabling Software Radio via Direct Modulation Based Synthesis	WI04 pg 18 Security from the Wireless Customer to the Web	IR04 pg 18 IrDA: Simply Wireless

Wednesday, February 14, 2001

9:00 AM – 10:00 AM	BS05 pg 18 Architecture Concerns in Modern Base Station Design	WP05 pg 18 LTCC Technology: Designing for Wireless Applications with Green Tape LTCC Ceramic Technology	BB05 pg 18 Fixed Wireless Access	WLA05 pg 19 High Performance Wireless LANs	3G05 pg 19 Spread Spectrum Fundamentals	WE05 pg 19 Mobilizing Internet Content	PB05 pg 19 Memory Components for Wireless Applications
11:00 AM – NOON	BS06 pg 19 3G Challenges to Base Station System Designers	WP06 pg 19 Trends in Wireless Packaging and LTCC Design	BB06 pg 19 Broadband Wireless Access Systems	WLA06 pg 19 WLAN and Bluetooth Co-existence Issues	3G06 pg 20 Code Domain Measurements	WE06 pg 20 Mobilizing Enterprize Data	PB06 pg 20 Filterless Class-D Audio Amplifiers for Wireless Phones
NOON – 1:30 PM	EXHIBITS						
1:30 PM – 3:00 PM	BS07 pg 20 High Power Amplifiers for Base Station Applications	WP07 pg 20 LTCC Materials and Applications	BB07 pg 20 Fixed Wireless Access Solutions	WLA07 pg 20 Wireless Networking Fundamentals	3G07 pg 21 Components for 3G	WE07 pg 21 Enterprise Solutions to the Wireless Web	PB07 pg 21 Enabling Low Cost Chargers for Portable Systems
3:30 PM – 4:30 PM	BS08 pg 21 Base Station Devices and Modules	WP08 pg 21 Plated and Bonded Cu and Interactive Discussion Session	BB08 pg 21 Technology Update	WLA08 pg 21 Real World Experiences WLAN Systems	3G08 pg 21 3G Outlook: Evolving Standards and Alternatives	WE08 pg 22 Personalizing, Transcoding, and Repurposing Content for the Wireless Web	PB08 pg 22 Rotating-Wheel Braille Display Provides Accessibility for Compact Portable Devices

Thursday, February 15, 2001

9:00 AM – 10:00 AM	TM09 p23 Real World Measurements	AN09 p23 Active Integrated Antennas	MT09 p23 Identifying Modulation Error Sources	BT09 p23 Bluetooth Case Study	IC09 p24 New Developments in Wireless IC/RF IC Solutions	WC09 p24 Understanding, Predicting, and Measuring Wireless Capacity	BP09 p24 Batteries & SuperCaps
11:00 AM – NOON	TM10 p24 Testing for Bluetooth, Wireless LAN and Other Short-Range Wireless	AN10 p24 Compact Antenna Design	MT10 p24 Taming the Quadrature Modulator	BT10 p25 Bluetooth Coexistence with Other Protocols	IC10 p25 Is the Super-Heterodyne Radio Dead?	WC10 p25 Understanding, Predicting, and Measuring Wireless Capacity	BP10 p25 Rechargeable Batteries and Battery Recycling
NOON – 1:30 PM	EXHIBITS						
1:30 PM – 3:00 PM	TM11 p25 Wide Dynamic Range Measurements	AN11 p25 Practical Approaches to Antenna Design	MT11 p25 Improving Modulators for Specific Signals	BT11 p25 Bluetooth Applications and Developments	IC11 p26 RFIC Fundamentals, I, II, and III	WC11 p26 Understanding, Predicting, and Measuring Wireless Capacity	BP11 p26 Chargers & Battery Management
3:30 PM – 4:30 PM	TM12 p26 3G Testing	AN12 p26 Antenna Design	MT12 p26 Advanced Modulation Schemes that Improve System Performance	BT12 p26 Bluetooth Access Points	IC12 p27 Wireless IC Issues	WC12 p27 Understanding, Predicting, and Measuring Wireless Capacity	BP12 p27 Chargers & Battery Management

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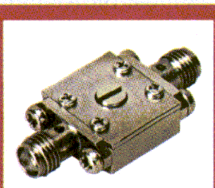
Frequency Range	~ 1GHz	1 ~ 2GHz	2 ~ 3GHz
Insertion Loss (Max.)	0.15dB	0.25dB	0.35dB
VSWR (Max.)	1.25:1	1.25:1	1.25:1
Incremental Phase Shift	90 degree min. @ 2GHz		
Electrical Delay	125 psec min.		
Nominal Impedance	50 ohm		
I/O Port Connector	SMA(F) / SMA(F)		
Average Power Handling	20W @ 2GHz		
Temperature Range	-30°C ~ +60°C		
Dimension (inch)	A type : 1.496*1.102*0.457 B type : 1.225*1.102*0.457		

KPH30OSCL000



KPH35OSCL000

Miniature CPS

Product Code No.	Drop-In type (KPH30OSCL000)			Connectorized type (KPH35OSCL000)		
Frequency Range	~ 1GHz	1 ~ 2GHz	2 ~ 2.5GHz	~ 1GHz	1 ~ 2GHz	2 ~ 3GHz
Insertion Loss (Max.)	0.15dB	0.25dB	0.35dB	0.15dB	0.25dB	0.35dB
VSWR (Max.)	1.3:1	1.3:1	1.3:1	1.25:1	1.25:1	1.25:1
Incremental Phase Shift	30 degree min. @ 2GHz			35 degree min. @ 2GHz		
Electrical Delay	41.7 psec min.			48.6 psec min.		
Nominal Impedance	50 ohm			50 ohm		
I/O Port Connector	Drop-In			SMA(F) / SMA(F)		
Average Power Handling	30W @ 2GHz			30W @ 2GHz		
Temperature Range	-30°C ~ +60°C			-30°C ~ +60°C		
Dimension (inch)	0.709*0.433*0.244			0.630*0.551*0.244		

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SOFTWARE may power the Internet as a recent television ad claims, but as any designer knows, it takes a combination of hardware, test equipment, software, and brainware to power a communications system into operation. Many of the products which do just that will be on display when the Ninth Annual Wireless/Portable Symposium & Exhibition opens its doors at the Convention Center in San Jose, CA, February 12-15, 2001. Approximately 400 manufacturers of electrical/electronic components, instruments, design automation software and services are preparing their wares for the thousands of designers who will hit the floor looking for the pieces to build their Bluetooth devices, wireless local-area networks (WLANs), third-generation (3G) wireless systems, and other products of the new millennium. The following is a bird's eye view of what will appear on this year's expanded show floor.

LDMOS RF power transistors push 60 W

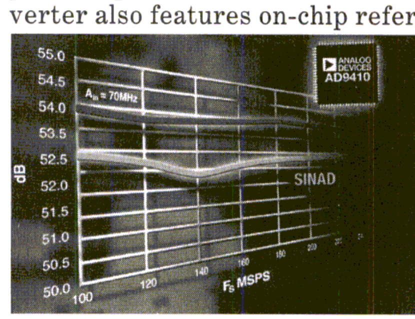
The UPF18060 line of laterally-diffused-metal-oxide-semiconductor (LDMOS) power transistors generates a minimum of 60 W of RF power at frequencies that range from 1.805 to 1.880 GHz. The transistors are ideally suited for use in Class A or Class AB base-station amplifiers for code-division-multiple-access (CDMA), time-division-multiple-access (TDMA), Global System for Mobile Communications (GSM), and multicarrier applications. The devices can serve as drop-in replacements for Motorola's MRF18060 transistors. **UltraRF, 160 Gibraltar Court, Sunnyvale, CA 94089; (408) 745-5700, FAX: (408) 541-0139, Internet: http://www. ultrarf.com.**

Test solution qualifies CDMA2000 equipment

The model E1962A IS-2000 mobile test-mode application and the model E5515T wireless communication test set combine to help manufacturers qualify CDMA2000 mobile phones based on the new IS-2000 standard for code-division multiple access (CDMA). After building special test modes into their phones, manufacturers can use the E1962A application and the E5515T test set to perform a series of IS-2000 transmitter (Tx) and receiver (Rx) tests, including power, frequency, and waveform-quality measurements. The solution also provides flexible IS-2000 forward-link emulation that enables the control of the pilot, sync, paging, and other channel levels and data rates. **Agilent Technologies, Inc., 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; (800) 452-4844, Internet: http:// www.agilent.com.**

ADC boasts high speed, high resolution

The model AD9410 analog-to-digital converter (ADC) delivers 10-b resolution at 210 MSamples/s and is ideal for communication systems that require very-high data rates such as point-to-point radio links. The converter also features on-chip refer-



ence and track-and-hold circuitry to ease the design of high-speed conversion into a variety of communication systems, such as local multichannel distribution systems (LMDS) and multipoint, multichannel distribution services (MMDS). **Analog Devices, Inc., Roy Stata Technology Center, 804 Woburn St., Wilmington, MA 01887; (800) 262-5643, FAX: (781) 937-1021, Internet: http://www.analog.com.**

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Chip set enables Bluetooth applications

A chip set comprising two integrated circuits (ICs) is designed to be a complete solution for manufacturers who want to incorporate Bluetooth capability into their products, including phones and computers. The BSN6030 chip is a read-only-memory (ROM)-based Bluetooth baseband controller that includes a fully integrated Bluetooth software stack. The chip has an embedded 32-b ARM7 reduced-instruction-set-computer (RISC) microprocessor, 116 K-word ROM and 16 K of random-access memory (RAM). It is manufactured using a 0.18-μm complementary-metal-oxide-semiconductor (CMOS) process, and is available in several package types, including an 80-pin, 6 × 6-mm package. The TRF 6001 chip is an RF transceiver that has a sensitivity better than –86 dB/mW. The transceiver is capable of 2.4-GHz frequency-hopping, spread-spectrum transmission and reception. It is available in a 56-lead, 5 × 5-mm package. Both chips operate from a +3.3-VDC power supply and have a power-down mode. **Texas Instruments, Inc., P.O. Box 172228, Denver, CO 80217; (800) 477-8924, Internet: http://www.ti.com.**

PA targets GSM, CDMA, TDMA, 3G handsets

The model AWT6107 indium-gallium-phosphide (InGaP), heterojunction-bipolar-transistor (HBT) power amplifier (PA) is designed for dual-band wireless-handset applications such as Global System for Mobile Communications (GSM), code-division multiple access (CDMA), time-division multiple access (TDMA), and third generation (3G). Over the GSM frequency range from 880 to 915 MHz, the amplifier will accept up to +15 dBm of input power and provides at least +34.5 dBm of output power. Over the digital-communication-system (DCS) frequency range from 1710 to 1785 MHz, it typically accepts +8 dBm of input power and provides at least +31.5 dBm of output power. Over both bands, the amplifier exhibits a maximum isolation of –30 dBm and a maximum second- and third-harmonic distortion of –7 dBm. The device can operate at power-supply voltages from +2.9 to +4.5 VDC and temperatures ranging from –25 to +85°C. **ANADIGICS, 35 Technology Dr., Warren, NJ 07059; (908) 668-5000, FAX: (908) 688-5132, Internet: http://www.anadigics.com.**

Air-vent panels block EMI and fire

The Stream Shield air-vent panels provide electronic enclosures with fire containment and 50 dB of shielding against electromagnetic interference (EMI) from 1 to 10 GHz. If exposed to flame or heat in excess of 300°F (149°C), a thin layer of intumescent coating in the panels' honeycomb cells expands rapidly and fills the cells with a

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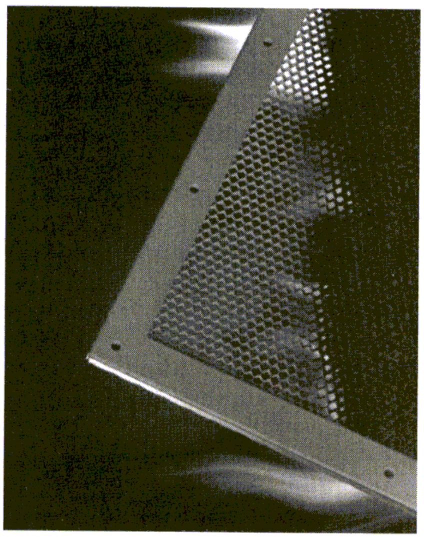
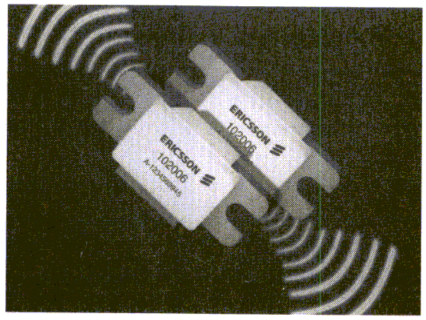
carbonaceous foam that prevents flames from propagating through the honeycomb. The coating is based on a fire-retardant chemistry that meets ASTM E-84 test-procedure requirements, and is classified by Underwriters Laboratories (UL) as providing Class A flame-spread protection and low smoke density. The standard panels are constructed of one or two layers of 0.125-in. (3.175-mm) cell and 0.50-in. (12.7-mm)-thick aluminum



(Al) honeycomb crimped in a stamped Al frame. The panels are available for round or rectangular openings. **Chomerics, Div. of Parker Hannifin Corp., 77 Dragon Ct., Woburn, MA; (781) 935-4850, FAX: (781) 935-4318, Internet: http://www.chomerics.com.**

LDMOS transistor reaches 2.5 GHz

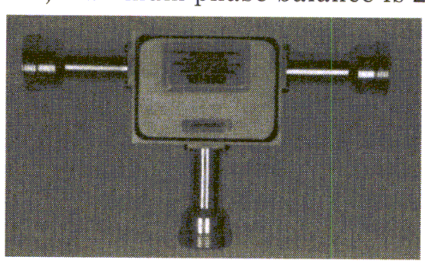
The model PTF 102006 laterally-diffused-metal-oxide-semiconductor (LDMOS) power transistor claims to be the first such device to reach an operating frequency of 2.5 GHz. The internally matched device offers a typical gain of 11 dB and output power to 25 W at the 1-dB compression point. It can tolerate a load mismatch of 10:1. The transistor is manufactured with all-gold (Au) metallization, ion implantation, and surface passivation, which are said to endow it with long life and good reliability. It operates at a nominal +28



VDC and has a drain-source breakdown voltage of +65 VDC. The device is available in a flange package measuring 0.385 × 1.03 in. (9.78 × 26.16 mm). **Ericsson Microelectronics, 18275 Serene Dr., Morgan Hill, CA 95037; (877) 465-3667, Internet: http://www.ericsson.com/rfpower.**

Divider/combiner defies harsh environments

The model 350-BD-FFE-2 two-way divider/combiner operates from 460 to 960 MHz in harsh environments. The weather-tight unit has a 350-W rating when operating with matched loads and a 150-W rating in mismatched conditions. Input VSWR is 1.3:1, and output VSWR is, at most, 1.2:1. Insertion loss is typically less than 0.4 dB and always less than 5.5 dB. Minimum isolation is 20 dB, maximum phase balance is 2



deg., and maximum amplitude balance is 0.2 dB. **Bird Component Products, 10950 72nd St. N., Suite 107, Largo, FL 33777-1527; (727) 547-8826, (727) 547-0806, Internett;: http://www.birdfla.com.**

Combiner spans 18 to 26.5 GHz

The model PS8-116 eight-way power divider/combiner operates from 18 to 26.5 GHz with a VSWR of 1.6:1. The divider/combiner offers a minimum isolation of 17 dB and a maximum insertion loss of 2.8 dB over nominal loss. Amplitude balance is ±0.5 dB and phase balance is ±12 deg. The device is housed in an aluminum (Al) enclosure and has female SMA connectors. **Microwave Communications Laboratories, Inc. (MCLI), 7225 Thirtieth Ave. N., St. Petersburg, FL 33710; (800) 333-6254, FAX: (727) 381-6116, Internet: http://www. mcli.com.**

Voltage supervisor monitors to 300 mV

The model MIC2776 ultra-low-voltage supervisor integrated circuit (IC) monitors power supplies to voltages as low as 300 mV. The MIC2776's monitoring voltage is user adjustable. The chip operates at voltages from +1.5 to +5.5 VDC and typically draws only 3 μA. It is ideal for monitoring low-voltage power supplies such as those used in portable products containing microprocessors, memories, digital-signal processors (DSPs), systems on a chip (SoC), and application-specific integrated circuits (ASICs). The supervisor has a debounced, manual-reset input and generates a power-on reset pulse with a minimum duration of 140 ms. The chip is housed in an SOT23-5 package and comes in three versions: active high output, active low output, and open-drain, active low output. **Micrel, Inc., 1849 Fortune Dr., San Jose, CA 95131; (408) 944-0800, FAX: (408) 944-0970, Internet: http://www.micrel.com.**

Photo-etched lids seal microcircuits

A line of photochemically etched metal lids are available for seam-sealing microcircuit packages. The lids are photochemically etched to maintain tight depth tolerances, assure high uniformity in sealing the seam, and maximize yields in the seam-sealing process. Lids can be etched to a thickness of 50 mils (1.27 mm) with a

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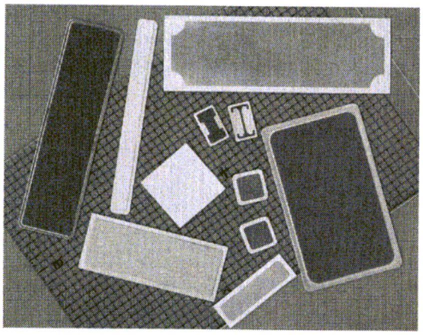


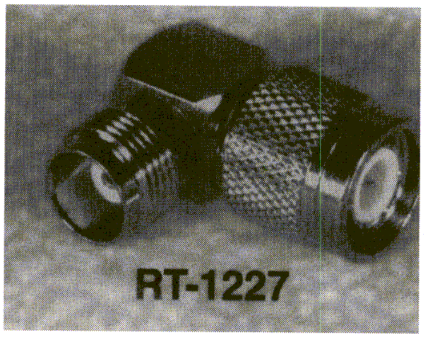
nominal flange thickness of 0.005 in. (0.127 mm). The lids can be etched with graphics, slots, or holes for glass windows. Typical metals for lids include Kovar, Alloy 42, nickel (Ni), and stainless steel. The lids can be plated with electrolytic Ni, electroless Ni, and Ni followed by gold (Au). **Photofabrication Engineering, Inc., 500 Fortune Dr., Milford, MA 01757; (508) 478-2025, FAX: (508) 478-3582, Internet: http://www.photofabrication.com.**

VCO serves ISM applications

The model RF 2506 low-power, voltage-controlled oscillator (VCO) integrated circuit (IC) for applications such as industrial-scientific-medical (ISM) band, cordless phones, and broadband radios. The eight-pin monolithic device provides a reference frequency from 10 MHz to 1 GHz with phase noise of –110 dBc at 100-kHz offset. The device operates at power-supply voltages from +2.7 to +3.6 VDC and puts out –3 dBm of power. It will also operate with the supply voltage reduced to +2.2 VDC with a reduced output power of –11 dBm. The device has a digitally controlled power-down mode that reduces current consumption to under 1 μA. The chip is manufactured using bipolar-complementary-metal-oxide-semiconductor (BiCMOS) technology and is offered in an SOP-8 package. **RF Micro Devices, 7625 Thorndike Rd., Greensboro, NC 27409-9421; (336) 664-1233, Internet: http://www.rfmd.com.**

RF connectors comply with FCC

A specialized line of interface adapters and connectors achieve compliance with Part 15.203 of the Federal Communication Commission's (FCC's) requirements by offering reverse polarity (gender), reverse (left-handed) threads, and metric threads instead of Unified Standard threads. One such adapter is the model RT-1227 TNC-male-to-TNC-female, right-angle adapter. It features reversed (left-handed)



threads at both ends, a nickel (Ni)-plated body, gold (Au)-plated contact and pin, and Teflon insulation. **RF Industries, 7610 Miramar Rd., San Diego, CA 92126-4202; (800) 233-1728, FAX: (858) 549-6345, Internet: http://www.rfindustries.com.**

Power MOSFETs span 5 to 300 W

A family of RF power metal-oxide-semiconductor field-effect transistors (MOSFETS) span RF power outputs from 5 W at a power-supply voltage of +28 VDC to 300 W at +50 VDC. The SD29xx series boasts enhanced ruggedness for applications such as magnetic-resonance imaging (MRI) and plasma discharge where severe load mismatch can occur. The transistors are also said to have reduced capacitance and improved gain, making them suitable for a wide range of high-frequency (HF) very-high-frequency (VHF), and ultra-high-frequency (UHF) applications such as frequency-modulation (FM) radio, TV, military communications, and radar. **STMicroelectronics, Inc., Lexington Corporate Center, 10 Maguire Rd., Bldg. 1, Third Fl., Lexington, MA 02421; (781) 861-2650, FAX: (781) 861-2678, Internet: http://www.st.com.**

VCTCXOs cover 12 to 20 MHz

The TT/VT3000 line of voltage-controlled temperature-compensated crystal oscillators (VCTCXOs) are available at frequencies from 12 to 20 MHz. They are ideal for a wide range of applications, including telecommunications, wireless, networking, cellular radio, remote meter reading, phase-locked loops (PLLs), and other systems that require a stable frequency source in a space-efficient configuration. The ultra-miniature, low-profile, surface-mount crystals are housed in hermetically sealed, 7 × 5-mm ceramic packages and have a seated height of 2 mm. The crystals emit a clipped sine wave, and the integral voltage-control feature permits phase locking to a stable reference. Operating temperature ranges from –40 to +85°C. **Tellurian Technologies, Inc., 1801 Hicks Rd., Rolling Meadows, IL 60008; (847) 934-4141, FAX: (847) 934-4175, Internet: http://www.telluriantech.com.**

Capacitors reach gigahertz range

A line of dual-tracking, precision trimmer capacitors has expanded to include capacitors that function in the gigahertz range. The capacitors

have one common terminal and a split stator whose tuning screw adjusts two capacitors at the same rate. One member of this line, the sapphire dielectric model KZ3S, tunes from

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Wireless Portable Symposium & Exhibition

0.3 to 3 pF and can be used at frequencies up to and beyond 2 GHz. At 250 MHz, it has a Q of more than 1500. This 0.53-in. (1.33-cm)-long capacitor can be finely tuned over 10 full turns. **Voltronics Corp., 100 Ford Rd., Denville, NJ 07834; (973) 586-8585, (973) 586-3404, Internet: http://www.vol tronics.com.**

Divider/combiners span 0.8 to 2.0 GHz

A line of dual-band power divider/combiners operates from 0.8 to 2.0 GHz to cover all wireless bands from cellular through personal communication services (PCS). The model 802-2-1.400 two-way divider/combiner has a typical insertion loss of 0.3 dB, a VSWR of 1.1:1, and 30-dB isolation. It measures 1.5 × 2.0 × 0.44 in. (3.81 × 5.08 × 1.80 cm). The 804-2-1.400 four-way divider combiner has a typical insertion loss of 0.6 dB, a VSWR of 1.15:1, and 30-dB isolation. It measures 2.5 × 2.5 × 0.44 in. (6.35 × 6.35 × 1.18 cm). All models can handle 10 W of total RF power and operate at temperatures from –55 to +70°C. They are equipped with stainless SMA or brass type-N connectors, gold (Au)-plated beryllium-copper (BeCu) contact pins, electrical-grade Teflon insulation within the connectors, and aluminum (Al) housings. **MECA Electronics, Inc., 459 E. Main St., Denville, NJ 07834; (973) 625-0661, FAX: (973) 625-1258, Internet: http://www.e-meca.com.**

Generators test wireless and cable systems

A series of carrier-to-noise (C/N) generators produces noise at specific strengths and frequencies to test the performance of wireless-, satellite-, and cable-communications equipment and systems. The CNG series generators can test parameters such as the ratio of carrier to noise (C/N), the ratio of bit energy to normalized noise (E_b/N_o), the ratio of carrier to normalized noise (C/N_o), the ratio of carrier to interference (C/I), and noise only. The generators provide accuracy to 0.15-dB received signal strength (RSS) and have a true root-mean-square (RMS) power meter for advanced averaging and curve-fitting algorithms. They can automatically calculate ratio limits based on initial conditions. **Micronetics, Inc., 26 Hampshire Dr., Hudson, NH 03051; (603) 886-2900, (603) 882-8987, Internet: http://www.micronetics.com.**

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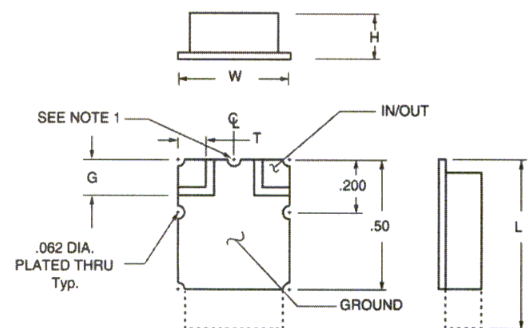

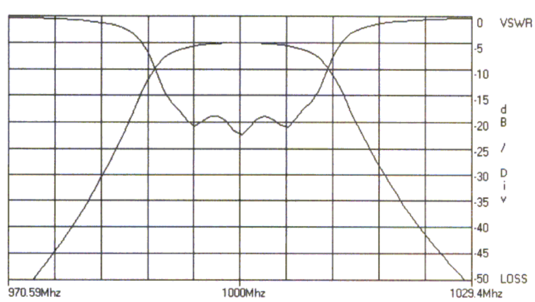

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Latest EDA Software Adds Wireless Features

The fourth release of the popular Advanced Design System for communications offers updated RF design, library, and test-simulation capabilities.

WITH WIRELESS COMMUNICATIONS MOVING quickly toward its third generation (3G), designers need frequent updating of the electronic-design-automation (EDA) software tools they use to develop the hardware of the technology. To reduce development time and further refine the design process, Agilent Technologies EEsof EDA Group (Palo Alto, CA) has made a number of important revisions to its widely used advanced design system (ADS) with the announcement of Release 1.5 (see figure). The improvements come in the areas of microwave/RF, RF integrated circuits (ICs), and communications systems.

The Momentum/Planar electromagnetic (EM) simulator of earlier versions sports a new "RF mode" that allows a designer to switch between the RF and microwave modes. The choice depends on the electrical size of the circuit relative to its wavelength. Included in RF mode are a quasistatic solver, arbitrary polygonal mesh, and a starloop-basis function which are intended to sharply reduce simulation time and increase capacity without the loss of accuracy for structures under a half wavelength. RF mode is suitable for wireless applications in ball-grid-array (BGA) packages and interconnecting complex RF circuit boards.

ADS *Release 1.5 incorporates a new and expanded EDA tool set to handle a variety of 3G wireless communications designs.*

The design guides that provide expert assistance to less-experienced users in complex design and verification tasks contain new guides geared toward the latest wireless applications. Release 1.5 has design guides for Bluetooth, cdma2000, a mixer, and an RF system. These will join the linearization, oscillator, power amplifier (PA), and other guides already in ADS. A design-guide developer studio is now available to develop custom content for ADS in the form of custom models and custom simulations. A library

Sofware Adds Wireless Design Features

browser is a new utility for setting up custom libraries that can be tailored to designer's needs by the familiar cut/copy/paste/drag/drop functions in Windows. The library serves to manage and list component information, and each component can be linked to a manufacturer's World Wide Web site for specifications, data sheets, and application notes.

A variety of design kits that are supplied and supported by IC foundries such as ANADIGICS, RF Micro Devices, ST Microelectronics, Triquint Semiconductor, and others are included in the new software. A design kit is a software model of a foundry's process for a particular semiconductor technology. These models are used by IC designers who want to have their design executed by a specific foundry.

Improved tools are available for system design and verification. Design libraries are software that provide behavioral models and simulation setups on the physical layer. They can generate the input stimulus (signals) to circuits under development to enable system engineers to verify their designs to current wireless standards. Release 1.5 offers such packages for emerging wireless standards such as the Third Generation Partnership Project (3GPP), wideband code-division multiple access (WCDMA), and the Enhanced Data Rate for GSM Evolution (EDGE). More than 130 models based on 3GPP specifications and more than 100 for EDGE are part of the new release.

An important addition to ADS is its upgraded support for test instrumentation. The software can now be integrated with test equipment such as the Agilent 89600 vector-signal analyzer (VSA), the 70900 spectrum analyzer, and the 546XX/548XX oscilloscopes. A signal, for example, can be generated with an Agilent ESG-D RF signal generator, captured with a VSA, and transported back into a design in ADS.

Most designers will want to bring their legacy designs into ADS 1.5, so file translators have been added to permit Series IV and multipoint-distribution-system (MDS) designs to be imported. The software will translate most schematics, layouts, analysis setups, and test benches, as well as user-defined custom-mapping rules. Vendor libraries and discrete-value parts can be transferred, along with various types of documentation and custom libraries. Another new feature is an RF IC dynamic link for Cadence 1.5.1. This permits the direct simulation in ADS of the schematic, extracted, and configuration views from Cadence. Also, designers can annotate DC current and voltage values on a Cadence schematic at all levels of the hierarchy. In addition to Cadence support, there is increased compatibility with SPICE simulators.

A new bondwire model includes the effects of bond wires in RF IC simulations. It computes the self- and mutual-inductance of bond wires based on their location and shape. Device-model "binning" is a way of storing several model cards for a device type based on geometries, length, width, temperature, and other variables. ADS selects the appropriate model card for each instance depending on the parameter value.

As part of the increased emphasis on wireless communications, the ADS 1.5 software's antenna and propagation library has been upgraded. This permits testing 3G wireless designs with realistic antenna and propagation models. These propagation models are the new antenna array, vector channel, and the WCDMA (3G).

ADS, Release 1.5 will be available in December starting at $8080. It runs on UNIX and Windows 95/98/2000/NT4.0. **Agilent Technologies, Test and Measurement Organization, 5301 Stevens Creek Rd., MS 54LAK, Santa Clara, CA 95052; (800) 452-4844 ext.7301, Internet: http://www.agilent.com.**

GENE HEFTMAN
Senior Editor

Software Tames Data Analysis

The latest release of this powerful graphing program allows users to select from more than 30 scientific and engineering graph formats.

SPREADSHEET PROGRAMS BUNDLED WITH DESKtop-publishing suites perform well for some functions, but are generally limited for plotting scientific or engineering data. Although numerous data-plotting packages are available, SigmaPlot 2000 from SPSS Science (Chicago IL) is one tool that can quickly eliminate the challenge of finding the optimum graphical presentation for a particular set of data. The software offers a choice of 22 engineering and scientific two-dimensional graph formats, nine three-dimensional (3D) formats, and eight views created through transforms. The flexible plotting tool includes 14 types of 2D scatter plots, four line-type plots, and 10 mixed scatter/line formats.

SigmaPlot 2000 supports large arrays of data. Its huge scientific worksheets can handle more than 32,000 columns by millions of rows. Built-in functions include automatic generation of column statistics, data sorting, and text support for up to 256 characters per plot.

The latest version of SigmaPlot 2000 offers enhanced features and a variety of improved functions. A new "arrange-graph" function allows an operator to see a preview of each layout template when the function's dialogue box is used to arrange a graph. Several new graph types have been added to this software version, including filled 2D contour plots, 3D waterfall plots, graphs with asymmetric error bars, range plots, quartile plots, and high-low-close plots.

A total of 13 user-definable functions have been added to SigmaPlot 2000's collection of technical-axis definitions. Among these are linear, logarithmic to base 10, natural log, and probability functions, with a user-defined custom axis to create Arrhenius, Weibel, and a variety of other plots. Included in the 13 mathematical transforms are histogram, one-way ANOVA, Fast Fourier with filters, ad statistics including skewness, 95-percent and 99-percent confidence, and t-tests.

New error-bar options automatically compute and graph percentile computations, standard deviations, mean, median, first and last values for symbols, minimum and maximum values, and 95- or 99-percent confidence values across columns and across rows.

SigmaPlot runs under the Windows 95, Windows 98, Windows 2000, or Windows NT 4.0 operating systems on a personal computer (PC) with at least 32 MB of random-access memory (RAM), 20 MB of available hard-disk memory, and an super video-graphics array (SVGA) or better monitor. P&A: $599.00; stock. **SPSS, Inc., 233 S. Wacker Dr., 11th Floor, Chicago, IL 60606-6307; (800) 525-4950, (312) 651-3690, FAX: (312) 651-3960, Internet: http://www.spss.com.**

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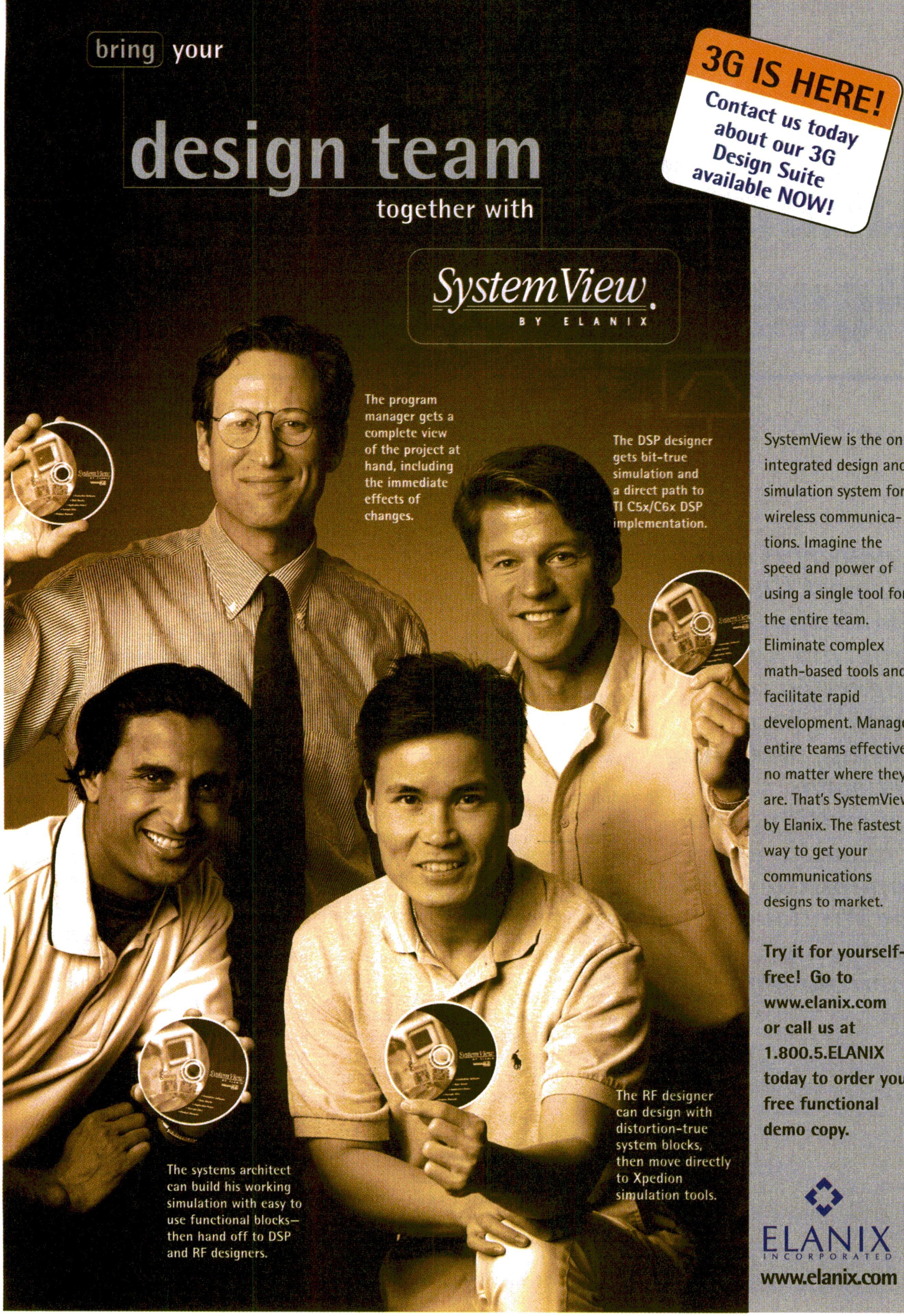
Special Projects Editor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The program manager gets a complete view of the project at hand, including the immediate effects of changes.
The DSP designer gets bit-true simulation and a direct path to TI C5x/C6x DSP implementation.
The RF designer can design with distortion-true system blocks, then move directly to Xpedion simulation tools.
The systems architect can build his working simulation with easy to use functional blocks—then hand off to DSP and RF designers.

Linear Simulator Hones Performance

A powerful and low-cost linear simulation program has been upgraded to include new tuning, matching-network-generation, and schematic-entry capabilities within the Windows operating environment.

CIRCUIT SIMULATION HAS ALWAYS BEEN AFFORDable with the aid of Applied Computational Sciences (Escondido, CA) software. But with the company's upgraded version of the LINC2 Pro circuit simulator, users can now access full-featured simulation capability and schematic-capture capabilities for about the price of a typical spreadsheet program.

The LINC2 Pro program is written for a personal computer (PC) operating with the Microsoft Windows environment. Operators can click on the "analyze" button directly from the software's schematic-entry page in order to generate simulation data, and then click on the "view" button to see the results. The software is that easy to use.

The upgraded version features improved RF impedance-matching network synthesis, microstrip and stripline transmission-line synthesis, pi- and T-pad design, and a powerful "circles" utility for designing input- and output-matching networks around a two-port network/device or transistor. Networks generated by the circle's utility are based on interactive displays of gain, noise figure, and stability circles overlaid on a Smith chart. The utility automatically synthesizes input- and output-matching networks for a user's choice of circuit topology and supplied impedance, working with L, pi, T, transmission-line, and stub formats.

LINC2 Pro features a built-in full-screen text editor to assist with generating and editing netlist circuit files. The text editor simplifies importing and exporting S-parameter data files from measured results and other simulation programs, as well as S-parameter-based circuit files, as available from a large number of component and device manufacturers.

The program offers a set of 18 analysis responses and performance indicators, including magnitude (logarithmic or linear) and phase for all S-parameters (forward and reverse transmission and reflection), as well as group delay, input impedance, output impedance, input VSWR, and output VSWR. If data must be plotted, the software offers a wide range of graphical options, including Smith charts, simultaneous rectangular graphs of any two circuit responses, and tabular displays of all circuit responses.

The software features over 2000 S-parameter files from major transistor suppliers, stored in the SDATA folder on the supplied compact-disc read-only memory (CD-ROM). In addition, this latest version of the software includes a wide range of S-parameter models for miniature and surface-mount inductors from Coilcraft (Cary, IL). P&A: $495.00; stock. Applied Computational Sciences, 1061 Dragt Pl., Escondido, CA 92029; (760) 612-6988, e-mail: linc2@appliedmicrowave.com, Internet: http://www.appliedmicrowave.com.

For more information, visit www.mwrf.com

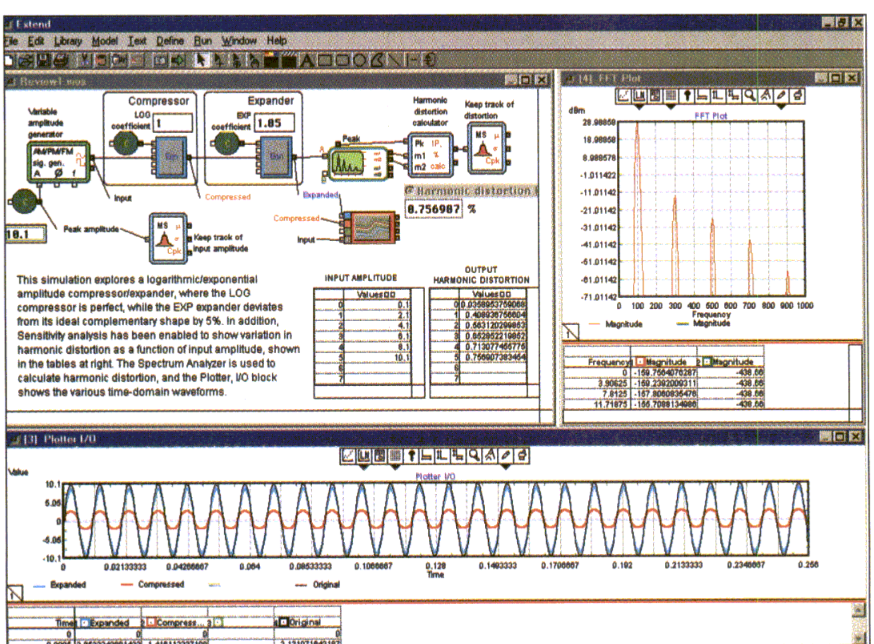
ALAN ("PETE") CONRAD
Special Projects Editor

Software Simulates Comm Systems

Engineers can easily design communications systems and perform time-domain simulations with this user-friendly software package.

COMMUNICATIONS SYSTEMS DESIGN CURRENTLY DOMINATES high-frequency engineering, given the growth in wired, optical, and wireless communications around the world. To speed the growth of those applications, RF Intercept from RHR Laboratories (Richmond Hill, Ontario, Canada) is a system-level simulator that provides useful insights into system-model behavior in the time domain. In addition to simulating entire systems and subsystems, the program can also simulate circuits whose topology contains separate functional subcircuit blocks. It operates as a comprehensive library within the EXTEND™ program, a general-purpose simulation tool from Imagine That, Inc. (San Jose CA).

RF Intercept can simulate signal-to-noise ratio (SNR), bit-error rate (BER), group delay, spectrum occupancy, intermodulation (IM) and cross modulation, triple beats, as well as harmonic distortion with user-defined output commands. The program is a collection of library blocks and functions that are dragged and dropped into a workspace and then connected together into a desired configuration. Component parameters are defined in drop-down windows before running a simulation. A dialogue box simplifies specifying the parameters of each individual block. Once parameters have been entered, a design is ready for simulation.



This example screen from RF Intercept within the EXTEND program shows an amplitude compressor/expandor (compandor), along with its transfer function and a Fast Fourier transform (FFT) plot.

RF Intercept operates within EXTEND's dynamic simulation environment with a built-in development system that supports the library models and functions of RF Intercept. Complementary libraries in EXTEND include printer and plotter drivers, animation routines, and electrical-engineering functions. The combination of RF Intercept and EXTEND enables users to effectively simulate discrete and continuous

(CONTINUED ON PAGE 227)

CD-ROM Encyclopedia Sorts Global Radars

Fanciers of the world's radar systems will find a wealth of information on different platforms and their manufacturers in this informative electronic collection.

ACTIVE RADAR PLATFORMS IN OVER 50 SYSTEM categories have been compiled into a single, powerful source—the International Radar Directory. This compact-disc read-only memory (CD-ROM) from Stephon L. Johnson (Huntsville, AL) offers platforms from 25 different countries and more than 130 different manufacturers. The reference source includes a variety of systems, such as ballistic-missile systems, airborne early-warning radars, battlefield-surveillance radars, bistatic-radar platforms, aperture-radar systems, terrain following, and terrain avoidance systems, air-to-air systems, and air-to-ground systems. Users can sort by manufacturer, country of origin, installation application, and function.

Countries on the selection list include Israel, Italy, Poland, Russia, South Africa, Spain, Sweden, the Ukraine, and the US. The 12 installation categories include fixed ground installations, mobile ground, and piloted and unpiloted airborne applications. Browsers will find more than 45 specific system functions. They include antiballistic missile (ABM) systems, airborne early-warning (AEW) systems, and fire-control radar systems.

Selecting the list of manufactures presents the browser with a choice of more than 130 worldwide radar-system manufacturers, with pictures and system specification for almost all platforms. For example, selecting Elta, a manufacturer located in Israel, opens a list of 23 radar platforms, such as maritime-surveillance radars (MSRs), fire-control radars, and general-purpose intrusion radar systems.

Choosing The Netherlands from the country list presents the browser with a list of 29 platforms. Included are battlefield radar systems, two-dimensional (2D) portable air-search systems, and a family of laser, electro-optical, and infrared (IR) systems. Selecting a particular system of interest displays an image of the platform or an installation picture along with system specifications. Choosing Japan presents the viewer with over 80 systems. Selecting the Japan Radio Co. from the list presents the user with a new list containing a choice of 20 systems. Selecting Russia presents the viewer with a list of 170 platforms. These include missile-guidance, air-to-air, air-to-ground, and electro-optical systems. Each listing typically contains a profile of operational parameters. The CD-ROM is a true collector's item for fans of radar systems, or engineers working in the field in need of general information. P&A: $599.00; stock. **Stephen L. Johnson, 4015 Devon St., Huntsville, AL 35802; (256) 881-9020, FAX: (256) 881-9020, e-mail: jonskaat @advicom.net.**

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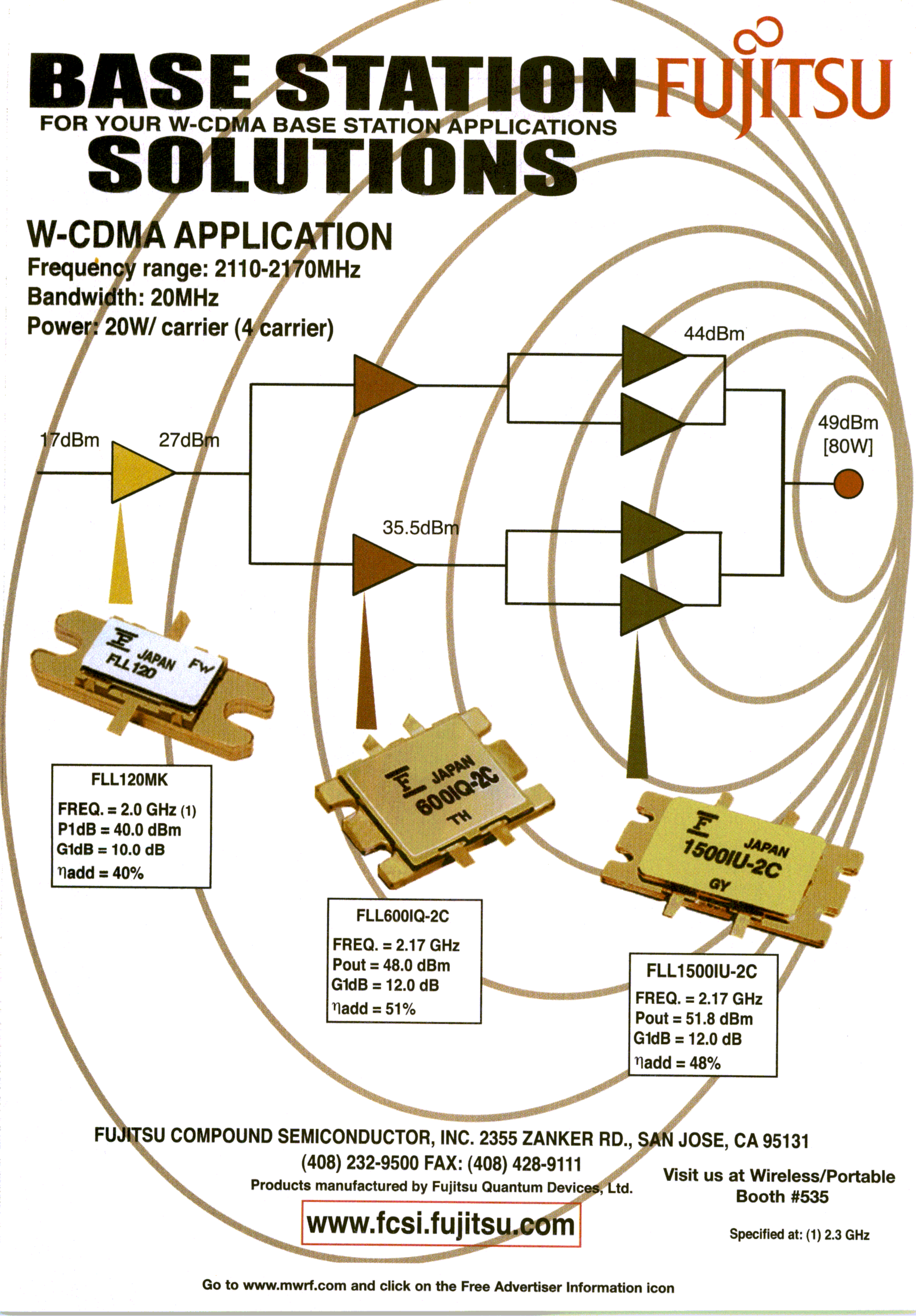
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Study phase-noise theory and measurements

Phase-noise measurements have grown in importance due to the proliferation of digital modulation schemes in modern communications systems. Since phase states are used to represent digital codes, rather than the traditional use of amplitude or frequency to carry messages, the phase noise of a communications system's local oscillator (LO) must be extremely low for reliable operation. For those in need of education on phase noise and how to measure it, an excellent application note entitled "Phase Noise Theory and Measurement" is available from Aeroflex Comstron (Plainview, NY).

The note describes phase and other types of noise, first in the time domain (in relation to time) and then in the frequency domain (as a function of frequency). In the time domain, noise appears as a random function, which can be characterized statistically by its distribution, typically as a Gaussian function. In the frequency domain, noise can be shown as the spectral density of phase fluctuations, frequency fluctuations, amplitude fluctuations, and other disturbances.

The note goes on to define the relationship of noise to a desired signal, and how a signal's spectral purity is expressed in terms of noise sidebands relative to the desired signal carrier. The literature describes amplitude noise and phase noise, the relationship between spectral purity and spectral density, the time-domain characterization of phase noise and frequency noise, how to characterize the jitter of a source, how to demodulate the frequency noise of a signal, techniques for making measurements of frequency noise with a frequency counter and of jitter with an oscilloscope, noise sources in signal generators, noise in oscillators, and how to characterize a signal generator in terms of its spectral purity.

The 36-page application note is an excellent single source for information about the sources of phase noise and how to measure them. The application note is available upon request from the company. It is also available as a free download from the TestMart website at http://www.testmart.com. **Aeroflex/Comstron, 35 South Service Rd., Plainview, NY 11803; (516) 694-6700, FAX: (516) 694-6771, Internet: http://www.aeroflex.com.**

For more information, visit www.mwrf.com

Make CATV forward-sweep and balance tests

Engineers and technicians faced with evaluating the performance of cable-television (CATV) systems must inevitably perform forward-sweep and balance measurements on the system. Fortunately, a concise six-page application note from Wavetek Wandel Goltermann provides precise details about setting up and performing these tests.

The application note (No. 1) is based on the use of the company's StealthSweep family of test instruments. In setting up the CATV head end for forward-sweep measurements, for example, the application note recommends the use of a diplexer filter rather than a power splitter (due to isolation issues) to combine reverse signals. Since the return signals are generally over the range of 5 to 200 MHz, the note cautions that improperly setting up the measurement system could result in jitter added to the forward sweep. It recommends that the levels be set between 4 and 12 dBmV. If the levels are set too high, unwanted channels will be enabled and will confuse the measurement.

The note also recommends that a practical channel plan be established, if a channel plan has not already been created. The channel plans are stored in the memory of the test equipment. Following this, it is necessary to build sweep points for the transmitter (Tx), if it is required to examine vacant bandwidth during a test.

The note provides guidance on how to copy channel plans with the test receiver (Rx), how to change settings in the field, and balance signal levels. It includes a troubleshooting section on common forward-sweep problems, and how the portable measurement Rx can be used for other test applications.

The six-page application note is available upon request from the company. It is also available as a free download from the TestMart website at http://www.testmart.com. **Wavetek Wandel Goltermann, 1030 Swabia Court, P.O. Box 13585, Research Triangle Park, NC 27709-3585; (919) 941-5730, FAX: (919) 941-5751, Internet: http://www.wwgsolutions.com.**

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Novel Passive FET Mixers Provide Superior Dynamic Range

The dual-double-balanced configuration of these FET mixers helps to improve dynamic range with reduced conversion loss and noise figure without expending DC bias.

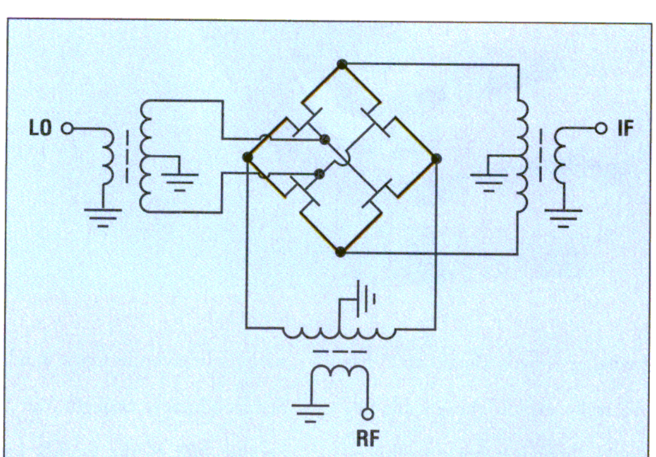
Daxiong Ji and Radha Setty
Engineering Department
Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235; (718) 934-4500, FAX: (718) 332-4661, Internet: http://www.minicircuits.com.

RECEIVERS (Rxs) in support of the continually expanding wireless marketplace rely heavily on improved performance from mixer components. What was once considered adequate performance in terms of dynamic range—mixer noise figure at the low-level end of the dynamic range and third-order intercept point (IP3) at the high-level end—is no longer good enough. Since modern mixers must provide third-order intercept performance in excess of +35 dBm, the engineers at Mini-Circuits (Brooklyn, NY) set out to beat that number by at least 3 dB, with a new line of field-effect-transistor (FET) mixers designed for third-order intercept performance to +38 dBm.

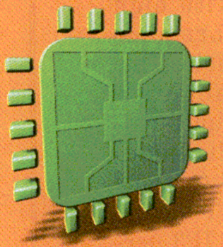
Due to the crowding of licensed and unlicensed bandwidths by an increasing number of wireless applications, including cellular telephones, wireless local-area networks (WLANs), and the coming of Bluetooth devices (see the supplement on Bluetooth packaged with this issue), Rxs are faced with a growing number of undesired carriers along with the wanted signal carriers. When the unwanted carriers are close in frequency to the desired carrier, front-end Rx filters cannot remove the interference signals. The unwanted carriers then mix with each other and with the desired signals and generate intermodulation distortion (IMD).

Every system designer wants to minimize IM products. In narrowband Rxs, one of the most troublesome IM products is the third-order product, which is measured in relation to the IP3 of the Rx. The higher the Rx's IP3, the better suited it is to capture the desired signal in the presence of unwanted IMD.

Conventional double-balanced and triple-balanced mixers are produced using Schottky barrier-diode quads. An IP3 of +25 to +31 dBm can be achieved by using this technique. However, to achieve such high IP3 performance in a diode-based mixer requires a great deal of tuning, which then increases the manufacturing complexity and cost. Well-designed FET mixers, on the other hand, can provide extremely linear performance, and can be used as mixing elements, with high IP3 performance readily possible. This article highlights a series of double-balanced and dual-double-balanced (patent-pending) FET mixers designed for IP3 per-



1. This schematic diagram shows the basic configuration for a double-balanced FET mixer.



The future of wireless is here: Bluetooth™* has arrived. And to really exploit those cable-free market opportunities - in phones, home appliances, computers and peripherals - you'll need a semiconductor vendor that delivers quickly. Philips Semiconductors is that vendor. Evidence? Already a leader in wireless interconnectivity standards like 802.11 and IEEE 1394, Philips Semiconductors brought the first Bluetooth chipsets to market. And became one of the world's largest producers of Communication ICs. More than just chipsets, we provide optimized solutions involving ICs, software, OEM designs and unrivalled support in all stages of development. So if you have Bluetooth capabilities, we provide embedded cores for


create a cable-free world.
Say hello to Bluetooth.

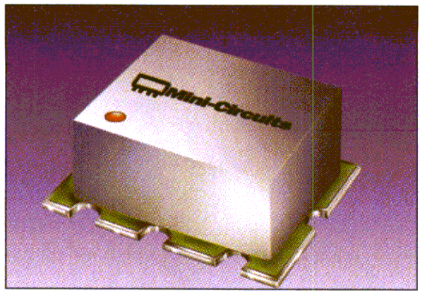
formance to +38 dBm.

Modern mixers with IP3 on the order of +30 dBm and higher typically use FETs as mixing elements. Some of the disadvantages of commercially available FET mixers are a higher conversion loss/noise figure of approximately 9 dB, and the need for DC bias current.

Mixers are usually specified for their input IP3 performance. The corresponding output IP3 performance is the difference between the input IP3 and the conversion loss. Thus, higher conversion loss results in lower output IP3. Higher mixer noise figure results in higher Rx noise figure. To reduce the Rx noise figure, high-gain low-noise amplifiers (LNAs) must be used in the front end. However, this increases the signal level (wanted and unwanted) reaching the mixer, and limits system performance due to the IP3 limitation of the amplifier.

The need for DC current increases the complexity of a circuit design. The current supply should have low noise, or it may introduce spurious signals at the output. It requires additional real estate on a printed-circuit board (PCB) to transfer the current from its source to the mixer. The need for mixer current increases the DC power budget for an Rx design.

Fortunately, the traditional shortcomings of FET-based mixers have been addressed by a line of dual-double-balanced FET mixers and double-balanced FET mixers from Mini-Circuits. The patent-pending dual-double-balanced and double-balanced FET mixers feature low conversion loss, low noise figure, and high IP3 performance, even though they do not require DC bias current and use patented[1] FET quads.



2. The model HJK-21H is a double-balanced FET-based mixer designed for use with RF signals from 1850 to 1910 MHz and LO signals from 2090 to 2150 MHz.

Figure 1 shows a schematic diagram of a double-balanced mixer based on FET devices. It consists of four FETs in a quad configuration, along with RF, local-oscillator (LO), and intermediate-frequency (IF) balanced-unbalanced (balun) transformers. The operation of this type of mixer is similar to that of a conventional diode-based double-balanced mixer. The main difference is that the FET mixer has six terminals, compared to the four terminals of the double-balanced diode mixer. During the positive half-cycle of the LO signal to the FET mixer, two of the FETs are in conduction while the other two are turned off. As a result, the secondary winding of the RF balun is connected to the secondary winding of the IF balun through the FETs that are switched on. During the LO signal's negative half-cycle, the FETs which were on during the positive half-cycle are turned off and vice versa. This results in a reversal of the polarity of the RF signal reaching the IF balun. The frequency at which the FETs are turned on and off is determined by the frequency of the LO signal. This is mathematically equivalent to a multiplication of the RF and LO signals, resulting in the generation of sum and difference frequencies at the IF port.

To obtain high IP3, all the switching elements in the mixer circuit should be linear and well balanced. To achieve even higher IP3 and isolation compared to a standard double-balanced FET mixer, a dual double-balanced mixer configuration (patent pending) is used in the new series of FET mixers from Mini-Circuits. These high-IP3 mixers are available in numerous cellular and personal-communications-services (PCS) RF ranges through 2 GHz (see table).

An example of the new FET mixer line is the model HJK-21H (Fig. 2), which operates with RF signals from 1850 to 1910 MHz and LO signals from 2090 to 2150 MHz. It yields IF signals from 180 to 300 MHz and is designed for LO power levels of +17 dBm. The mixer exhibits maximum conversion loss of 8.9 dB, with typical performance of 7.6 dB. The HJK-21H achieves typical input IP3 performance of +36 dBm (Fig. 3). The LO-to-RF isolation is typically 28 dB, while the LO-to-IF isolation is typically 25 dB. The mixer, with return loss of typically better than 9 dB, exhibits minimal change in return-loss and isolation-performance levels as a function of LO power. The effect of LO power on RF and LO return loss is minimal for the FET-based mixer, although the effect of varying the LO power on IF return loss is comparable to the effects seen with diode-based mixers.

A significant advantage of a FET mixer over diode is in its compression

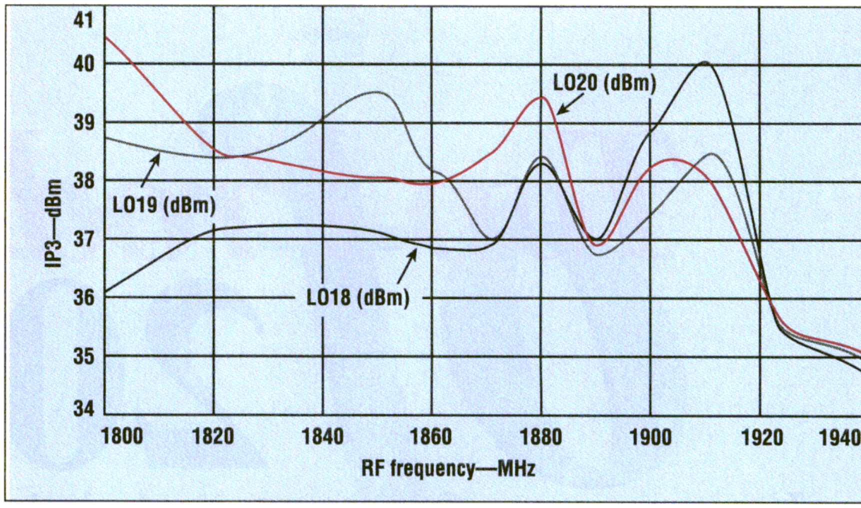
Electrical specifications (FET mixers)

Model no.	Frequency (MHz) RF	LO	IF	LO level (dBm)	IP3 input (dBm) typ.	Conversion loss (dB) Typ.	σ	Max.	L-R isolation (dB) Typ.	Min.	L-I isolation (dB) Typ.	Min.	Case style
HJK-21H	1850 to 1910	2090 to 2150	180 to 300	17	36	7.6	0.2	8.9	28	20	25	18	TTT167
HUD-19SH	1819 to 1910	1710 to 1769	50 to 200	19	38	7.5	0.2	8.9	38	27	36	25	BK377
HJK-19H	1850 to 1910	1780 to1840	70 to 130	17	36	7.5	0.2	8.9	28	20	22	16	TTT167
HJK-9H	818 to 853	753 to 778	40 to 100	17	33	6.7	0.2	8.0	35	24	31	23	TTT167

characteristics. The RF power level at which the conversion loss of the mixer increases by 1 dB, when compared to the conversion loss at low RF power, is known as the 1-dB compression point. The 1-dB compression point of a diode mixer is generally 4 to 6 dB lower than the power level of the LO signal, whereas the 1-dB compression point of a FET mixer such as the HJK-21H is typically +20 dBm, or 3 dB higher than the power level of the LO signal.

Dual double-balanced mixers employ two FET quads and a novel balun arrangement (patent pending) to achieve high IP3 and high isolation. An example of such a mixer is the model HUD-19SH, which has a typical IP3 of +38 dBm (Fig. 4). This IP3 performance is high enough to meet the most demanding requirements of today's communication equipment. The FET-based mixer is designed for RF signals from 1819 to 1910 MHz and LO signals from 1710 to 1769 MHz. It yields IF signals from 50 to 200 MHz. Its conversion loss, which is typically 7.5 dB for an LO power level of +19 dBm, suffers variations within 0.2 dB for changes in LO power level. The LO-to-RF isolation is also tightly controlled. The isolation performance of this mixer is approximately 8 to 10 dB better than that of a double-balanced mixer, with return loss that is comparable to the performance of a diode-based mixer.

Two other mixers are listed in the table, models HJK-19H and HJK-9H.



4. The IP3 of the HUD-19SH FET mixer was measured from 1800 to 1940 MHz for LO power levels of +18, +19, and +20 dBm.

The former is designed for RF signals from 1850 to 1910 and LO signals from 1780 to 1840, and yields IF signals from 70 to 130 MHz. The latter is designed for RF signals from 818 to 853 MHz and LO signals from 753 to 778 MHz and yields IF signals from 40 to 100 MHz. Both mixers are suitable for use with an LO power level of +17 dBm. The HJK-19H achieves IP3 performance of typically +36 dBm with typical conversion loss of 7.5 dB, LO-to-RF isolation of typically 28 dB, and LO-to-IF isolation of typically 22 dB. The HJK-9H achieves IP3 performance of +33 dBm with typical conversion loss of 6.7 dB, typical LO-to-RF isolation of 35 dB, and typical LO-to-IF isolation of 31 dB.

Future designs will address applications beyond 2 GHz. These FET-based mixers have been developed to satisfy the demanding requirements of modern communications applications. In these mixers, the IP3 performance is predictably sensitivity (with a shift of approximately 2 dB in IP3 performance for every 1-dB shift in LO power) over a ±2-dB level of nominal LO power requirements. This is useful for system designers when budgeting for power consumption. In addition to superior IP3 performance, these mixers provide conversion loss and isolation performance that is comparable with the state of the art of present day mixers.

A series of FET mixers, which offer an IP3 of +15 dBm in excess of LO power (i.e., +7-dBm LO power mixer offering +22-dBm IP3), is also being offered to complement this series of mixers.

The HJK and HUD series of FET mixers have been designed by using standardized fixtures and internal design layouts, enabling automated manufacturing in Mini-Circuits manufacturing plants. Consequently, these mixers are offered at a lower cost compared to market offerings. **Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235; (718) 934-4500, FAX: (718) 332-4661, Internet: http://www.minicircuits.com.**

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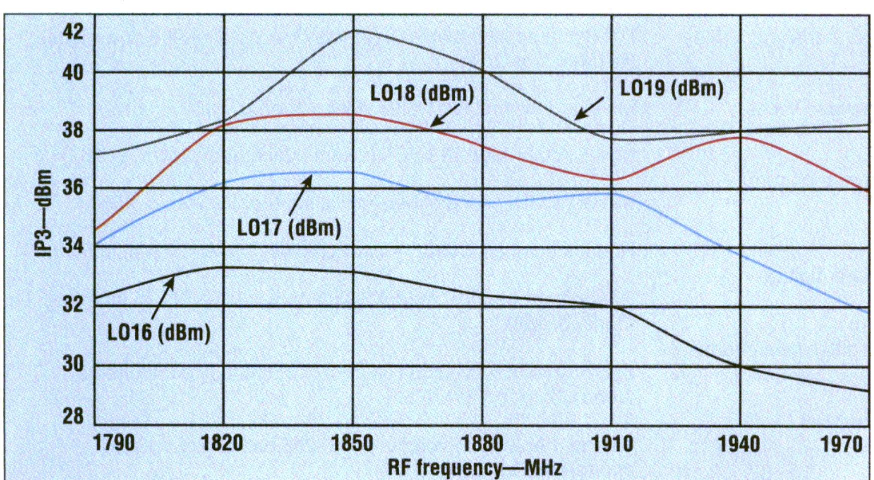


3. The IP3 of the HJK-21H FET mixer was measured from 1790 to 1970 MHz for LO power levels of +16, +17, and +18 dBm.

Reference

1. United States Patents, Nos. US5416043 and US5600169.

Top Products of 2000

In a year where the economy peaked, the industry produced solid product advances largely aimed at fueling continued growth in wireless and high-speed markets.

JACK BROWNE
Publisher/Editor

"SOLID, but not spectacular" might be a phrase to sum up the thousands of products introduced by high-frequency firms during the year 2000. Wireless communications continued to be the major driving force behind many new product developments, although some of the products among this year's picks indicate a movement of the microwave industry toward the realm of high-speed data communications.

This year's lineup of Top Products is based not only on technological innovation, but also on perceived practical benefit to the high-frequency engineering community. As always, the list offers a variety of different product types, from tiny integrated circuits (ICs) to costly measurement equipment. Each product or product series represents a significant development, as well as many long hours of development and toil by dedicated engineering teams. Congratulations are due to all of the engineering teams represented by the list below for their efforts in bringing these products to market.

Since instrumentation is vital to the characterization of new circuits and devices for communications applica-

Top Products of 2000 (in alphabetical order)

Agilent Technologies' NFA Series of noise-figure analyzers (May Cover, p. 199)

Agilent Technologies' PNA Series of RF/microwave VNAs (September, p. 140)

Agilent Technologies' PSA Series of microwave spectrum analyzers (November Cover, p. 137)

Analog Devices' model AD9857 14-b quadrature digital upconverter (August Cover, p. 159)

ATN Microwave's model ATN-4002A 20-GHz differential-mode test system (March Cover, p. 126)

Celerity Systems' model CS29010 distortion test set (April, p. 150)

Dow-Key Microwave's space-qualified S-band T-switch (October Cover, p. 135)

ITT Systems, Microwave Systems Group's Stel-966 dual digital Rx (March, p. 154)

Melexis' low-cost Rx/Tx ICs (December, p. 196)

Mini-Circuits' high-IP3 FET mixers (December Cover, p. 167)

MITEQ's MDD series fiber-optic links (April Cover, p. 133)

Radiata's 5-GHz CMOS WLAN chip set (November, p. 156)

Silicon Laboratories' model Si4136 single-chip PLL synthesizer (June, p. 158)

Synergy Microwave's SYNSTRIP Technology components (June Cover, p.131)

Telecom Analysis Systems' TAS8250 cable network and interference emulator (January Cover, p.124)

tions, it is not surprising to see a number of test instruments on the Top Products list for 2000. The first issue of the year, in fact, introduced the TAS 8250 cable network and interference emulator from Telecom Analysis Systems (Eatontown, NJ). Now known as Spirent Communications, the company created a multifunction instrument to accurately model the characteristics of hybrid-fiber/coaxial (HFC) networks, including cable modems and cable-modem termination systems.

The TAS 8250 provides wideband channel emulation of the 50-to-860-MHz cable-television (CATV) downstream frequency band, as well as the 5-to-42-MHz upstream frequency band. The unit can generate additive impairments such as wideband noise, along with key cable-network characteristics such as amplitude tilt, network-filter emulation, and intermodulation distortion (IMD). The instrument allows users to independently control the level, frequency, and burst-timing characteristics of all impairment conditions in the upstream and downstream channels, making it possible to evaluate the effects of cable-network impairments under a controlled environment.

Celerity Systems (Cupertino, CA) also brought a communications tester to market in 2000 with their model CS29010 distortion test set (Fig. 1). Based on a personal-computer (PC) platform, the innovative tool generates and analyzes complex modulated waveforms over instantaneous bandwidths as wide as 40 MHz, making it ideal for all formats of code-division multiple access (CDMA), including the widest-bandwidth proposed formats.

The CS29010 digitizes input signals across an instantaneous bandwidth of 45 MHz, converting them to 12 b of digital data. The system can be specified with a variety of frequency-conversion options for operation with carrier frequencies up to 40 GHz. It has a standard input amplitude measurement range of –60 to 0 dBm, with a high-power option for handling signal levels up to +20 dBm. The CS29010 incorporates an arbitrary waveform generator (AWG) for creating all forms of digitally modulated signals with bandwidths as wide as 40 MHz.

1. The model CS29010 distortion test set uses a personal-computer platform to provide generation and analysis of broadband modulated signals.

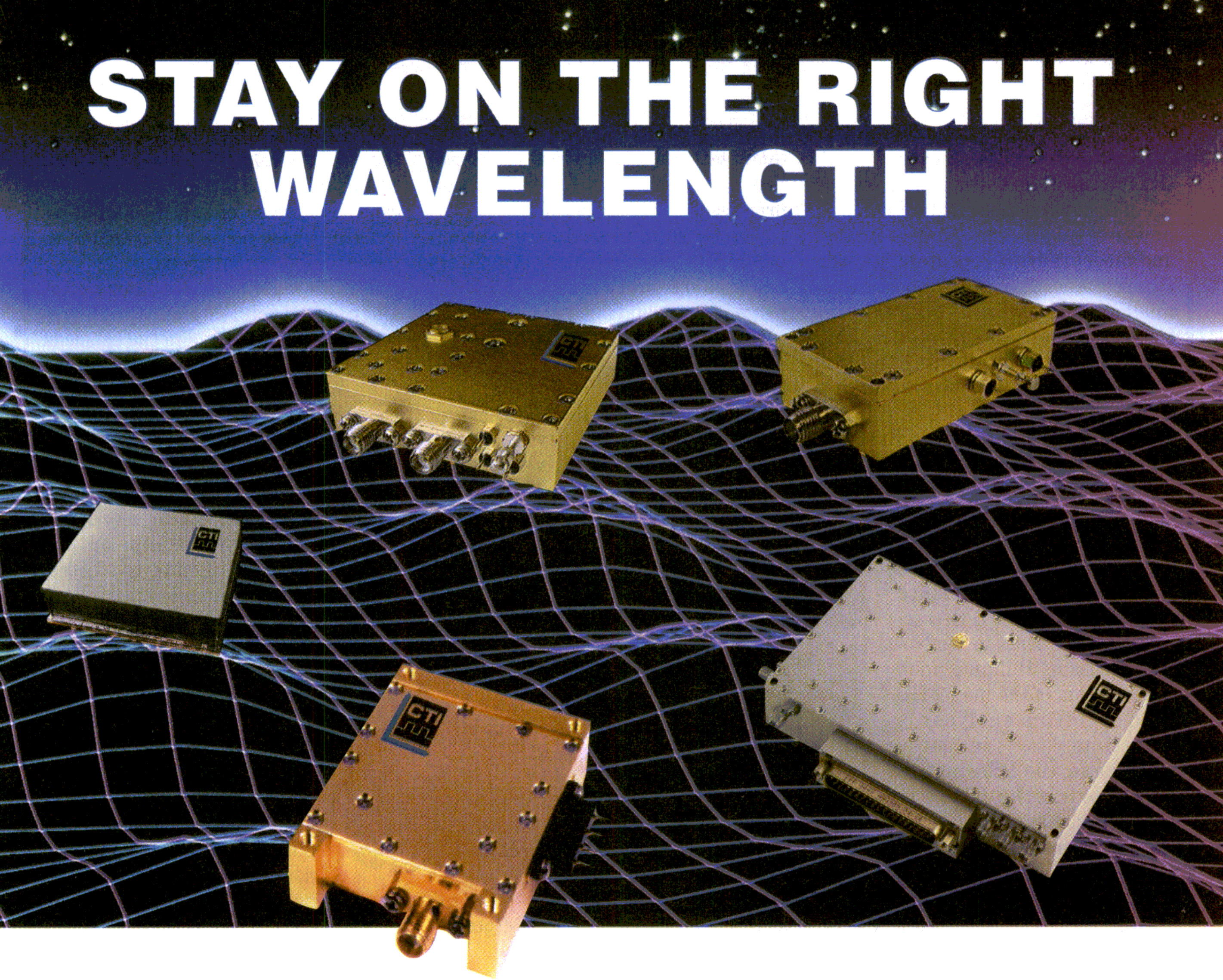
As digital circuits increase in speed, they behave more like traditional microwave circuits—affected by parasitic-circuit elements with circuit geometries that depend upon wavelengths. In response to a growing need, ATN Microwave (North Billerica, MA) made news with their model ATN-4002A measurement system. Based on a vector- network-analysis mainframe, the system is designed to evaluate the differential (matched) circuits common to digital applications. The measurement system features a 20-GHz bandwidth and uses mixed-mode scattering parameters to track the flow of energy through balanced circuits and components. Compared to single-ended S-parameters where stimuli and responses are analyzed in terms of single-terminal devices, mixed-mode parameters examine circuits and devices as having two terminals. In essence, the ATN-4002A is the first measurement system to bring the precision of a microwave vector network analyzer (VNA) to the digital realm.

Agilent Technologies (Santa Rosa, CA) "scored" high marks in this year's Top Products awards with three major product introductions. The first was the NFA series of noise-figure analyzers, unveiled in the May issue of Microwaves & RF. The first major upgrade to the industry's venerable 8970 noise-figure analyzer in approximately two decades, the NFA analyzers provide new levels of accuracy over their predecessor, with the measurement speed needed for modern, high-volume communications device and component testing.

The first two instruments in the NFA series (Fig. 2) are the model N8972A with a frequency range to 10 MHz to 1.5 GHz, and the model N8973A with a frequency range of 10 MHz to 3 GHz. The measurement noise-figure uncertainty of the lower-frequency unit is a low ±0.10 dB, while the measurement noise-figure uncertainty of the higher-frequency unit is an impressive ±0.05 dB. A noteworthy enhancement to these analyzers over their predecessor is the addition of selectable measurement bandwidths (in the higher-frequency unit). Operators of the N8973A can choose from an array of measurement bandwidths, including 100 kHz, 200 kHz, 400 kHz, 1 MHz, 2 MHz, and 4 MHz. With the choice of measurement bandwidths, operators can select a bandwidth that is closer to the actual bandwidth "seen" by a particular application, such as using 200 kHz for evaluating Global System for Mobile Communications (GSM) filters.

Later in the year, the company brought the PNA series of VNAs to market which featured upgrades in speed, accuracy, and ease of use compared to their predecessors, the 8753 line. The new analyzers offer measurement speeds between 6 and 35 times faster than their predecessors, and as fast as 35 μs per point. The trace noise is as low as 0.0005 dB, the lowest level the company has ever achieved with a VNA.

Unlike earlier sampler-based VNAs, the new analyzers have mixer-based front ends. Mixers help to lower the test system noise floor (and



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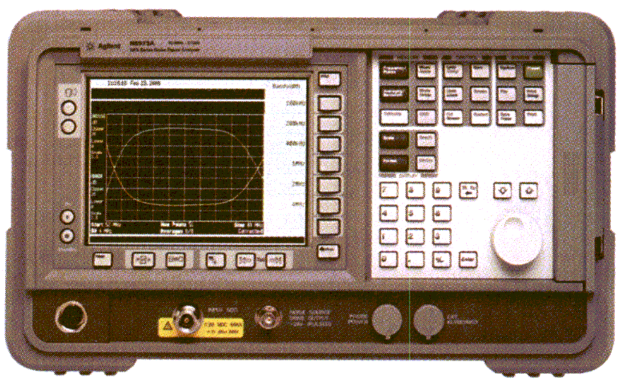
increase dynamic range). The analyzers also use two reference receivers (Rx) rather than the single reference Rx of their predecessors, for improved power-level accuracy, source match, and measurement repeatability. The two reference Rxs also support transmission-reflect-line (TRL) calibrations, which are useful when making probe-based measurements. The analyzers offer an operator system that will be familiar to many engineers, since they are among the first microwave measurement instruments to be based on Microsoft's Windows 2000 operating system.

The company closed out a successful year with the introduction of the Performance Spectrum Analyzer (PSA) series of instruments in the November issue. Building upon the tradition of the model HP 8566 spectrum analyzer, a long-time industry workhorse, the PSA instruments bring the latest in phase-locked-loop (PLL) synthesizer technology and digital resolution-bandwidth filtering to the world of spectrum analysis. The model E4440A is the first analyzer in the new line, with coverage from 3 Hz to 26.5 GHz. It embodies several innovations that enable it to set new standards for measurement speed, accuracy, and dynamic range at a competitive cost.

The E4440A (Fig. 3) carries an impressive list of credentials, including sweep speeds of 1 ms, sensitivity of –153 dBm, logarithmic linearity of 0.1 dB across a 100-dB dynamic range, a distortion-free dynamic range of 113 dB, and an absolute amplitude accuracy of ±0.35 dB. Across a frequency range of 26.5 GHz, microwave engineers now truly have an open window to a wide range of continuous and intermittent signals.

The complex intermediate-frequency (IF) circuitry found in the predecessor 8566A/B instruments has been reduced to a single IC. And what required eight circuit boards in signal-processing electronics in the 8566 is just a single circuit board in the E4440A. The new analyzer, which is based on a reduced-instruction-set-computer (RISC) microcontroller, takes advantage of advances in microprocessor technology for enhanced processing speed and accuracy.

The E4440A offers 160 resolution-bandwidth-filter settings, with filters adjustable from 1 Hz to 3 MHz in 10-percent steps, and fixed at 4, 5, 6, and 8 MHz. All resolution-bandwidth filters are digital, contributing to the excellent absolute amplitude accuracy and measurement speed. By implementing the filters with digital-signal-processing (DSP) techniques, it is possible to achieve near-ideal shape factors (the ratio of the 3-dB bandwidth to the 60-dB bandwidth). Traditional analog resolution-bandwidth filters exhibit shape factors on the order of 12:1. The digital filters in the E4440A boast nominal selectivity of better than 4.1:1. Due to this improved performance, operators can use wider resolution-bandwidth filters with the E4440A than in conventional spectrum analyzers with analog filters, resulting in improved measurement speed.



2. The NFA series of noise-figure analyzers bring new levels of accuracy and speed to noise-figure measurements through 3 GHz.

The E4440A offers absolute amplitude accuracy of ±0.3 dB at 50 MHz. The noise floor sits at –156 dBm, while the analyzer can also handle signals as "hot" as +30 dBm with a built-in input attenuator (and up to +5 dBm without the attenuator). The spectrum analyzer achieves a third-order intercept-to-noise dynamic range of 76 dB, which is suitable for evaluating the adjacent-channel-power (ACP) characteristics of wideband-CDMA (WCDMA) signals. The phase noise for offset frequencies from 10 to 100 kHz is typically –113 to –118 dBc/Hz, but drops to –142 dBc/Hz offset 1 MHz from the carrier. The E4440A's phase noise can be optimized manually, or operators can choose an automatic mode that selects the phase-noise setting that optimizes measurement speed.

The increasing use of fiber optics and digital technologies at high-frequencies was reflected in the choice of the MDD series of fiber-optic links from MITEQ, Inc. Hauppauge, NY). Designed as replacements for coaxial lines, the fiber-optic links offer analog bandwidths as wide as 10 GHz from 1 to 11 GHz. Supplied with 50-Ω input and output ports for ease of connection to RF systems, the optical links are immune to electromagnetic interference (EMI), relatively secure from jamming and interception, with low susceptibility to interference from lightning.

The MDD series of optical links operates at a wavelength of 1550 nm with a 3-dB bandwidth of 1 to 11 GHz. The links have an input/output (I/O) transfer function of nominally 10 dB, with a nominal noise figure of 14 dB at 4 GHz. The links suffer only 0.1 ns nominal peak-to-peak group delay with nominal I/O VSWR of 1.25:1. The noise figure is nominally 14 dB at 4 GHz, while the output third-order intercept point (IP3) is nominally +7 dBm at 4 GHz. The links offer the advantages of fiber-optic technology to RF/microwave designers, with simple 50-Ω interfaces that ease interconnection with RF/microwave systems.

On the component side, the Top Products list featured numerous advances in "building-block" technologies. The model 511HAJ-730322-3 T-Switch from Dow-Key Microwave (Ventura, CA) brought new levels of performance to an S-band space-qualified electromechanical switch. Designed for durability over time (15 years or more) rather than switching cycles, it can handle average power levels of 140 W at S-band and peak levels up to 560 W. The switch is designed for deep-space use from 2.5 to 4.8 GHz. It exhibits minimum isolation of 70 dB between ports across its full frequency

(continued on p. 229)

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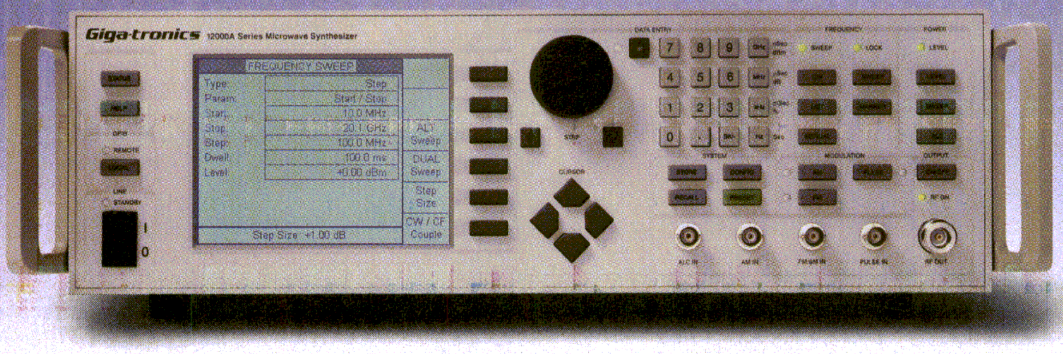

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DON KELLER

Senior Editor

RF power amplifiers (PAs) are integral components of cellular networks. An RF PA must support current analog and digital cellular standards. Ideally, it would also be adaptable to emerging third-generation (3G) standards. Paradigm Wireless Systems (Irvine, CA) offers a series of RF amplifiers that meet these criteria. The MAF Slim series includes five multichannel, 50-to-60-W PAs that support current and emerging wireless applications, including Advanced Mobile Phone Service (AMPS), time-division multiple access (TDMA), code-division multiple access (CDMA), wideband code-division multiple access (WCDMA), Global System for Mobile Communications (GSM) Enhanced Data rate for GSM Evolution (EDGE), and IMT-2000. The amplifiers use feedforward control-loop technology to enhance linearity and reduce distortion.

The main difference among the five amplifiers is the frequency range in which they operate, and the bandwidth over which they deliver their specified parameters. Model MAF800-60S operates over the 25-MHz band from 869 to 894 MHz, model MAF900-50S operates over any 20-MHz band between 920 and 960 MHz, model MAF1800-60S operates over any 30-MHz band between 1805 and 1870 MHz, model MAF1900-60S operates over any 30-MHz band between 1930 and 1990 MHz, and model MAF 2100-50S operates over the 60-MHz band from 2110 to 2170 MHz. Other differences among the models include average power output, intermodulation distortion (IMD), and power-supply current requirements (see table).

The differences among the five Slim series amplifiers

	MAF800-60S	MAF900-50S	MAF1800-60S	MAF1900-60S	MAF2100-50S
Frequency range (MHz)	869 to 894	920 to 960	1805 to 1870	1930 to 1990	2110 to 2170
Bandwidth (MHz)	25	20	30	30	60
Average output power (W)	60	50	60	60	50
IMD (dBc)	−65	−72	−60	−60	−60
Current draw (A)	25	25	27	27	24

The amplifiers are otherwise similar. For all models, RF gain is 60 dB, gain flatness is ±0.5 dB, and minimum input and output return loss are 14 dB. The amplifiers produce second harmonics of better than −50 dBc, third harmonics of better than −60 dBc, and out-of-band harmonics of better than −60 dBc. They operate from a +27-VDC power supply and require external forced-air cooling to stay within their operating temperature range of 0 to +50°C.

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Model, Analyze, And Simulate ΣΔ Fractional-N Frequency Synthesizers

Linear and nonlinear analysis techniques have been applied to the study of several fractional-N frequency-synthesizer architectures.

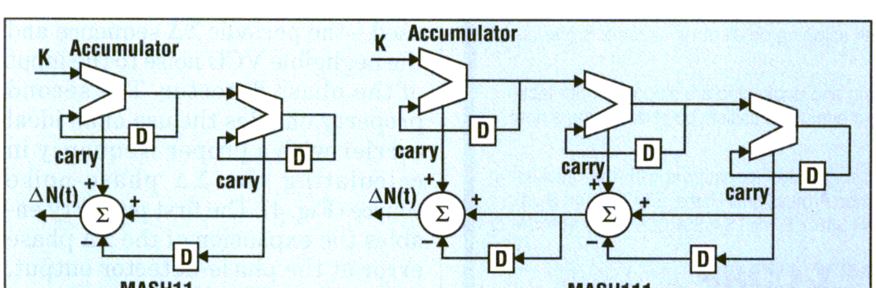
Part 1 of 2 parts

Yiping Fan

Senior Design Engineer

NOISE and speed are critical performance parameters for frequency synthesizers in communications systems. One of the more versatile synthesizer architectures is the ΣΔ fractional-N circuit, which combines fast-switching speed, high resolution, and low phase noise. But to better understand how to apply such sources, techniques were developed at Philips Semiconductors (San Jose, CA) for the analysis and synthesis of ΣΔ fractional-N synthesizers. Work was applied to various synthesizer configurations (MASH1, MASH11, and MASH111), and a set of mathematical expressions were developed to show the relation between the ΣΔ sequence and ΣΔ phase noise. Through analysis and simulation, it will be shown that the inherent nonlinearity of the voltage-controlled oscillator (VCO) in a fractional-N synthesizer, in conjunction with insufficiently suppressed ΣΔ phase noise from the synthesizer, are causes of spurious generation in the synthesizer. In addition, gain mismatch of the charge pumps and other nonlinearities inside the synthesizer loop are major contributors to the phase-noise and spurious performance of a fractional-N frequency synthesizer.

Due to the rapid growth of communications applications worldwide, system designers require frequency synthesizers with faster switching speeds and improved spurious/phase-noise performance, along with fine-grained resolution (channel spacing). In an integer-N (or low-modulus fractional-N) frequency synthesizer, one must compromise the noise performance in order to obtain a higher switching speed, and vice versa. However, for a ΣΔ fractional-N frequency synthesizer, such a trade-off does not appear to be necessary. Since an RF divider can only divide a complete number of VCO cycles, a fractional dividing ratio must be realized by means of time averaging. The multistage-noise-shaping (MASH) structure is popular within the synthesizer-design community not only because it is simple to implement in hardware, but also because it has an attractive noise-transfer function and is unconditionally stable across the full fractional region.



1. The MASH11 (left) and MASH111 (right) fractional-N frequency synthesizers can be implemented with these hardware configurations.

Figure 1 shows two MASH structures (MASH11 and MASH111) where common digital blocks such as accumulators, adders, and D flip flops are used. To begin the analysis of a ΣΔ frequency synthesizer, it may help to review a basic block diagram (Fig. 2). The charge pump is assumed. The block diagram is almost identical to an integer-N synthesizer, except that the dividing number N(t) is varying according to the output of the ΣΔ calculator. The dividing number N(t) consists of two parts—the constant integer N and the time-varying integer ΔN(t), which is updated by the ΣΔ calculator between two divisions. Parameter ΔN(t) is a periodic number and its period is twice the accumulator's overflow value. Once the hardware of the calculator is specified, ΔN(t) is the function of the integer K. The average fractional dividing ratio is equal to the K value scaled by the overflow value. The states of the ΣΔ calculator is updated by the edges of the RF divider output. Therefore, the updates of the ΣΔ calculator are not in synchronization with the reference clock edges. The integer range of $\Delta N(t)$ depends on a particular $\Sigma\Delta$ modulation used by the $\Sigma\Delta$ calculator. Parameter $\Delta N(t)$ will have four levels from –1 to +2, and eight levels from –3 to +4 for the MASH11 and MASH111 configurations, respectively.

For a $\Sigma\Delta$ fractional-N frequency synthesizer, a phase error almost always exists at every compare instance. In the locked condition, the average phase error over a complete $\Sigma\Delta$ sequence, i.e., $\Delta N(t)$, must be zero. Due to the varying dividing number, the pulse edges of the RF divider output are position-modulated. When the divider output is edge-compared with the reference clock at the phase detector's input, the phase detector will generate a phase-error (or noise) waveform which is pulse-position and pulse-width modulated. The pulse width indicates the sign and magnitude of the phase error and the pulse position indicates when this phase error occurs within a period. It is intuitive that this phase error will modulate the VCO through the charge pump/loop filter and the VCO output influences the RF divider output. Due to this "chicken and egg" dilemma, this intuition leads to a difficult situation for analyzing the synthesizer performance. Further analysis shows that among all noise sources, the phase error at the phase detector is primarily contributed by the $\Sigma\Delta$ sequence. Therefore, the analytical model for the noise/spurious performance can be abstracted into a somewhat-modified block diagram (Fig. 3), where the phase error, due to the $\Sigma\Delta$ sequence, is taken out of the loop and treated as if it came from an independent noise source at the phase detector. In this model, N + n is the average dividing ratio, and n is the average fractional part.

Since the focus here is on the $\Sigma\Delta$ phase noise, other noise sources, such as those from the reference clock or the VCO itself, are not considered here. When the noise sources are not correlated, they additively contribute to the overall noise and spurious performance, and can be straightforwardly analyzed. Unlike the classic linear approach, the VCO block is split into two blocks—the VCO phase block and the sinusoidal block in this model. The feedback path starts at the VCO phase output. From the phase-feedback point of view, this point is the same as the VCO output used in hardware.

To quantify the $\Sigma\Delta$ phase-noise source in Fig. 3, two properties are used—the periodic $\Sigma\Delta$ sequence and the negligible VCO noise to the input of the phase detector. The second property enables the use of an ideal carrier with a proper frequency in calculating the $\Sigma\Delta$ phase-noise source (Fig. 4). The first property enables the expansion of the $\Sigma\Delta$ phase error at the phase-detector output, PE(t), by the Fourier series:

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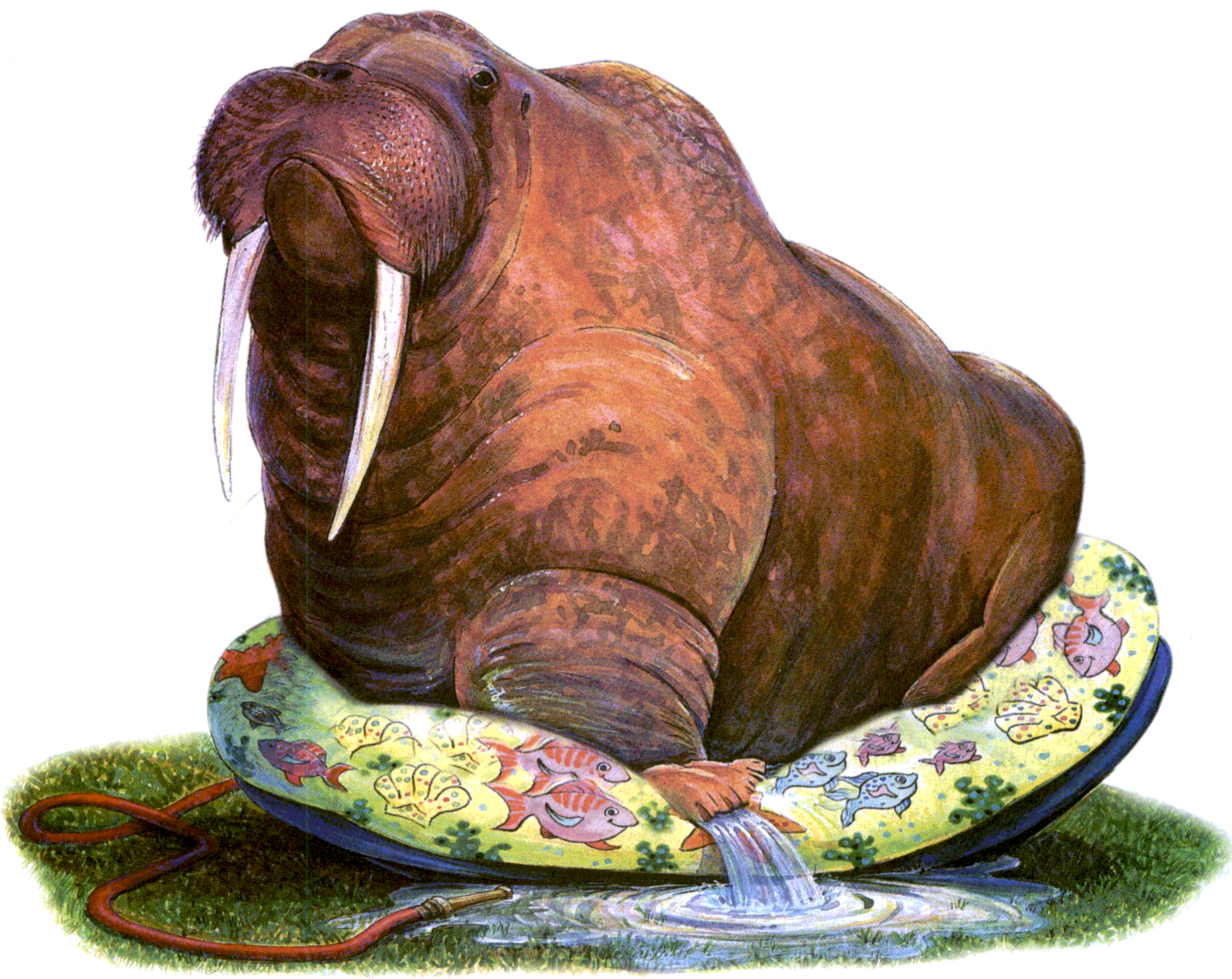

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$$PE(t) = \sum_{i=1}^{\omega} \begin{bmatrix} x(i)\cos(i\omega_0 t) \\ +y(i)\sin(i\omega_0 t) \end{bmatrix} \quad (1)$$

$$x(i) = \sum_{j=i}^{L} \left(\frac{2}{\pi i}\right) \sin\left\{\frac{i\,\omega_0\, P_W(j)}{2}\right\} \cos\left[i\,\omega_0\, P_p(j)\right] \quad (2)$$

$$y(i) = \sum_{j=i}^{L} \left(\frac{2}{\pi i}\right) \sin\left\{\frac{i\,\omega_0\, P_w(j)}{2}\right\} \sin\left[i\,\omega_0\, P_p(j)\right] \quad (3)$$

where:

P_p (i) = the pulse position at the ith reference clock instance (the pulse position is defined as the middle of each pulse),

P_p (i) = the pulse width at the ith reference clock instance,

I_s = the fundamental frequency of PE(t), and

L = the length of the ΣΔ sequence.

The pulse width can be calculated from:

$$P_w(i) = T_{\subset}\left[\sum_{j=1}^{i} \Delta N(j) - i\,n\right] \quad (4)$$

The pulse width and position are related according to Eq. 5:

$$P_p(i) = T_{\subset}\left[i\,N + \sum_{j=1}^{i} \Delta N(j)\right] - \frac{\left[P_w(i)\right]}{2} = T_{\subset}\; i\,Nn + \frac{P_w(i)}{2} \quad (5)$$

where:

T_c = the period of the carrier.

After eliminating $P_p(i)$ from Eqs. 2 and 3, the result is:

$$\frac{1}{\pi i}\begin{Bmatrix} \sin\left[i\,\omega_0\, P_w(j)\right] \\ \cos\left[\frac{2\pi}{L}\; i\,j\right] + \\ \left(1 - \cos\left[i\,\omega_0\, P_w(j)\right]\right) \\ \sin\left[\frac{2\pi}{L}\; i\,j\right] \end{Bmatrix} \quad (6)$$

$$y(i) = \sum_{j=1}^{L} \frac{1}{\pi i}\begin{Bmatrix} \sin\left[i\,\omega_0\, P_w(j)\right] \\ \cos\left[\frac{2\pi}{L}\; i\,j\right] + \\ \left(1 - \cos\left[i\,\omega_0\, P_w(j)\right]\right) \\ \sin\left[\frac{2\pi}{L}\; i\,j\right] \end{Bmatrix} \quad (7)$$

The ith harmonic power of the ΣΔ phase noise is then POW(i):

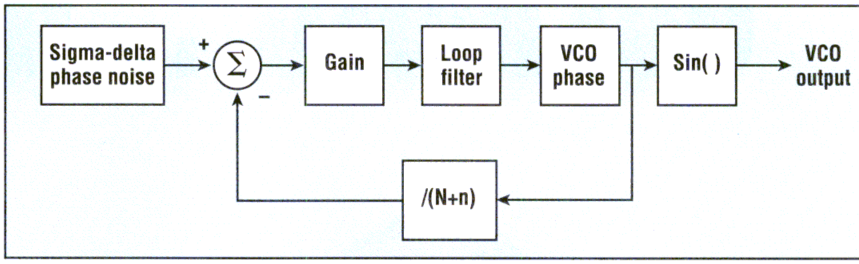
$$POW(i) = \frac{\left[x(i)\right]^2 + \left[y(i)\right]^2}{2} \quad (8)$$

Therefore, Eqs. 6, 7, and 8 establish a link between the phase error at the output of the phase detector in the time domain and the phase-noise power in the frequency domain. When $i\omega_0 P_w(j) \leq 2\pi$, $\sin[i\omega_0 P_w(j)] = i\omega_0 P_w(j)$ and $\cos[i\omega_0 P_w(j)] = 1$. Note that if $i < L/2$, that is, if it is half the reference frequency, these conditions are easily satisfied. Under this condition, Eqs. 6 and 7 become:

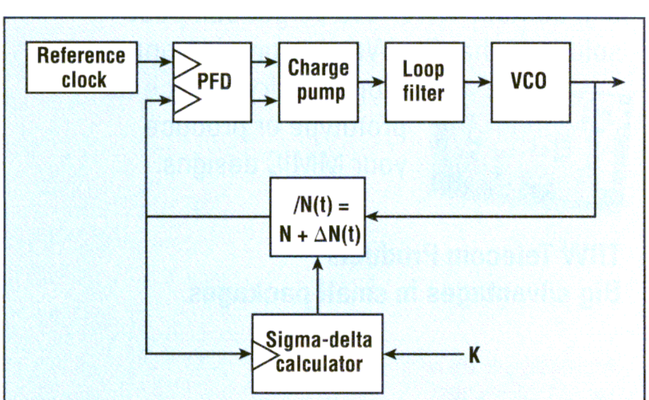
$$x(i) = \frac{\omega_0}{\pi}\sum_{j=1}^{L} P_w(j) \cos\left[\frac{2\pi}{L}\; i\,j\right] \quad (9)$$

$$x(i) = \frac{\omega_0}{\pi}\sum_{j=1}^{L} P_w(j) \sin\left[\frac{2\pi}{L}\; i\,j\right] \quad (10)$$

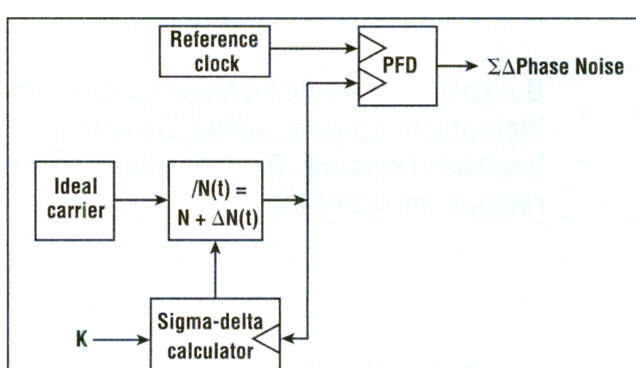
Equations 9 and 10 are simply the discrete Fourier transfer pair of the



3. This block diagram of a ΣΔ fractional-N frequency synthesizer has been modified for analysis purposes.



2. This basic block diagram shows the structure of a ΣΔ fractional-N frequency synthesizer.



4. This block diagram of a ΣΔ fractional-N frequency synthesizer has been modified to help in calculating phase noise.

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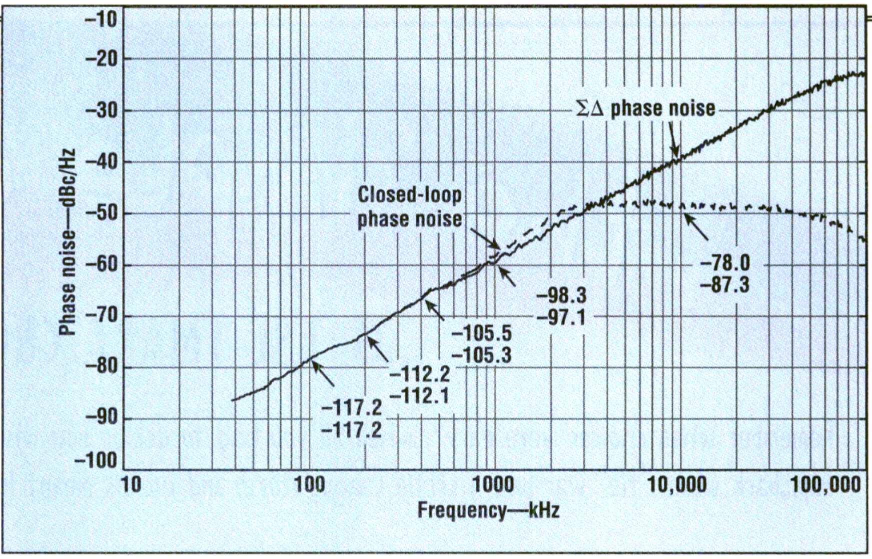
periodic phase error with a scale factor. This is why it is possible to use the FFT of the ΣΔ sequence to estimate the noise performance, because the AC relationship between the ΣΔ phase error and the ΣΔ sequence is an integration. Nevertheless, Eqs. 6 and 7 have an advantage in that they make it possible to explore the frequencies at higher than one-half of the reference frequency, such as the clock harmonics.

To analyze the closed-loop phase noise due to the ΣΔ phase noise, the classic linear approach or a novel nonlinear approach can be used. These approaches result in quite different noise/spurious performance levels. The closed-loop phase noise (or the ΣΔ phase noise with loop) is obtained by overlaying the closed-loop transfer function to the ΣΔ phase noise. The reason for this approach is that when the VCO phase noise is low, the phase modulation can be approximated by the double-sideband (DSB) amplitude modulation of as seen from:

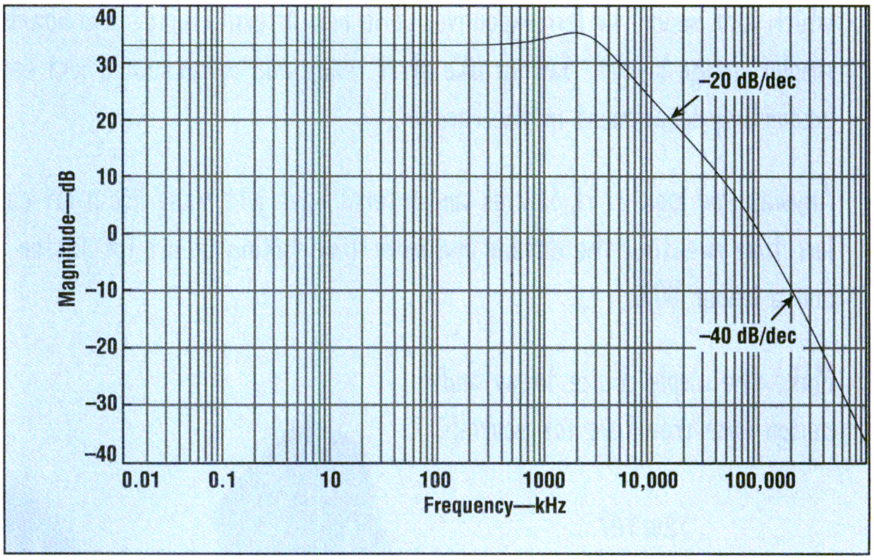
$$\cos[\omega_c t + \phi(t)] = \cos[\phi(t)] \cos(\omega_c t) - \sin[\phi(t)] \sin(\omega_c t) \quad (11)$$

$$\cos[\omega_c t + \phi(t)] = \cos(\omega_c t) - \phi(t) \sin(\omega_c t) \quad (12)$$

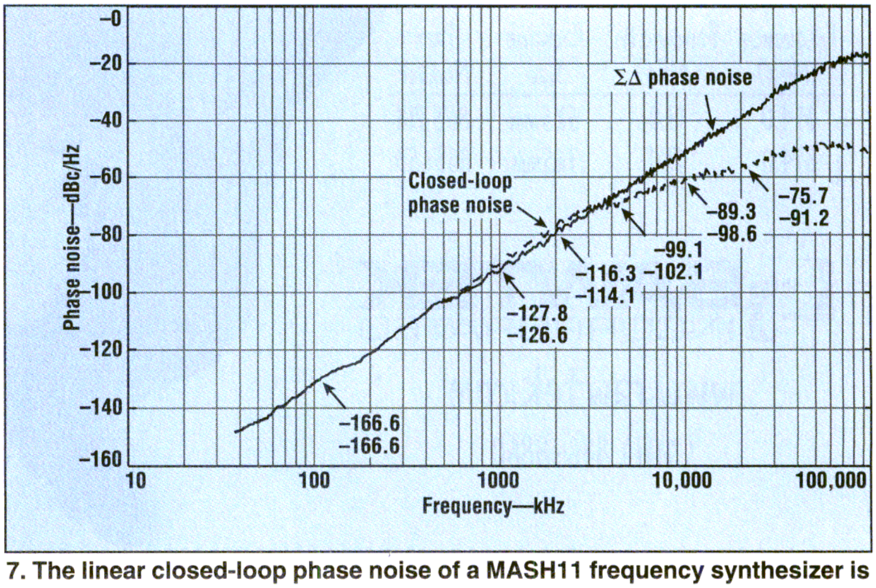
Figure 5 plots the closed-loop phase-noise spectrum (the dashed line) along with the ΣΔ phase-noise spectrum (the solid line) using the linear approach. The closed-loop transfer function, which incorporates a two-pole filter, is shown in Fig. 6. The spectrum was measured with a spectrum-analyzer resolution bandwidth of 7.6 kHz. MASH11 is used and K corresponds with a fractional frequency of 60 kHz with a 20-MHz reference frequency. The horizontal axis corresponds with the offset frequency from a 900.060 MHz carrier. Below 200 kHz, the ΣΔ phase noise and the closed-loop noise are the same; they increase with frequency at a rate of 20 dB/decade. After approximately 200 kHz, the loop filter kicks in and the slope (–20 dB/decade) of the loop transfer function cancels the ΣΔ phase-noise



5. This plot shows the linear closed-loop phase-noise response of a MASH11 synthesizer.



6. This plot shows the frequency response of the closed-loop transfer function for a fractional-N synthesizer, with slopes of 20 and 40 dB/decade.

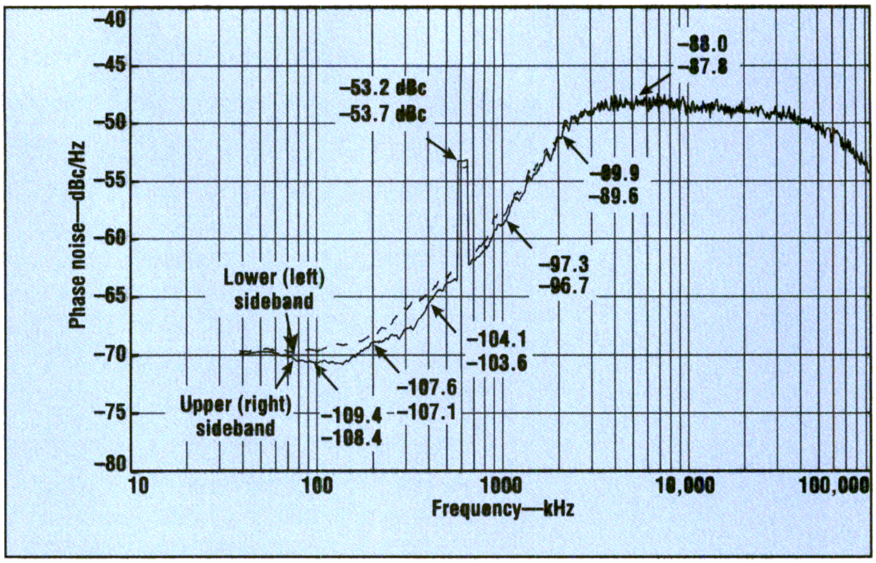


7. The linear closed-loop phase noise of a MASH11 frequency synthesizer is plotted here.

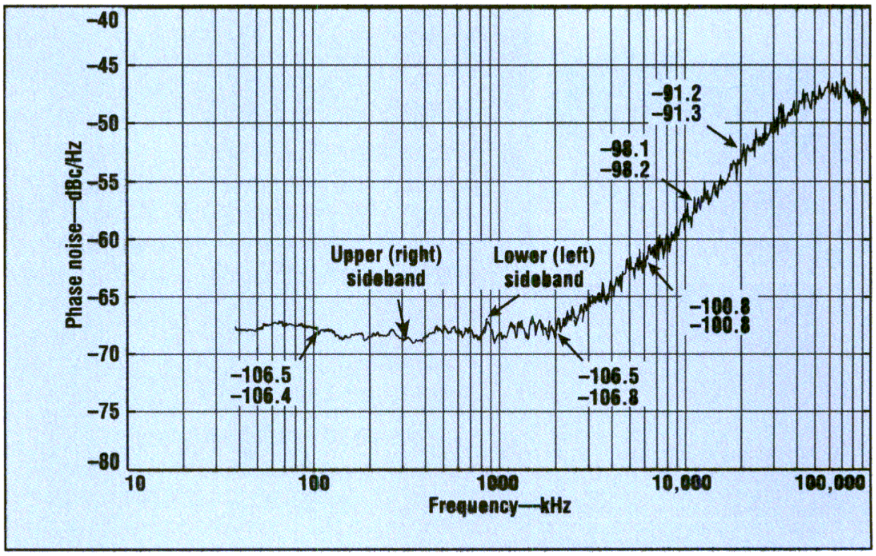
slope, which creates a flat area for the closed-loop phase noise. The close-in noise level is excellent and there is no spurious content. When the same setting is applied with the MASH111 structure, the results are somewhat different (Fig. 7). In this case, the noise slope is 40 dB/decade below 200 kHz and 20 dB/decade above 200 kHz. The close-in noise level at a 10-kHz offset for the MASH111 structure is approximately 50 dB below that for the MASH11 structure and also below the thermal-noise level.

When the $\Sigma\Delta$ phase noise is not sufficiently suppressed by the loop, the linear approach will not correctly predict the noise/spurious performance due to the inherent VCO nonlinearity (a sinusoidal function). The nonlinear approach, based on Eq. 11, better predicts the closed-loop phase-noise spectrum. By using the same parameters, Figs. 8 and 9 were generated, showing the closed-loop phase-noise spectrum for the MASH11 and MASH111 structures, respectively. The upper and lower sidebands are shown in each case.

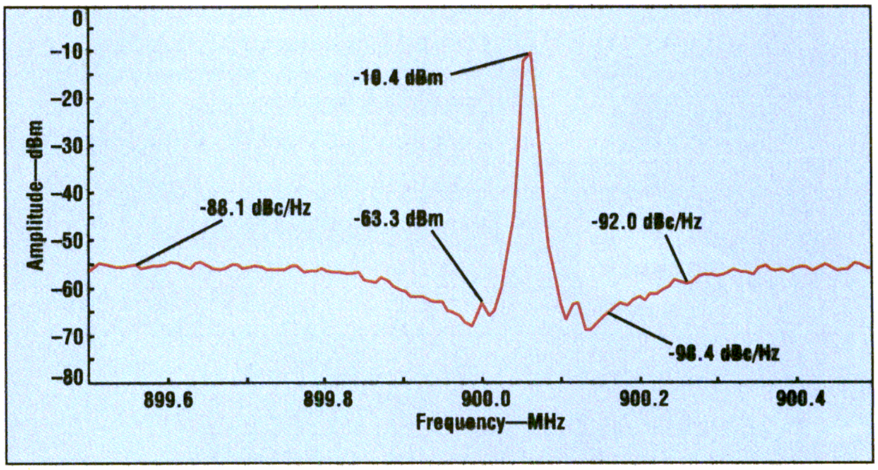
Huge differences are apparent when comparing the linear and nonlinear analysis approaches. With the MASH11 structure, there is a spur with magnitude of –53.2 dBc (in the right-hand sideband) and –53.7 dBc (in the left-hand sideband) at a frequency offset of 60 kHz, with a knee occurring at an offset frequency of approximately 10 kHz. Below the knee, the phase noise remains flat at approximately –108 dBc/Hz instead of having a slope of 20 dB/decade. Compared to Fig. 5, the close-in noise performance degradation at 10 kHz is approximately 9 dB. For offset frequencies above 100 kHz, the linear and nonlinear analyses produce similar results. With the results for the MASH111 structure shown in Fig. 9, however, no spurious content is evident. However, the knee frequency is higher than that of the MASH11 structure, at an offset frequency of approximately 2 MHz. Compared to Fig. 7, the noise performance loss at a 10-kHz offset is 60 dB. The close-in noise at a 10-kHz offset with the MASH111 structure is approximately 3 dB above that with



8. The nonlinear closed-loop phase noise of a MASH11 frequency synthesizer is plotted here.



9. The nonlinear closed-loop phase noise of a MASH111 frequency synthesizer is plotted here.



10. This plot shows the carrier spectrum of an ideal model for a MASH11 fractional-N frequency synthesizer.

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Table 1: Comparing simulations and analysis (Figs. 8 and 10)

Phase noises	Analysis	Simulation	Spurs	Analysis	Simulation
at 100 kHz	−97.3 dBc/Hz	−98.4 dBc/Hz	At 60 kHz	−53.7 dBc	−52.9 dBc
at 200 kHz	−89.9 dBc/Hz	−92.0 dBc/Hz			
at 500 kHz	−88.0 dBc/Hz	−88.1 dBc/Hz			
at 5 MHz	−89.9 dBc/Hz	−91.1 dBc/Hz			
at 10 MHz	−94.9 dBc/Hz	−96.1 dBc/Hz			

MASH11 when analyzed with the nonlinear approach. Therefore, nonlinear analysis applied to a perfect circuit configuration suggests that the MASH111 structure may not outperform MASH11 in close-in noise performance.

Generally speaking, idle tones or spurious signals appear when the phase noise is correlated. However, only when such a correlation interacts with the inherent VCO nonlinearity or other nonlinearities, can spurious generation occur. For the MASH11 structure, the spurious location is proportional to the fractional-dividing ratio. Thanks to noise shaping and loop-filter attenuation, a fractional-dividing ratio of approximately 0 or 1 tends to make the spurious levels obvious while they become less visible as the ratio approaches 0.5. Since the MASH111 structure has a higher noise power at high frequencies than the MASH11 structure with the same loop filter, the effect of folding back is worse for the MASH111 configuration. This is clearly evidenced with the greater knee frequency and greater degradation of the close-in noise performance. Nevertheless, the VCO nonlinear effect can be sufficiently reduced if the loop filter's bandwidth is narrow enough. When this happens, the linear and nonlinear analysis approaches produce similar results.

Simulations were performed to verify the noise-prediction approaches presented above. The simulation is functionally equivalent to a synthesizer circuit. Figure 10 shows an averaged carrier-spectrum measurement with a 7.6-kHz resolution bandwidth when the MASH11 structure is used. The VCO's nominal power is –3 dBm and only positive frequencies are counted in the measurement. A spurious level of –52.9 dBc at the 60-kHz offset is even with an ideal circuit design. This is the same spur predicted in Fig. 8 with a magnitude of –53.7 dBc, which shows a strong correlation between theory and computer simulation (see Table 1).

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Transmitter And Receiver ICs Run On ISM And SRD Bands

These transmitter and receiver ICs are ideal for a wide range of low-cost, low-power unlicensed wireless applications from 300 to 950 MHz.

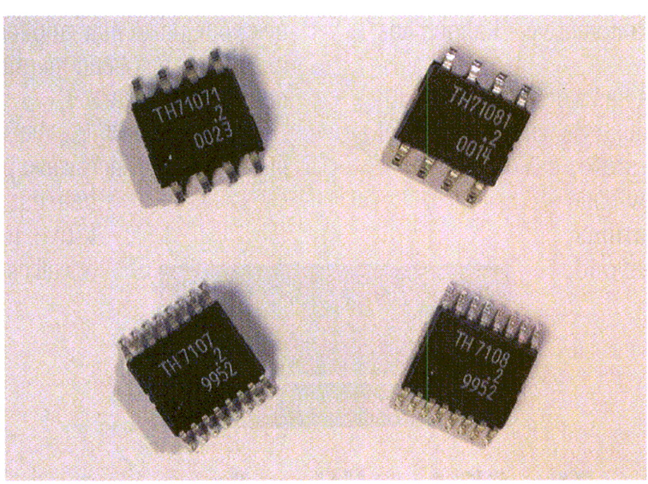
JACK BROWNE
Publisher/Editor

IMAGES of wireless technology usually include cellular telephones operating within the tightly licensed bands at 900 and 1800 MHz. Many wireless applications, however, are not licensed, working within allotted bands such as the industrial-scientific-medical (ISM) and short-range-devices (SRD) bands. In support of these applications, which include wireless remote keyless entry (RKE) for vehicles, remote tire-pressure control, alarm systems, security monitoring, telemetry, garage-door openers, baby monitors, and wireless door bells, Melexis, Inc. (Concord, NH and Erfurt, Germany) has developed lines of low-cost RF transmitters (Txs) and receivers (Rxs) for use from 300 to 950 MHz. These low-cost bipolar-complementary-metal-oxide-semiconductor (BiCMOS) RF devices feature transmit-current consumption of 5 to 13 mA and Rx current consumption of 6.5 to 9.0 mA, making them ideal for a wide range of commercial and consumer wireless products.

The Tx integrated circuits (ICs) offer adjustable differential or single-ended output-power levels from −18 to +3 dBm, depending upon model (see table), and a fully integrated phase-locked-loop (PLL) synthesizer for good frequency stability. They feature automatic power-amplifier (PA) turn-on after PLL lock, do not require external RF oscillator components, and offer good frequency stability over temperature and power-supply variations.

The Txs (Fig. 1) can be divided into two groups. The lower-frequency Txs operate in the 300-to-480-MHz range. Model TH7107 features a differential open-collector output optimized to drive a balanced RF load, such as a printed-circuit-board (PCB) loop antenna. It can be used in frequency-modulation (FM), frequency-shift-keying (FSK) modulation, as well as amplitude-shift-keying (ASK) modulation systems. Model TH71071 features the same balanced RF output, but has been designed for either ASK or continuous-wave (CW) operation only. Model TH71072 has a single-ended RF output and a microcontroller clock output.

The higher-frequency models TH7108, TH71081, and TH71082 (see table) have been designed for applications from 850 to 950 MHz. Model TH7108, with a differential open-collector output for driving a balanced RF load, is designed for FM, FSK, and ASK. Model TH71081 also has the balanced RF output, but is designed for CW or ASK use. Model TH71082 has a single-ended RF output and a microcontroller clock output.



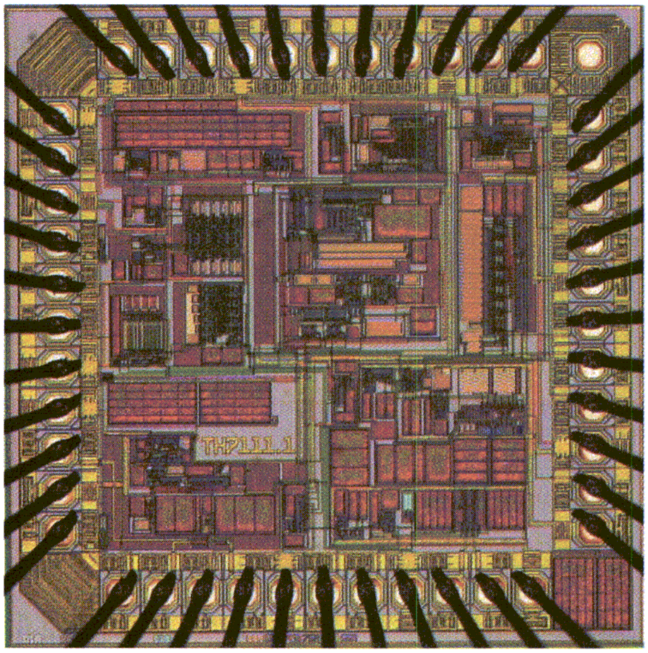
1. The TH710xx series of Tx ICs are available in two frequency bands from 300 to 950 MHz in SOP-8 and SSOP-16 housings.

In general, the Tx ICs are designed for operating voltages from +2.0 to +5.5 VDC, with typical supply currents of 5 to 12 mA and typical current consumption of less than 100 nA in standby mode. The Txs are supplied in eight-pin surface-mount SOP-8 packages, with the exception of the model TH7107 and TH7108, which are supplied in a 16-pin SSOP housing. The Txs are designed for operating temperatures from –40 to +85°C.

The TH710xx Tx ICs, which are fabricated with a 0.8-μm silicon (Si) BiCMOS process, combine flexibility with high levels of circuit complexity. Compared to so-

lutions based on surface-acoustic-wave (SAW) resonators, the TH710xx PLL-based Txs offer substantially more frequency stability. While SAW-based solutions are limited to the operating frequency bands covered by the SAW resonators, the TH710xx series of Txs can be easily reconfigured for another output frequency just by changing the crystal frequency.

The companion Rx ICs enable designers to perfectly match their RF system requirements for each application's frequency range, modulation scheme, blocking, and channel requirements. The models TH7110 through TH71112 Rx ICs are designed for use in the unlicensed ISM and SRD bands from 300 to 950 MHz with operating flexibility similar to that of the Tx ICs.



2. The TH711xx series of Rx ICs are fabricated with a reliable 0.6-μm Si BiCMOS semiconductor process.

The Rx ICs can be used in single-channel, single-conversion designs as well as single-channel, double-conversion designs. The Rxs can handle most modulation schemes used in modern low-power Rxs, including FSK, FM, and ASK. For FM and FSK applications, designers have a choice of phase-coincidence or more advanced PLL demodulator-type techniques. ASK demodulation is achieved by a received-signal-strength-indication (RSSI) data-slicer circuit. In addition, an automatic-frequency-control (AFC) circuit can be configured in case the RF input signal suffers from wide carrier-frequency tolerances, as is the case with some non-PLL Txs.

As with the Txs, the Rx ICs can be divided into 310-to-480-MHz models and 800-to-950-MHz models. Models TH7110, TH71101, and TH71102 operate in the lower-frequency band with supply voltages from +2.2 to +5.5 VDC and supply currents from 6.5 to 7.8 mA. These Rx ICs achieve signal sensitivity of –112 dBm in a 26-kHz channel bandwidth. Models TH7110 and TH71102 are designed for double-conversion use while model TH71101 is geared for single-conversion superheterodyne Rx architectures. The Rx ICs can handle maximum input signals to –2 dBm.

The higher-frequency Rx ICs, models TH7110, TH71111, and TH71112, operate with typical supply currents ranging from 7.6 to 9.0 mA at supply voltages of +2.2 to +5.5 VDC. These ICs and the three lower-frequency Rx IC models, feature a standby-current consumption of less than 50 nA. Models TH7111 and TH71112 are designed for double-conversion use while model TH71111 is aimed at single-conversion superheterodyne Rx architectures. The Rx ICs feature slightly less sensitivity than their lower-frequency counterparts, at –110 dBm in a 26-kHz bandwidth. The higher-frequency models are designed to handle input signal levels up to 0 dBm.

The USM/SRD transmitter/receiver ICs at a glance

Model	Function	Frequency range	RF output/ sensitivity
TH7107	Transmitter	310 to 480 MHz	–12 to +3 dBm
TH71071	Transmitter	310 to 480 MHz	–12 to +3 dBm
TH71072	Transmitter	310 to 480 MHz	–14 to 0 dBm
TH7108	Transmitter	800 to 950 MHz	–16 to +1 dBm
TH71081	Transmitter	800 to 950 MHz	–16 to +1 dBm
TH71082	Transmitter	800 to 950 MHz	–18 to –3 dBm
TH7110	Receiver	310 to 480 MHz	–112 dBm at 26-kHz BW
TH71101	Receiver	310 to 480 MHz	–112 dBm at 26-kHz BW
TH71102	Receiver	310 to 480 MHz	–112 dBm at 26-kHz BW
TH7111	Receiver	800 to 950 MHz	–110 dBm at 26-kHz BW
TH71111	Receiver	800 to 950 MHz	–110 dBm at 26-kHz BW
TH71112	Receiver	800 to 950 MHz	–110 dBm at 26-kHz BW

All of the Rx ICs are fabricated with a 0.6-μm BiCMOS process (Fig. 2). They share low spurious-emission levels that are less than –70 dBm. In conjunction with an RF front-end filter, the Rxs can achieve more than 65-dB image rejection. The models with multichannel option, TH7110 and TH7111, are supplied in 44-pin surface-mount LQFP44 housings while the single-channel, low-cost Rx ICs are supplied in 32-pin surface-mount LQFP32 packages. All of the Rx ICs are designed for operating temperatures ranging from –40 to +85°C. P&A: $1.50 and up (100,000 qty.). **Melexis, Inc., 41 Locke Rd., Concord, NH 03301; (603) 223-2362, FAX: (603) 223-9614, Internet: http://www.melexis.com.**

For more information, visit www.mwrf.com

Broadband Fixed Wireless Transceiver Serves UNII Band

This RF head operates in the UNII band and is compatible with Cisco point-to-point routers for fixed wireless communications.

DON KELLER
Senior Editor

IN 1997, the Federal Communications Commission (FCC) established three frequency bands in the 5-GHz region, collectively called the Unlicensed National Information Infrastructure (UNII), to help schools and businesses connect to the Internet without incurring the expense of hardwiring. One of the main devices that makes up this new wireless infrastructure is the RF transceiver, which connects between the hardwired Internet and the antenna. When this transceiver is used in a point-to-point configuration, it is referred to as a "head" or "outdoor unit" (ODU). The model SX1115, produced by Watkins-Johnson (Palo Alto, CA), is a point-to-point ODU that operates in the 5.8-GHz UNII band (see figure).

The SX1115 is compatible with Cisco System's uBR7246/7223 router and connects the router and the site antenna. The transmit and receive signals sent between the router and the ODU operate at intermediate frequencies (IFs) that are combined onto a single cable using frequency-division duplexing (FDD), along with the 24-MHz reference signal and DC bias. The ODU provides the conversions necessary to operate at UNII frequencies.

The SX1115 ODU uses a duplexer to allow it to transmit and receive over different frequency bands, called subbands A and B. Either subband can be used for transmission or reception; when one subband is used for transmission, the other is used for reception. Two duplexers are available. For the model SF1119 duplexer, subband A ranges from 5.727 to 5.751 GHz and subband B ranges from 5.775 to 5.779 GHz. For the model SF1120 duplexer, subband A ranges from 5.751 to 5.775 GHz, and subband B ranges from 5.779 to 5.823 GHz.

The RF output power of the transmitter (Tx) portion of the transceiver can be adjusted in 1-dB steps from +5 to +25 dBm. Maximum VSWR is 2:1. Close-in spurious response (1 kHz to 1 MHz) is –50 dBc, inband narrowband spurious response is –40 dBc, and wideband spurious response is –44 dBc.

The SX1115 can transmit up to +25 dBm of RF power for point-to-point data communications.

The RF receiver (Rx) portion can tolerate a maximum input power level of –20 dBm. It has a gain of 32 ± 2 dB, and a gain-control attenuator that can be adjusted over a range of at least 25 dB with an accuracy of ±3 dB. Its maximum noise figure is 3.8 dB.

On the IF side of the transceiver (connected to the router), the Tx input operates at 324 ±6 MHz. Its cable-compensation attenuator can be adjusted in 1-dB steps from –3 to –15 dBm. Maximum VSWR is 2:1. The IF Rx operates at 420 ±6 MHz with a maximum VSWR of 1.75:1. Close-in spurious response (1 kHz to 1 MHz) is –50 dBc, narrowband spurious response is –50 dBc, and maximum wideband spurious response is –44 dBc.

The SX1115 has four female connectors. One of the type-N connectors is for the RF antenna; the other is for the cable that carries the IF signal, the 24-MHz reference signal, and the DC bias. The mono phono jack is for antenna alignment, and the "lemo" jack carries the signals used to control the ODU and to monitor its status.

The transceiver can operate at voltages from –33 to –60 VDC (–48 VDC nominal) and draws a maximum of 5.55 A. It is encased in an aluminum (Al) heat-sink housing with overall measurements of 14.7 × 9.5 × 6.69 in. (37.34 × 24.13 × 16.99 cm). **Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, CA 94304-1223; (800) 951-4401, FAX: (650) 813-2447, Internet: http://www.wj.com.**

For more information, visit www.mwrf.com

FEC Chips

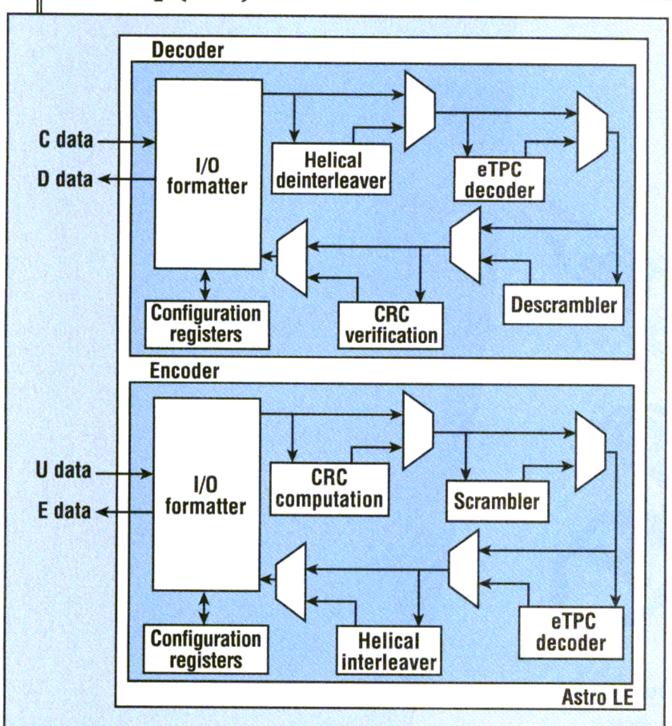
Error-Correction ICs Bolster Wireless Internet Access

These forward-error-correction chips offer designers numerous options for upgrading wireless system performance at modest cost.

GENE HEFTMAN

Senior Editor

AFTER years of fixing the faulty bits in high-end data-communications systems, forward-error-correction (FEC) technology is moving into the mainstream with the introduction of a pair of low-cost FEC chips from Advanced Hardware Architectures (Pullman, WA), a 12-year-old fabless semiconductor company. The ICs are the Astro LE family with block sizes of 2 and 4 kb (see figure). With prices targeted at $5 per chip in large quantities for the 2-kb version, the company is promoting the devices as a way to improve the performance of wireless Internet access and wireless local loop (WLL) with advanced error-correction technology at low cost.



Separate and independent decoder and encoder sections are built into the Astro LE FEC devices from Advanced Hardware Architectures (the 2-kb block diagram is shown here and a 4-kb version is available).

The Astro LEs are single-chip turbo-product-code (TPC) FEC encoders/decoders capable of up to 35-Mb/s coded data rates and code rates from 0.25 to 0.95. The company's TPC is patented and is said to provide more than 3 dB of coding gain over other methods such as Reed-Solomon/Viterbi. The standard Reed-Solomon and the high-performance Reed-Solomon/Viterbi were supposedly the most-effective FEC techniques available.

Coding gain is a key parameter in the design of communications systems because it provides a designer with a range of options for increasing the capabilities of a system or decreasing its cost. Some options include reducing the required bandwidth, increasing the throughput, reducing transmitter (Tx) bandwidth by a factor of 2, increasing range by 40 percent, and reducing antenna size by 30 percent. Coding gain and increased bandwidth efficiency translate into cost savings in satellite applications where transponder costs are a direct function of the power and bandwidth used. A major application for Astro LE chips is in modems designed for high-speed wireless Internet access including point-to-multipoint terrestrial and satellite connections. They are also intended for power-line network access which supports home and business networks on standard electrical outlets.

The Astro LE devices incorporate an independent decoder and encoder and can operate in full- or half-duplex mode. The 2-kb version is for low-cost systems while the 4-kb version offers additional coding gain for less cost-sensitive applications.

Astro LE prototypes will be available in the first quarter of 2001 with volume shipment in July. P&A: $5.00 (1,000,000 qty.) for the 2-kb version. **Advanced Hardware Architectures, Inc., 2365 NE Hopkins Ct., Pullman, WA 99163-5601; (509) 334-1000, FAX: (509) 334-9000, Internet: http://www.aha.com.**

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Crystal-Clock Oscillator Reaches New Supply Low

It takes a supply voltage of only +1.8 VDC to power this family of low-power crystal-clock-oscillator integrated circuits.

GENE HEFTMAN

Senior Editor

SYSTEM designers of all stripes need new varieties of miniature, low-voltage, low-power components to design the portable and handheld products of today's communications and computing world. Making a contribution to this end in frequency-control devices is SaRonix (Menlo Park, CA) with its high-density complementary-metal-oxide-semiconductor (HCMOS) crystal-clock-oscillator integrated circuit (IC) that is available in two types of small packages and runs from a nominal supply voltage of +1.8 VDC. Supply voltages for logic and other devices have fallen over the years from the once-standard +5.0 to +3.3 VDC and are heading toward +2.0 VDC or less.

The crystal-clock ICs are supplied in a metal-package version (NTH series) and in a leadless ceramic surface-mount package (S1612 series) for pick-and-place surface-mount-technology (SMT) manufacturing environments (see figure). The NTH package is a half-size, four-pin, through-hole mount, metal dual-in-line package (DIP) that addresses the needs of system developers who prefer leaded devices that fit sockets on their development boards. The same functionality is provided in the 5 × 7 × 1.9-mm high ceramic package with gold (Au)-plated contact pads.

NTH-type oscillators cover a frequency range of 20 to 70 MHz while the S1612 devices are rated for 40 to 70 MHz. Two ranges of frequency stability are available: ±50 PPM and ±100 PPM. Each is specified over all conditions of the operating-frequency range—calibration tolerance, operating temperature, input voltage change, load change, aging (one year at 25°C ambient operating temperature), shock, and vibration. The operating-temperature range for both package types is 0 to 70°C.

The recommended supply voltage is +1.8 VDC, ± 5 percent. Supply current is a maximum of 6 mA for operation between 20 and 50 MHz and 10 mA maximum for the 50-to-70-MHz range. The devices have a three-state function that enables the frequency-output pin to go into a high-impedance state. Rise and fall times are a maximum of 2.5 ns. Period jitter specifications are a maximum of 8 ps for the NTH series and 10 ps for the S1612 series.

The demand for low-voltage, low-power components is driven by three technical factors—lower power consumption to extend battery life in portable products, the need to reduce heat generation in components resulting from faster clock speeds, and the evolution to lower breakdown voltages resulting from finer-line geometries in ICs. Typical applications for the oscillators involving these factors are microprocessor-based systems such as notebook and palmtop computers, Personal Computer Memory Card International Association (PCMCIA) cards, or any battery-operated SMT product. **SaRonix, 141 Jefferson Dr., Menlo Park, CA 94025; (650) 470-7700, FAX: (650) 462-9894, e-mail: saronix@saronix.com, Internet: http://www.saronix.com.**

Two different package styles are available in SaRonix's line of +1.8-VDC crystal-clock-oscillator ICs. The metal DIP is for development applications while the surface-mount type is for end-product use.

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Surface-Mount Attenuators Tune Levels To 5 GHz

These compact analog voltage-variable attenuators provide linear attenuation as a function of voltage with low insertion loss and negligible phase-shift variations.

JACK BROWNE

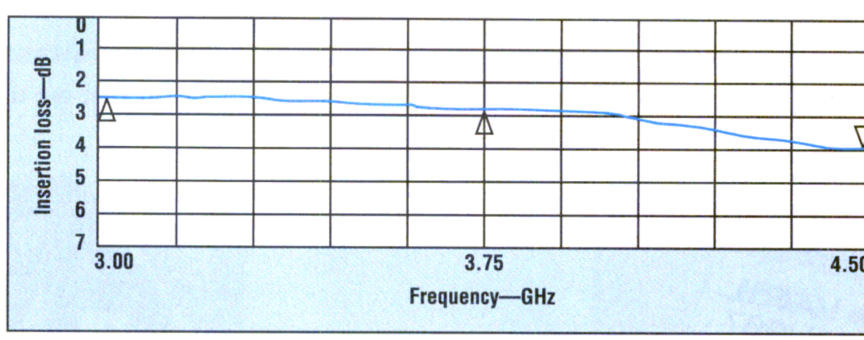
Publisher/Editor

ATTENUATORS are essential in high-frequency systems for controlling signal levels. In many ways, they are the perfect companion components to phase shifters, especially in communications systems that rely on precise amounts of phase and amplitude to create digital modulation formats, such as quadrature-amplitude modulation (QAM) and quadrature-phase-shift-keying (QPSK) modulation. For designers in need of compact surface-mount attenuators for use with phase shifters or other applications, the Commercial Products Group of SV Microwave (Largo, FL) offers several lines of analog voltage-variable attenuators (VVAs) covering bands from 30 MHz through 5 GHz. The components are available with minimum attenuation ranges of 15 and 30 dB.

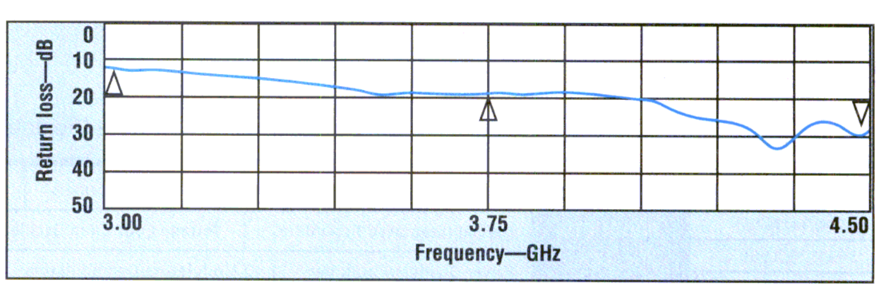
The miniature surface-mount attenuators are ideal companions for the company's line of surface-mount phase shifters (see *Microwaves & RF*, May 2000, p. 210). Similar to the phase shifters, the attenuators are supplied in six-lead surface-mount-technology (SMT) packages measuring 0.6 × 0.38 × 0.2 in. (1.52 ×0.97 × 0.51 cm). They do not require DC bias voltages; rather, attenuation is adjusted by means of standard 0- to +5-VDC control voltages. DC current is typically less than 10 mA at +5-VDC control voltage.

A typical model for applications from 3550 to 4000 MHz, model VA382A-35A, is rated for minimum attenuation of 30 dB, although the unit typically provides more than 40-dB attenuation with a control voltage of +5 VDC. The typical insertion loss is rated as 2.8 dB, with a maximum rating of 3.5 dB (Fig. 1). The VVA is rated for a typical return loss of 18 dB, with a minimum rating of 12 dB (Fig. 2). The applied attenuation features little penalty in phase shift, since the VA382A-35A suffers phase shift versus attenuation of 1 deg/1 dB. The model VA382A-35A VVA is rated for a nominal maximum RF input power of 0 dBm. The minimum third-order intercept point (IP3) is +35 dBm with two 0-dBm input tones; the typical performance is closer to +40 dBm. **SV Microwave, Commercial Products Group, 7247 Bryan Dairy Rd., Largo, FL 33777; (727) 541-5800, FAX: (727) 541-5869, e-mail: salescpg@svmicro.com, Internet: http://www.svmicrowave.com.**

For more information, visit www.mwrf.com



1. Measured insertion loss for the VA382A-35A VVA is rated as typically 2.8 dB from 3550 to 4000 MHz, with a maximum value of 3.5 dB.



2. Measured return loss for the VA382A-35A VVA is rated typically as 18 dB with a minimum rating of 12 dB.

DC Block Provides Broadband Voltage Protection Through 50 GHz

This rugged coaxial DC block provides a good measure of protection while keeping VSWR and insertion loss tightly controlled.

JACK BROWNE
Publisher/Editor

PROTECTION against DC energy flowing through sensitive RF components is a major concern for designers of receivers and test equipment. With the growing use of millimeter-wave frequencies for such applications as optical networking, line-of-sight communications links and RF identification (RFID), protection against unwanted DC energy becomes an even greater concern, given the cost of components at millimeter-wave frequencies. Fortunately, the model 8535E from Inmet Corp. (Ann Arbor, MI) is an extremely broadband DC block developed for such DC protection in millimeter-wave designs. The rugged DC block operates from nearly DC through 50 GHz using 2.4-mm connectors to link to associated hardware.

A DC block is essentially a capacitor in series with a transmission line. The capacitor prevents the flow of DC energy while allowing a broad range of RF signals to pass, ideally with only nominal attenuation. The trick in designing a high-performance DC block such as the 8535E (Fig. 1) is to select a capacitor with high-enough voltage rating that also exhibits a high self-resonance frequency.

Obviously, the correct choice in capacitors was made in the 8535E. The broadband coaxial DC block provides a high level of DC protection with minimal sacrifice in RF performance. The component is rated for DC voltages up to +30 VDC, yet features less than 1-dB insertion loss through 32 GHz. The insertion loss through 50 GHz is still less than 1.25 dB (Fig. 2). Similarly, the voltage-standing-wave-ratio (VSWR) performance is as impressive, reaching a maximum of 1.20:1 for frequencies through 32 GHz and a maximum of 1.60:1 for signals from 32 to 50 GHz. The return-loss performance is better than 25 dB at 10 GHz, better than 23 dB at 32 GHz, and almost 20 dB at 50 GHz.

The 50-Ω DC block is manufactured with gold (Au)-plated beryllium copper (BeCu) and is supplied with 2.4-mm coaxial connectors. It is rated for operating temperature from −35 to +85°C. **Inmet Corp., 300 Dino Dr., Ann Arbor, MI 48103; (888) 244-6638, (734) 426-5553, FAX: (734) 426-5557, e-mail: sales@inmetcorp.com, Internet: http://www.inmetcorp.com.**

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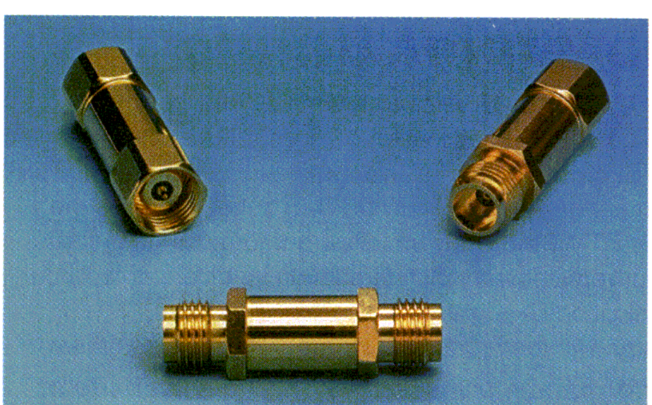
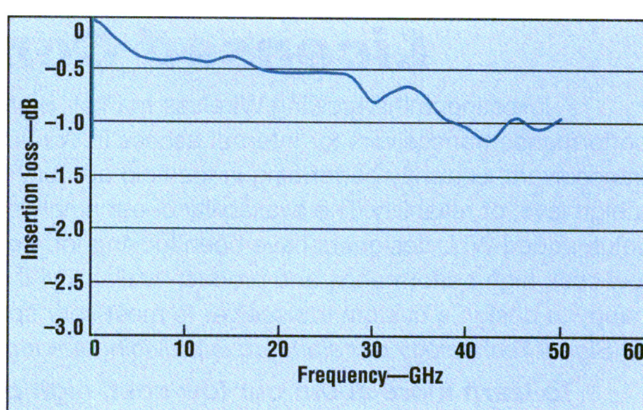
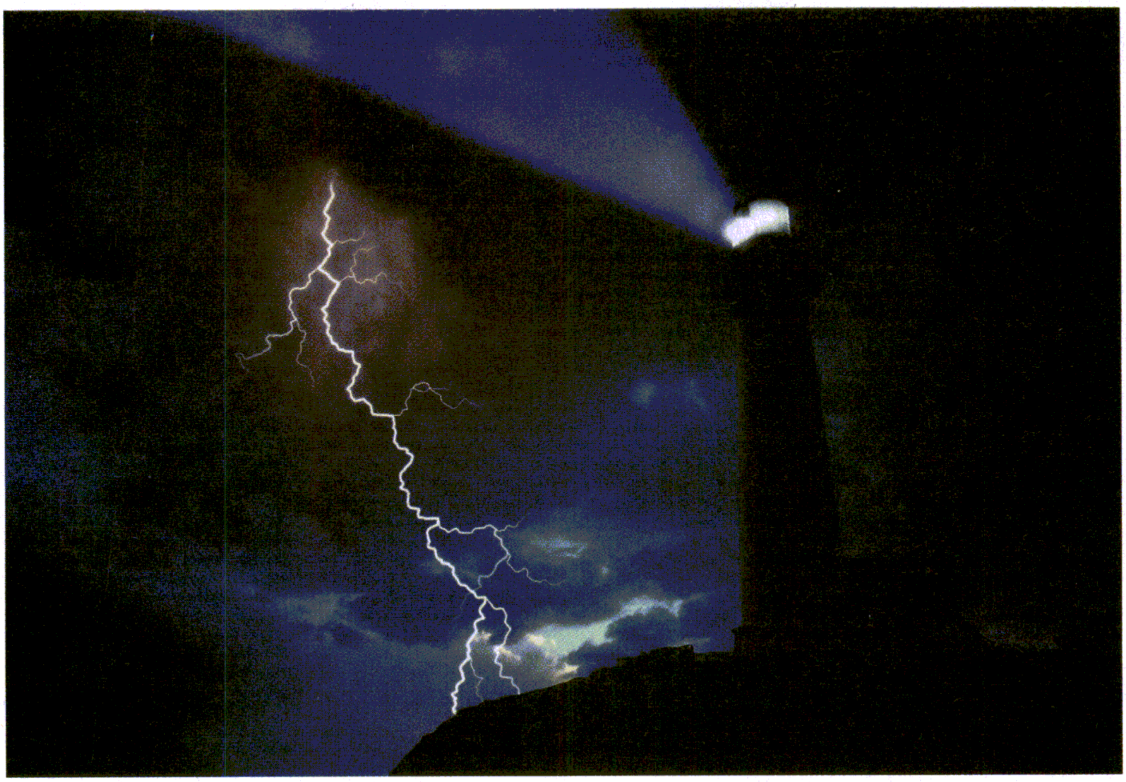


1. Model 8535E is an extremely broadband coaxial DC block capable of passing RF signals with minimal loss through 50 GHz.



2. The measured insertion-loss performance of the 8535E DC block exceeds the specified value of 1.5 dB at 50 GHz.



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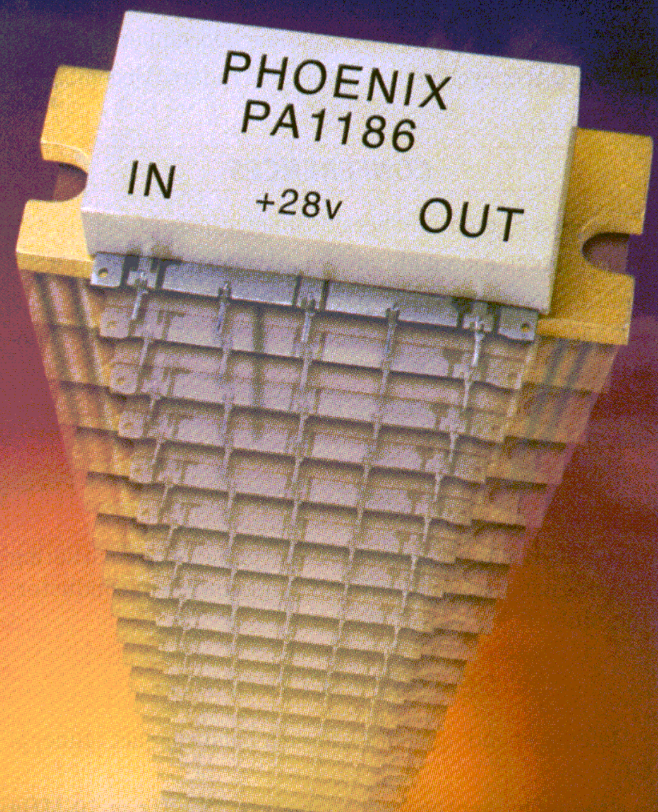

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Gain (dB.)	29.0	26.0	25.0	25.0	23.0
Pout @ 1 dB. comp. (dBm.)	38.0	38.0	37.5	37.5	37.5
Noise Figure (dB.)	2.4	2.7	3.0	3.0	3.0
ACPR (30kHz BW)*	-50.0	-54.0	-47.0	-47.0	-47.0
VSWR (Input/Output)	1.5:1/2:1	1.5:1/2:1	1.5:1/2:1	1.5:1/2:1	1.5:1/2:1
IP3 (two tone)**	+56.0	+54.0	51.0	51.0	51.0
Supply Required	+28/1000	+28/1000	+28/1000	+28/1000	+28/1000

* ±850kHz from fc at power level of 30 dBm. (IS-95)
** IP3 measured with 2 tones @ +25dBm. per tone

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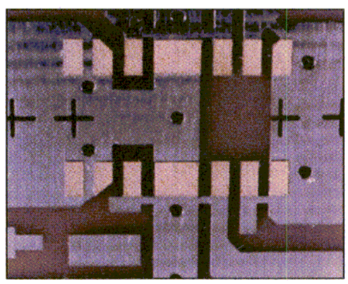

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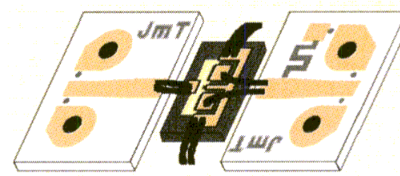

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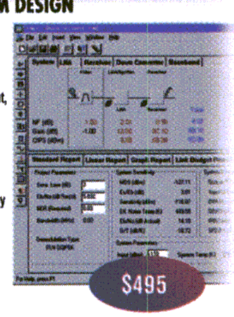

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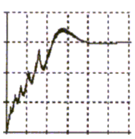

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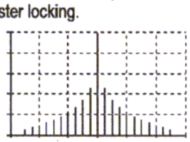

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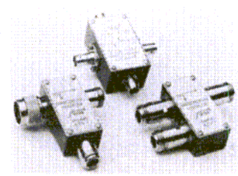

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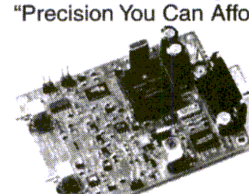

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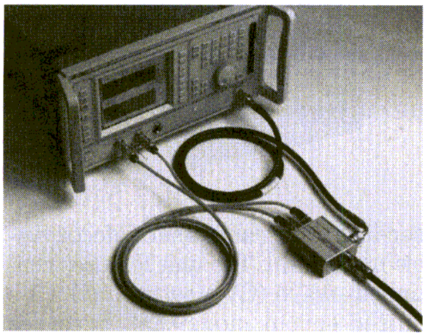


unskilled operators can simply and precisely perform complex or repetitive measurements. The software enables the instruments to be customized for short-run production measurements on components, assemblies, as well as subsystems. **IFR Systems, Inc.; 10200 West York St., Wichita, KS 67215-8999, (800) 835-2352, (316) 522-4981, e-mail: info@ifrsys.com, Internet: http://www.ifrsys.com.**

Switch simplifies PCB layout complexity

The model AS196-307 is a high-isolation, nonreflective gallium-arsenide (GaAs) integrated-circuit (IC) switch with driver. Operating over the DC-to-6-GHz band, the unit is suitable for Global System for Mobile Communications (GSM), personal-communications-services (PCS), digital communications services (DCS), and base-station synthesizer switching with 55-to-60-dB isolation from 0.5 to 2.5 GHz. The switch offers single +3- or +5-VDC control with an integrated silicon (Si) driver. **Alpha Industries, 20 Sylvan Rd., Woburn, MA 01801; (781) 935-5150, FAX: (617) 824-4564, Internet: http://www.alphaind.com.**

Amplifier covers 150 to 2500 MHz

The model Rf2367 code-division-multiple-access/time-division-multiple-access/Global System for Mobile Communications power amplifier (CDMA/TDMA/GSM PA) driver amplifier spans the frequency range of 150 to 2500 MHz and is optimized for operation in the digital-communications-services (DCS) and personal-communications-services (PCS) bands (1700 to 2000 MHz) for applications where low-transmit noise power is of concern. The unit operates from a single +3-VDC (+2.5- to +6.0-VDC) power supply and features an adjustable bias current. The device's performance at 1880 MHz includes 21.5-dB gain, +24-dBm output third-order intercept point (IP3), and a 2.2-dB noise figure. **RF Micro Devices, 7625 Thorndike Rd., Greensboro, NC 27409-9421; (336) 664-1233, FAX: (336) 664-0454, Internet: http://www.rfmd.com.**

VCO generates frequencies from 1295 to 1385 MHz

The model CLV1350E is a voltage-controlled oscillator (VCO) that generates frequencies between 1295 and 1385 MHz within +0.5 to +4.5 VDC of control voltage with an average tuning sensitivity of 36 MHz/V. The device boasts a typical spectral signal of –109 dBc/Hz, at 10 kHz from the carrier while attenuating the second harmonic to better than –12 dBc. The unit's 1.1:1 linearity over frequency and temperature supports quick implementation into phase-locked loops (PLLs) where the error voltage can be taken directly from the integrated circuit's (IC's) charge-pump circuitry. The VCO operates from a +5-VDC source while drawing only 26 mA, typically, and it is designed to operate over the extended commercial temperature range of –40 to +85°C. **Z-Communications, Inc., 9939 Via Pasar, San Diego, CA 92126; (858) 621-2700, FAX: (858) 621-2722, e-mail: sales@zcomm.com, Internet: http://www.zcomm.com.**

Attenuator offers 23-dB return loss

Model VA182B-36C2 is a low-loss, surface-mount, analog-voltage variable attenuator designed to operate from within the digital-communications-services (DCS) receive band. The attenuator was designed for feedforward and multicarrier power-amplifier (PA) applications. The attenuator boasts superior attenuation flatness, a return loss of better than 23 dB typical across the entire attenuation range. Phase shift versus attenuation is less than 1 deg. per decibel, and third-order intercept point (IP3) is better than +45 dBm over a 20-dB minimum attenuation range. Attenuation is achieved with a control voltage from 0 to +5 typically, with less than 20 mA and no DC bias required. **SV Microwave, 7247 Bryan Dairy Rd., Largo, FL 33777; (727) 541-5800, FAX: (727) 541-5869, Internet: http://www.svmicrowave. com.**

Filters suit wireless markets

The MPC series is a line of highly stable filters that are for use in wireless and telecommunications market applications. The filters boast a center frequency of 881.5 MHz and a bandwidth of 25 MHz. The insertion loss is 2.6 dB maximum, with an attenuation of –12 dB at 849 and 914 MHz. **Spectrum Control, Inc., 8031 Avonia Rd., Fairview, PA 16415; (814) 835-1650, FAX: (814) 835-1651.**

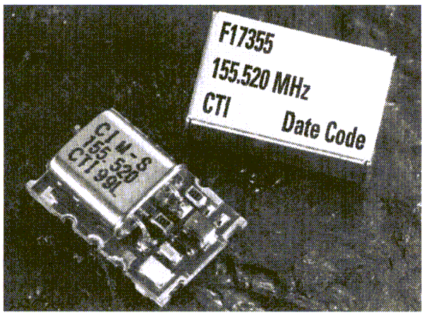
Power dividers operate to +125°C

A family of stripline power dividers includes 2-way, 4-way, and 8-way configurations. The models MDC2200 and MDC2400 provide 2- and 4-way division, respectively, from 0.5 to 18 GHz in octave and broadband models. The models—MDC2800 and MDC8PX00 are 8-way dividers covering the frequency range of 0.75 to 18 GHz, respectively, in narrow and broadband frequency ranges. **MIDISCO, 1707 Veterans Memorial Highway, Unit 32, Islandia, NY 11749-1581; (800) 637-4353, (631) 234-3505, FAX: (631) 234-3913, Internet: http://www.microwave_distributors.com/midisco.**

For more information, visit www.mwrf.com

VCXO outputs 155.52 MHz

Model F17355 is a surface-mount-technology (SMT), industry-compatible, positive-emitter-coupled-logic (PECL) voltage-controlled crystal oscillator (VCXO) that is powered by a +3.3-VDC supply voltage and has an



output frequency of 155.52 MHz. The unit features a frequency stability of ±30 PPM at –10 to +70°C and ±50 PPM at –40 to 85°C. The VCXO also provides a minimum deviation of ±60 PPM, low jitter characteristics of 1 ps root mean square (RMS) typical, and rise/fall times of less than 450 ps. **Champion Technologies, Inc., 2553 N. Edgington St., Franklin Park, IL 60131; (800) 888-1499, Internet: http://www.champtech.com.**

Diplexer filters UMTS signals

The model W2446D is a miniature intermodulation-distortion (IMD)-free diplexer that filters Universal Mobile Telecommunications System (UMTS) signals. Designed for video reception and transmission in the UMTS band, the unit's operating temperature is –40 to +70°C. Insertion loss is 1 dB at a 60-MHz digital-communication-services (DCS)/UMT bandwidth (2110 to 2170 MHz). Two standard +43-dBm input test signals produce less than –100 dBm of IMD signals. **Wireless Technologies Corp., 1009 Shaver St., Springdale, AR 72762; (501) 750-1046, FAX: (501) 750-4657, e-mail: wireless@ipa.net, Internet: http://www.duplexers.net.**

Coupler targets 800 to 2500 MHz

The model 100-AC-FFN-20 is a 100-W coupler with a frequency range of 800 to 2500 MHz that couples at 20 dB with a directivity of 20 dB minimum, making it ideal for cellular and personal-communications-services (PCS) applications. The operating temperature extends to 105°C, while insertion loss is 0.25 dB (excluding coupled power) and 0.3-dB through line. **Bird Component Products, 10950 72nd St. N., Suite 107, Largo, FL 33777-1527; (727) 547-8826, FAX: (727) 547-0806, e-mail: sales@birdfla.com, Internet: http://www. birdfla.com.**

Cable offers 2.3-dB loss factor

The KW800 is a line of flexible cable that is specifically designed to provide extra performance margins for applications with demanding specifications. The cable boasts a loss factor of 2.2 dB/100 ft. at 1 GHz and can be formed by hand into a 4-in. (10.16 cm) diameter loop without the need for special mandrels or bending apparatus. **Semflex, Inc., 5550 E. McDowell Rd., Mesa, AZ 85215; (800) 778-4401, (480) 985-9000, FAX: (480) 985-0334, Internet: http://www.semflex.com.**

Gaskets provide 100-dB shielding

The models SNK 45 and SNG 55 are single-component, silicone (Si)-based, automated form-in-place electromagnetic-interference (EMI) gaskets. The gaskets are filled with proprietary conductive particles and provide shielding effectiveness of greater than 100 dB at 1 GHz. The gaskets do not have to be mixed, enabling them to shorten production cycles and reduce waste. They adhere to a variety of materials. **Instrument Specialties, Shielding Way, P.O. Box 650, Delaware Water Gap, PA 18327-0136; (570) 424-8510, FAX: (570) 424-6213, e-mail: info@instr.com, Internet: http://www.instr.com.**

Visual fault finder identifies bending losses

The model 263MT visual fault finder aids in quickly identifying breaks and bending losses in fiber-optic cables terminated with MT-RJ small-form-factor (SFF) duplex connectors. A powerful 0-dBm (1-mW) 635-nm red laser launched into the fibers makes breaks,

bending losses, and other defects visible up to 1 km. The unit features continuous-wave (CW) output and a 1-s pulsed output mode that increases viewing contrast in difficult lighting conditions. **RIFOCS Corp., 1340 Flynn Rd., Camarillo, CA 93012; (805) 389-9800, FAX: (805) 389-9808, e-mail: sales@rifocs.com, Internet: http://www. rifocs.com.**

Synthesizer features low distortion

The model AN2050A-NARB is a nonarbitrary waveform synthesizer suitable for hard-disk-drive (HDD) industry needs. The synthesizer features an integrated thermal asperity generator, which enables the waveform data to maintain 8-b resolution through most of the data pattern. The accuracy of an 8-b digital-to-analog converter (DAC), followed by a 12-b variable gain stage, allows very-small amplitude variations to be studied while the DAC operates at full range. The unit's sampling clock operates at 2.4 GHz, producing an 800-Mb/s waveform with 3×oversampling or 1.2 Gb/s at 2× oversampling. The 850-MHz bandwidth keeps distortion of the signal at high data rates to a minimum, enabling input to be easily varied in order to investigate performance and yield effects in the channel around Monte Carlo distributions, rather than a single waveform. **Analogic Corp., 8 Centennial Dr., Peabody, MA 01960; (978) 977-3000, e-mail: T&M_info@analogic.com, Internet: http://www.analogic.com.**

For more information, visit www.mwrf.com

VCO ranges to 5420 MHz

The model V940ME02 is a voltage-controlled oscillator (VCO) operating in the 5220-to-5420-MHz frequency range. Tuning voltage spans +0.5 to 4.5 VDC, the phase noise at 10 kHz offset is –83 dBc/Hz, harmonic suppression is –25 dBc, and power output is –1 ± 3 dBm. With a load impedance of 50 Ω, the maximum input capacitance is 50 pF, pushing is less than 10 MHz/V, pulling is less than 35 MHz, and operating temperature range is –30 to 85°C; supply voltage is +5 VDC. Applications include microwave radios, satellite communications, and direct broadcast. **Z-Communications, Inc., 9939 Via Pasar, San Diego, CA 92126; (858) 621-2700, FAX: (858) 621-2722, e-mail: sales@zcomm.com, Internet: http://www.zcomm.com.**

Rx operates to 0 dBm

Model AMT128503T56F is a small-form-factor (SFF) fiber receiver (Rx) that is designed for Gigabit Ethernet and fiber-channel fiber-optic network systems. The fiber receiver offers a typical sensitivity of –22 dBm with a minimum responsivity of 1000 V/W with a total power dissipation of approximately 120 mW. Operating from a +3.3-VDC supply, the device provides a minimum bandwidth of 1000 MHz and features an on-chip automatic-gain-control (AGE) circuit, enabling the unit to handle high optical input powers up to 0 dBm. The unit consists of a monolithically integrated metal-semiconductor-metal (MSM) diode and a transimpedence amplifier (TIA) integrated in a small TO-56 package. **ANADIGICS, 35 Technology Dr., Warren, NJ 07059-5148; (908) 668-5000, FAX: (908) 668-5132, Internet: http://www.anadigics.com.**

Rx boasts conversion gain of 475 V/W

The model R402HR is a PIN and Telecommunications Industry Association (TIA) optical receiver (Rx) boasts a conversion gain of 475 V/W (at 1550 nm). This fiber-optic pigtailed component serves the standard OC-192/STM-64 telecommunications market with sensitivity of –20 dBm and bandwidth of 30 kHz to 8 GHz. Featuring low ripples, low group delay, and low electrical return loss, the device provides designers of telecommunications systems with the signal level needed for driving filter, automatic gain control (AGC), or limiting amplifier stages. Circuit-board footprint is 13 × 18 mm. **Discovery Semiconductors, Inc., 186 Princeton-Hightstown Rd., Princeton Junction, NJ 08550; (609) 275-0011, FAX: (609) 275-4848, e-mail: sales@chipsat.com, Internet: http://www.chipsat.com.**

Coupler works to 2200 MHz

Model CK-55N is a directional coupler that operates across the 800-to-2200-MHz wireless frequency bands for use in in-building applications. The directional coupler unequally splits wireless carriers ranging up to 200 W to a secondary antenna feed or distribution cable. Main line loss has been minimized by using an air dielectric between silver (Ag)-plated conductors, resulting in passive intermodulation (PIM) that is less than –140 dBc. **Microlab/ FXR, 10 Microlab Rd., Livingston, NJ 07039-1682; e-mail: sales@microlab.fxr.com, Internet: http://www.microlab.com.**

Packaging technology reduces costs

Alpha-2 is a proprietary multichip module packaging technology. Alpha-2 modules reduce the cost of manufacturing high-speed and high-frequency data-communications equipment by replacing labor- and capital-intensive wirebonding with a surface-mounted package that is specifically designed for high-speed and high-frequency integrated circuits (ICs). Alpha-2 packaging is compatible with standard tape-and-reel manufacturing. These modules are suitable for high-speed data-communications equipment, such as local-multichannel-distribution-system (LMDS) wireless systems as well as OC-192 and future OC-768 high-speed fiber-optic systems. **Alpha Industries, 20 Sylvan Rd., Woburn, MA 01801; (781) 935-5150, FAX: (617) 824-4564, Internet: http://www.alphaind.com.**

Capacitors run to +150°C

The SPC is a series of surface-mount-device (SMD) capacitors that are manufactured of double-metalized PPS film. The capacitor series offers low electrostatic discharge (ESR) of less than 0.2 percent DF at 100 kHz, the ability to handle high-frequency AC currents, and excellent pulse-handling capability. The series is rated for +630 VDC (350 VAC) in capacitance values from 470 to 4700 pF. With an operating temperature up to +150°C, the capacitor series is well- suited for automotive electronics, including hybrid/ electric vehicles, snubbing and power-factor correction in SMPS, as well as other applications requiring the handling of pulse or high-frequency AC. **Evox Rifa, 300 Tri-State International, Suite 375, Lincolnshire, IL 60069; (847) 948-9511, FAX: (847) 948-9320, e-mail: service@evox-rifa.com, Internet: http://www.evox-rifa.com.**

Choke spans –40 to 125°C

A surface-mount toroidal-core transformer is characterized as a current-compensated choke with inductance values ranging from 11 to 4700 μH. The choke operates across the temperature range of –40 to 125°C and is suitable for applications including electromagnetic-interference (EMI) isolation in switching-mode power supplies as well as other line-filtering requirements. Measuring 8.5 × 6.0 × 4.5 mm in a pick-and-placeable liquid-crystal polymer plastic housing, the parts are supplied on carrier and reel. **Sprague-Goodman Electronics, Inc., 1700 Shames Dr., Westbury, NY 11590; (516) 334-8700, FAX: (516) 334-8771, e-mail: info@sprague-goodman.com.**

For more information, visit www.mwrf.com

Software Simulates Communications Systems

(CONTINUED FROM PAGE 160)

events and combined discrete and continuous events. Operators can model circuits with topologies that contain separate functional subblocks, including feedforward amplifiers, balanced amplifiers, modulators, demodulators, signal processors, as well as cable repeaters.

The libraries within RF Intercept consist of devices, instruments, signal processors, sources, and systems. The device library includes four amplifier models, attenuators, mixers, couplers, and power-divider modules. The instrument library includes a BER counter, a bitstream monitor, an eye-pattern plotter, a phase detector, and a spectrum analyzer.

RF Intercept offers versatile signal-processing functions, such as convolution, signal detection, sampling, and a phase-shift-keying (PSK) demodulator. Sources include amplitude-modulated (AM), phase-modulated (PM), and frequency-modulated (FM) generators, a random-number generator, and an impulse generator. Systems include an AM fiber-optic link and a channel-allocation module. The AM fiber-optic link can calculate the carrier-to-noise ratio (per channel) performance of a multichannel AM fiber-optic link as a function of optical loss. The model determines the optical transmitter's (Tx's) contribution, due to a laser's relative intensity noise (RIN), and the optical receiver's (Rx's) contribution (due to quantum limits and circuit noise) independently. The complete link performance is then determined by summing together all the independent noise-power components. A channel-allocation module simplifies the allocation of system frequencies free of mutual third-order intermodulation-distortion (IMD) interference.

The libraries within RF Intercept consist of devices, instruments, signal processors, sources, and systems.

An example of the functions contained in the software is a logarithmic/exponential compressor/expandor (compandor) module (see figure). The software makes it possible to perform a sensitivity analysis to show the variation in harmonic distortion as a function of input amplitude. The simulation in the figure is a logarithmic and exponential amplitude compressor and expander. The LOG compressor block is perfect. The EXP expander block deviates from its ideal complementary shape by 5 percent. A spectrum-analyzer block can be used in order to calculate harmonic distortion, while plotter and input/output (I/O) blocks can be used to show time-domain waveforms.

The software is provided with documentation and a host of useful examples (within RF Intercept and EXTEND). RF Intercept with EXTEND requires a computer with at least a Pentium or Pentium Pro microprocessor and Windows 3.1 or higher or Windows NT 3.5 or higher, 8 MB of random-access memory (RAM), and a minimum of 20 MB of available hard-disk memory. P&A: $1165.00 (including EXTEND); stock. **RHR Laboratories, 207 Harding Blvd. W., Richmond Hill, Ontario L4C 8X6, Canada; (905) 884-2392, FAX: (905) 884-6843, e-mail: 104673.3110@com puserve.com, Internet: http://www.rhrlaboratories.com.**

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ALAN ("PETE") CONRAD
Special Projects Editor

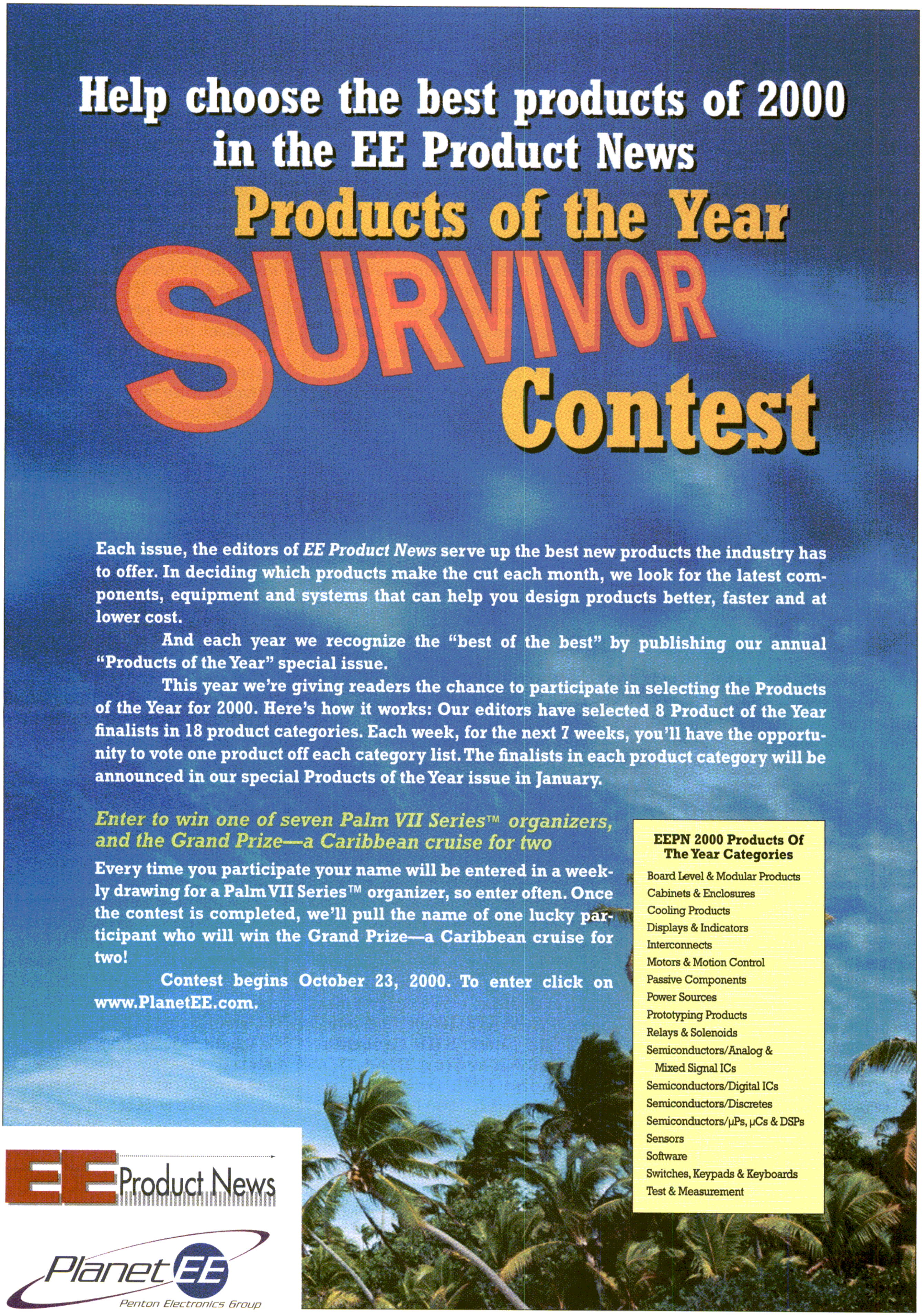
Resistors operate to +95°C

The DS1847 and DS1848 dual temperature-controlled NV-variable resistors incorporate temperature-compensation circuitry with dual variable resistors and electrically erasable programmable-read-only memory (EEPROM), enabling a higher level of precision in controlling laser intensity in optical transceivers. The units operate with either +3- or +5-VDC supplies within a temperature range of –40 to +95°C. Dual 256-position, linear taper resistors are used in optical transceiver modules to control current to vertical-cavity surface emitting lasers (VCSELs) or laser diodes. During operation, an integrated digital thermometer continuously measures temperatures, which are compared to resistance characteristics stored in on-chip EEPROM. As temperatures vary, the DS1847 and DS 1848 automatically compensate by precisely adjusting resistance. **Dallas Semiconductor, 4401 S. Beltwood Pkwy., Dallas, TX 75244-3292; (972) 371-4448, Internet: http://www.dalsemi.com.**

Divider/combiner spans 0.8 to 4.0 GHz

The model P6W-10-1 is a six-way broadband Wilkinson power divider/combiner offering multi-octave bandwidth and high reliability for test equipment. Frequency range is 0.8 to 4.0 GHz, VSWR input is 1.6:1 and output is 1.6:1, and maximum insertion loss is 1.45 dB. Typical isolation is 18 dB, intermodulation (IM) ranges from –100 to –135 dBc optional, and maximum amplitude balance is 0.5 dB. Applications include automated testing needs for RF, microwave, and wireless manufacturers. **Dow-Key Microwave, 4822 McGrath St., Ventura, CA 93003-7718; (805) 650-0260, FAX: (805) 650-1734, Internet: http://www.dowkey.com.**

For more information, visit www.mwrf.com



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And each year we recognize the "best of the best" by publishing our annual "Products of the Year" special issue.
This year we're giving readers the chance to participate in selecting the Products of the Year for 2000. Here's how it works: Our editors have selected 8 Product of the Year finalists in 18 product categories. Each week, for the next 7 weeks, you'll have the opportunity to vote one product off each category list. The finalists in each product category will be announced in our special Products of the Year issue in January.
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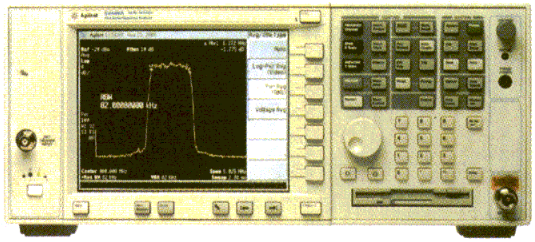
(continued from p. 178)
range, with maximum full-band insertion loss of 0.2 dB and maximum fullband VSWR of 1.25.

Another fundamental component that received a new look was the RF/microwave mixer. The engineering department at Mini-Circuits (Brooklyn, NY) unveiled a line of field-effect-transistor (FET)-based mixers designed for high IP3 performance.



3. Model E4440A is a 26.5-GHz spectrum analyzer that employs completely digital resolution-bandwidth filters.

An example of the new FET mixer line is the model HJK-21H, which operates with RF signals from 1850 to 1910 MHz and local oscillator (LO) signals from 2090 to 2150 MHz. It yields IF signals from 180 to 300 MHz and is designed for LO power levels of +17 dBm. The mixer exhibits a maximum conversion loss of 8.9 dB, with typical performance of 7.6 dB. The HJK-21H achieves typical input IP3 performance of +36 dBm. The LO-to-RF isolation is typically 28 dB, while the LO-to-IF isolation is typically 25 dB. The mixer, with return loss of typically better than 9 dB (Fig. 3), exhibits minimal change in return loss and isolation performance levels as a function of LO power.

Rather than develop a single component, Synergy Microwave (Paterson, NJ) chose to rethink the entire way that high-frequency components are designed, and developed a practical, three-dimensional (3D) multilayer approach called SYNSTRIP Technology. The new technology supports the fabrication of traditional high-frequency components, such as power dividers and mixers, in extremely compact configurations with excellent performance. SYNSTRIP Technology blends the best features of know planar transmission-line techniques, such as microstrip and stripline, using a "mixed-mode" propagation concept that allows a designer to distribute a circuit across different circuit layers with different transmission media. As a result, structures such as mixer baluns, can be miniaturized well beyond conventional circuit-fabrication techniques.

In the IC area, Silicon Laboratories (Austin, TX) demonstrated impressive integration with the Si4136, a synthesizer capable of operating from 2.0 to 2.6 GHz in support of IEEE 802.11 wireless local-area networks (WLANs) at 2.4 GHz. The chip also generates intermediate-frequency (IF) signals from 62.5 MHz to 1 GHz. It consists of three complete PLLs, with three on-chip voltage-controlled oscillators (VCOs), loop filters, reference and VCO dividers, and phase detectors. The phase noise at a 1-MHz offset from 2.4 GHz is –131 dBc/Hz.

Rx AND Tx ICs

Low-cost wireless applications were the driving force behind the development of a line of Rx and transmitter (Tx) ICs by Melexis, Inc. (Concord, NH and Erfurt, Germany). Costing as little as $0.75 in large quantities, these Rx and Tx ICs are ideal for a wide range of low-cost, low-power unlicensed wireless applications from 300 to 950 MHz, including wireless remote keyless entry (RKE) for vehicles, remote tire-pressure control, alarm systems, security monitoring, telemetry, garage-door openers, baby monitors, and wireless door bells. The ICs are designed to work within allotted bands such as the industrial-scientific-medical (ISM) and short-range-devices (SRD) bands. The low-cost bipolar-complementary-metal-oxide-semiconductor (BiCMOS) RF devices feature transmit current consumption of 5 to 13 mA and Rx current consumption of only 6.5 to 9.0 mA, making them suitable for a wide range of commercial and consumer wireless products.

The Txs offer adjustable differential or single-ended output-power levels from –18 to +3 dBm, and a fully integrated PLL synthesizer for good frequency stability. They feature automatic power amplifier (PA) turn-on after PLL lock, do not require external RF oscillator components, and offer good frequency stability over temperature and power-supply variations. The Rx ICs achieve signal sensitivity of – 112 dBm in a 26-kHz channel bandwidth and can handle maximum input signals up to 0 dBm, depending upon the model.

Analog Devices (Wilmington, MA) was represented on the Top Products list by the AD9857 quadrature digital upconverter. The 14-b IC provides improved dynamic range and sensitivity compared to its 12-b predecessor, with enhanced power-conservation circuitry. Based on direct-digital-synthesis (DDS) technology, the IC incorporates baseband signal processing, quadrature mixing, and oscillator functions, all implemented in digital technology. It delivers analog output signals by virtue of its integrated 14-b digital-to-analog converter (DAC).

The AD9857 is designed to operate with a +3.3-VDC supply (with ±5-percent regulation) over the extended industrial temperature range of –40 to +85°C. The device can be used as a single-tone clock source or LO, as a rate-programmable interpolating DAC, or as a quadrature digital upconverter in a wide variety of applications.

Radiata (San Jose, CA) brought silicon (Si) CMOS to new heights with a set of ICs for 5-GHz WLANs. Designed according to the new IEEE 802.11a specifications for 54-Mb/s WLANs in the 5-GHz unlicensed bands, the R-M11a baseband modem and the R-RF5 5-GHz radio transceiver prove that CMOS has not come close to reaching its high-frequency ceiling.

For system designers, the Microwave Systems group of ITT Industries (Lowell, MA) introduced a strong example of what digital circuitry can do in an RF application, with its model STel dual digital Rx. Based on a pair of high-performance ADSP21062 SHARC processors from Analog Devices, the two-channel Rx features digital filters that can be programmed in software for a wide range of modulation schemes. The Rxs pair of 12-b analog-to-digital converters (ADCs) capture IF signals to 25 MHz with a spurious-free dynamic range of better than 70 dB. ••

(continued from p. 98)

$$k_{i,i+1} = \frac{1}{\Delta\omega_1\sqrt{g_i g_{i+1}}} \left(\frac{f_2 - f_1}{f_0}\right) \quad (8)$$

For the internal resonators, therefore:

$$9a.\ ZAZB = X_0^2 Cosh^2\left(\frac{\gamma L}{2}\right)$$

$$9b.\ ZBZC = X_0^2 Cosh^2\left(\frac{\gamma L}{2}\right)$$

$$9c.\ ZAZC = \frac{X_0^2}{4} Coth^2\left(\frac{\gamma L}{2}\right) \quad (9)$$

From the Π structure and Eqs. 8 and 9a to c, and after algebraic manipulation:

$$k_{i+1,i+2} = \frac{1}{\left(1 + 4Sinh^2\left(\frac{\gamma L}{2}\right)\right)} \quad (10)$$

Equating Eq. 10 to the evanescent waveguide equations yields:

$$k_{i+1,i+2} = \frac{1}{\Delta\omega_1\sqrt{g_{i+1}g_{i+2}}} \left(\frac{f_2 - f_1}{f_0}\right) = \frac{1}{1 + 4Sinh^2\left(\frac{\gamma L}{2}\right)} \quad (11)$$

Rearranging Eq. 11 provides:

$$Sinh\left(\frac{\gamma L}{2}\right) = \frac{1}{2}\sqrt{\Delta\omega_1\sqrt{g_{i+1}g_{i+2}}\,\frac{f_0}{f_2 - f_1} - 1} \quad (12)$$

Similarly, for the first and last resonators:

$$k_{1,2} = k_{n-1,n} = \frac{1}{\sqrt{\left(1 + 4Sinh^2\left(\frac{\gamma L}{2}\right)\right)\left(1 + 2Sinh^2\left(\frac{\gamma L}{2}\right)\right)}} \quad (13)$$

To add more detail to Eq. 13:

$$k_{1,2}^2 = \frac{1}{1 + 6Sinh^2\left(\frac{\gamma L}{2}\right) + 8Sinh^4\left(\frac{\gamma L}{2}\right)} = \frac{1}{\Delta^2 g_1 g_2}\left(\frac{f_2 - f_1}{f_0}\right)^2 \quad (14)$$

$$Sinh^4\left(\frac{\gamma L}{2}\right) + .75Sinh^2\left(\frac{\gamma L}{2}\right) + .125 - \frac{1}{8k_{1,2}^2} = 0 \quad (15)$$

$$Sinh^2\left(\frac{\gamma L}{2}\right) = \frac{-.75 + \sqrt{.75^2 - 4\left(.125 - \frac{1}{8k_{1,2}^2}\right)}}{2} \quad (16)$$

$$Sinh\left(\frac{\gamma L}{2}\right) = \frac{\left[-.75 + \sqrt{.75^2 - 4\left(.125 - \frac{1}{8k_{1,2}^2}\right)}\right]^{\frac{1}{2}}}{\sqrt{2}} \quad (17)$$

A FILTER DESIGN

An evanescent-mode filter can be designed using the closed-form Eq. 13. As a check, the results are compared against the example presented in the paper by Howard and Lin.[2] This example used a lengthier iterative design example. Given that f_o) = 3 GHz and f_c = 6.5571 GHz. The ripple is 0.01 dB, stop-band attenuation is 50 dB (min) at 2.72 GHz and 50 dB (min) at 3.28 GHz. The waveguide chosen for this design is WR 90, with a length L of 0.9 in. (2.29 cm) and width, W of 0.4 in. (1.02 cm).

$$\gamma = \frac{2\pi fo}{c}\sqrt{\left(\frac{fc}{fo}\right)^2 - 1} = 122.1997 \quad (18)$$

The lowpass prototype parameters for this filter design are given by:

$$ak = Sin\left[\frac{(2k-1)\pi}{2n}\right] \quad k = 1,2...n \quad (19)$$

$$bk = \gamma^2 + Sin^2\frac{k\pi}{n} \quad k = 1,2,....n \quad (20)$$

From these equations, the g parameters are derived as:

$$g_1 = 2a_1/_\gamma \quad (21)$$

$$\gamma = sinh\left(\frac{B}{2n}\right) \quad (22)$$

$$g_k = \frac{(4a_k - 1)}{b_{k-1}}\frac{a_k}{g_{k-1}} \quad k = 2,3,...n \quad (23)$$

$$B = ln\left(cotn\frac{am}{17.37}\right) \quad \text{am in dB} \quad (24)$$

After the g values are determined, the Δ factor is determined.[1] It is applied as a correction for the different reactance slope encountered in evanescent wave, g.

$$\Delta = \frac{2}{1 + \frac{1}{1 - \left(\frac{\lambda c}{\lambda o}\right)^2}} = 0.8831 \quad (25)$$

Solving for the inner resonators:

$$Sinh\,\gamma l_{\frac{1}{2}} = \frac{1}{2}\sqrt{\Delta w_1\sqrt{g_{i+1},\ g_{i+2}}\,\frac{f_0}{f_2 - f_1}} \quad (26)$$

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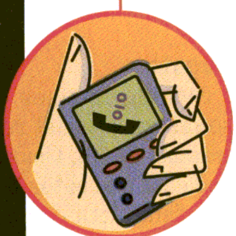

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Penton's Embedded Systems Development — Electronic Design — EE Product News — Microwaves & RF — Wireless Systems Design

$$Sinh\ \gamma l_{\frac{1}{2}} = \frac{1}{2}$$

$$\sqrt{1(0.88)\sqrt{0.80(1.39)}\left(\frac{3}{0.23} - 1\right)} \quad (27)$$

Sinh $\gamma\ l_{1/2} = 1.66$
$\gamma\ l_{1/2} = 1.28$
$\gamma\ l_1 = 2.56$
$l_1 = 2.56/122.2 = 2.09$ cm = 0.82 in.

The percentage difference from the Howard and Lin calculations is[2],

(2.09 – 2.06)/2.06 × 100 =1.37 percent.

$$Sinh\ \gamma l_{\frac{2}{2}} = \frac{1}{2}$$

$$\sqrt{\Delta w_1 \sqrt{g_{i+1},\ g_{i+2}}\ \frac{f_0}{f_2 - f_1}} \quad (28)$$

$$Sinh\ \gamma l_{\frac{2}{2}} = \frac{1}{2}$$

$$\sqrt{1(0.88)\sqrt{1.39(1.75)}\left(\frac{3}{0.23} - 1\right)} \quad (29)$$

Sinh $\gamma\ l_{2/2} = 2.05$
$\gamma\ l_{2/2} = 1.46$
$\gamma\ l_2 = 2.93$
$l_2 = 2.93/122.2 = 2.40$ cm = 0.94 in.

The percentage difference from the Howard and Lin calculations is (2.40 – 2.39)/2.39 × 100 = 0.44 percent.

$$Sinh\ \gamma l_{\frac{3}{2}} = \frac{1}{2}$$

$$\sqrt{\Delta w_1 \sqrt{g_{i+1},\ g_{i+2}}\ \frac{f_0}{f_2 - f_1} - 1} \quad (30)$$

$$Sinh\ \gamma l_{\frac{3}{2}} = \frac{1}{2}$$

$$\sqrt{1(0.88)\sqrt{1.75(1.63)}\left(\frac{3}{0.23} - 1\right)} \quad (31)$$

Sinh $\gamma\ l_{3/2} = 2.13$
$\gamma\ l_{3/2} = 1.50$
$\gamma\ l_3 = 3.00$
$l_3 = 2.46$ cm = 0.97 in.

The percentage difference from the Howard and Lin calculations is (2.46 – 2.45)/2.45 × 100 = 0.24 percent.

For end resonators:

$$k_{1,2} = k_{n-1,n} = \frac{1}{\Delta\omega_1\sqrt{g_1 g_2}}\left(\frac{f_2 - f_1}{fo}\right) \quad (32)$$

$$k_{1,2} = \frac{1}{1(0.88)\sqrt{0.8(1.39)}}\left(\frac{0.23}{3}\right) = 0.88 \quad (33)$$

$$Sinh\ \gamma\ \frac{l_0}{2} = \frac{\left[0.75 - \sqrt{4\left\{0.125 - \frac{1}{8(0.088)^2}\right\}}\right]^{\frac{1}{2}}}{\sqrt{2}} \quad (34)$$

Sinh $\gamma\ l_{o/2} = 2.09$
$\gamma\ l_{o/2} = 1.48$
$l_o/l_n = 2.97/122.2 = 2.43$ cm = 0.96 in.

In summary:

l_o/l_n = 2.43 cm = 0.96 in., Δ of 30.3 percent.

l_1 = 2.09 cm = 0.82 in., Δ of 1.37 percent.

l_2 = 2.40 cm = 0.94 in., Δ of 0.44 percent.

l_3 = 2.46 cm = 0.97 in., a Δ of 0.24 percent.

Since end lengths l_o and l_n of the evanescent waveguide are arbitrary, the 30.3-percent difference provided by the two methods has an insignificant effect on the filter performance. Compare Fig. 4, which illustrates the loss versus frequency plot for an iterative design, with Fig. 5, which shows the results obtained with the new closed-form solution.●●

References

1. G. Craven and C. Mok, "The Design of Evanescent Waveguide Bandpass Filter for a Prescribed Insertion Loss Characteristic," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-19, March 1971.
2. J. Howard and W. Lin, "Evanescent Mode Filter: Design and Implementation," *Microwave Journal*, Vol. 32, October 1983, pp. 121-136.
3. R.V. Snyder, "New Applications of Evanescent Mode Waveguide Filter Design," *IEEE Transactions On Microwave Theory and Techniques*, Vol. MTT-25, December 1977.
4. S.B. Cohn, "Direct Coupled Resonator Filters," *Proceedings of the IRE*, Vol. MTT-5, February 1957, pp. 187-196.

NEW LITERATURE

Tool kits

Tool kits and test equipment are discussed in a 300-page catalog. Hand, power, and specialty tools; wire and cable; soldering equipment; computer and local-area-network (LAN) products; telecom test equipment; workstations; and shop supplies are presented. **Jensen Tools, Inc.;** *(800) 426-1194, (602) 453-3169, FAX: (800) 366-9662, (602) 438-1690, e-mail: jenson@stanleyworks.com, Internet: http://www.jensentools.com.*

Dielectric resonators

A 92-page catalog focuses on dielectric resonators, coaxial resonators, and ceramic filters. Coaxial inductors and coaxial resonator kits are highlighted, along with ceramic filter packaging. **Trans-Tech;** *(301) 695-9400, FAX: (301) 695-7065, e-mail: transtech@alphaind.com, Internet: http://www.trans-tech inc.com.*

Signal conditioning

A front-end, personal-computer (PC)-based signal-conditioning platform is the subject of a 64-page booklet. The booklet is a collection of customer solutions spanning diverse industries and applications, including research and development (R&D), aerospace, electronics, and semiconductor. **National Instruments;** *(800) 258-7022, FAX: (512) 683-9300, e-mail: info@ni.com, Internet: http://www.ni.com.*

Signal recovery

Signal recovery products are covered in a 128-page catalog. Preamplifiers, lock-in amplifiers, transient recorders, digital delay generators, AC voltmeters, and supporting software are offered. Applications include spectroscopy and light measurement, materials characterization, electrochemistry, and medical research. **Perkin Elmer Instruments;** *+44 (0) 118 977 3003, FAX: +44 (0) 118 977 3493, Internet: http://www.signalrecovery.com.*

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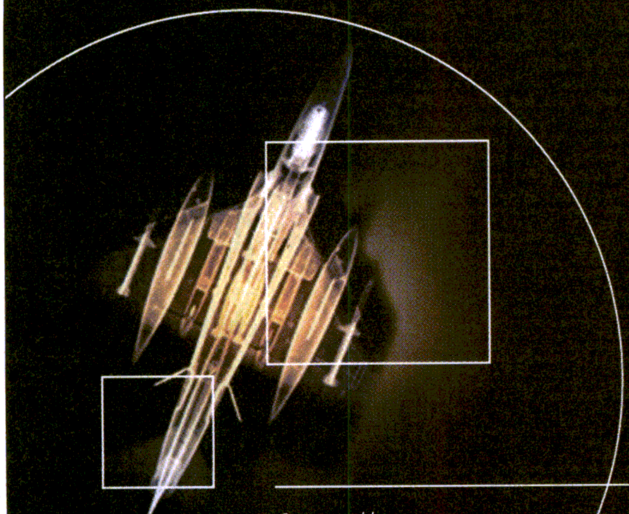

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Analog devices

Analog and interface devices are the subject of a 600-page handbook. Product briefs on high-performance analog microcontrollers and analog development tools are featured. Application notes and data sheets are also provided. **Microchip Technology, Inc.;** *(480) 786-7200, FAX: (480) 899-9210, Internet: http://www.microchip.com.*

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A 22-page brochure covers power amplifiers (PAs). Specifications include rated output power, power output at 3- and 1-dB compression, frequency response, and harmonic distortion. The brochure also features a section detailing the company's design theories and capabilities. **Amplifier Research;** *(215) 723-8181, FAX: (215) 723-5688, Internet: http://www.amplifiers.com.*

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Varactor diodes are presented in an 80-page selection guide. Amplitude-modulation (AM), frequency-modulation (FM), and ultra-high-frequency (UHF) varactor diodes are offered. Complete specifications and features are provided. **TOKO, Inc.;** *(800) PIK-TOKO, FAX: (03) 3727-1176, (03) 3727-1169, Internet: http://www.toko.co.jp.*

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Frequency converters

A series of data sheets provides information on solid-state amplifiers, frequency converters, power dividers/combiners, as wel as instrumentation systems. Specifications, descriptions, features, operating conditions, and applications information are also included. A special section on corporate information and capabilities is also offered. **Shason Microwave Corp.;** *(281) 526-0536, FAX: (281) 526-0541, Internet: http://www.shason.com.*

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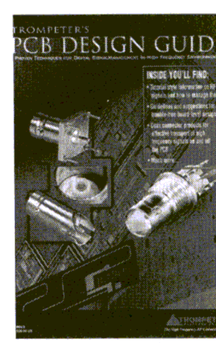
A 12-page brochure focuses on Class A, solid-state, high-power microwave amplifiers covering the frequency range of 80 MHz to 10 GHz, with particular emphasis on 800 MHz to 2.2 GHz. Specifications include frequency, output power, nominal input, minimum gain, power consumption, dimensions, as well as weight. A section on the company's capabilities is provided. **Milmega;** *+44 (0) 1983 616863, FAX: +44 (0) 1983 616864, e-mail: sales@milmega.co.uk, Internet: http://www.milmega.co.uk.*

RF signals



Printed-circuit boards (PCBs) are the subject of a 46-page design guide. Tutorial-style information on RF signals and information on how to manage them is presented. A selection of coax-connector products for the transport of high-frequency signals on and off of a PCB is also discussed. **Trompeter;** *(800) 982-2629, Internet: http://www.trompeter.com.*

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(continued from p. 63)
are relatively small with respect to the carrier (25 dB or lower). Otherwise, the spurs steal significant energy from the carrier and grow by more than 20 × LOG(N) + input-spur power.

FREQUENCY DIVIDER

A frequency divider can be synthesized by downconversion mixing or with an active prescaler. The mixer and the multiplier have already been addressed, so the reader has the tools to derive his own equations for a downconversion frequency divider. This section focuses on frequency division by prescaling.

The prescaler is an active digital device. It has its own source of PM noise θ_0, which, in many cases, is the dominant noise source.

Another consequence of being an active device is that the prescaler compresses the input signal so the input-AM noise is suppressed. The output amplitude of the frequency divider V_s is independent of the input signal's amplitude.

When an input signal of the form of Eq. 7 drives the frequency divider, the output signal is:

$$y_{divider}(t) \approx V_s \times \sin\left(\frac{\omega_0 t}{N} + \frac{n_x(t)}{N \times A} + \theta_0(t)\right) \quad (28)$$

and the corresponding PM noise is:

$$\Theta_n\left(f_{offset}\right) \approx \frac{N_x\left(f_{offset}\right)}{N^2 \times A^2} + \theta_0\left(f_{offset}\right) \quad (29)$$

The PM noise power of the input-noise term is divided by the square of the divider factor N. The argument here is the same made in the previous section for the frequency multiplier. However, since the factor N appears in the denominator, –20 × LOG(N) + input-phase-noise power applies.

The second component of the PM noise is θ_0, which is the power spectrum of the frequency divider's internal phase noise and is not correlated to the input-phase-noise term.

Another consequence that can be inferred from Eq. 28 is that N also divides input FM spurs inside the argument of the sinusoidal as it did with the PM noise. Therefore, the power of the spurs is also reduced by –20 × LOG(N) + input spur power. However, their frequency offset relative to the carrier does not change.

JITTER AND PHASE NOISE

Phase noise manifests itself as jitter on timing signals such as analog-to-digital (A/D) clocks, and on the output signals of synchronization blocks such as phase-locked loops (PLLs).

An expression for jitter can be written as the ratio of the phase-angle wander over the carrier cycle times the duration of the carrier cycle $1/f_0$:

$$J(t) = \frac{\theta_n(t)}{2\pi f_0} \quad (30)$$

Replacing the phase $\theta_n(t)$ with Eq. 7 yields a familiar expression:

$$J(t) = \frac{n_x(t)}{2\pi f_0 A} \quad (31)$$

Since the jitter and noise are random signals, these equations are usually expressed as root-mean-square (RMS) values.

$$\sigma J = \frac{\sigma_{\theta_n}}{2\pi f_0} = \frac{\sigma_{n_x}}{2\pi f_0 A} \quad (32)$$

where:
σ is the standard deviation of the subscript signal.

Many of the equations presented in the previous sections were presented to develop output-noise expressions, and are not very practical. The table summarizes the AM and PM noise expressions that are practical.

When applying these equations, carefully note that component specifications, which are usually provided in –dBc/Hz, refer to the noise power relative to the carrier power. The carrier power $A^2/2$ is –3 dB lower than the carrier peak power A^2. Therefore, the noise-power-to-carrier-power ratio computed using the equations in the table need a +3-dB offset to match the numbers found on most specifications.

The equations of the table can be used to analyze the AM and PM noise output of cascaded RF elements. The recursive nature of spreadsheets lend themselves to this type of analysis.[2] This analysis can be accomplished by writing the AM and PM equations for each block type in a group of cells to form a block, then cutting and pasting these blocks to represent a specific chain of RF components.

Although the article only addresses the basic RF building blocks, these equations can be used to analyze more-complex RF blocks such as PLLs or direct digital synthesizers, which are considered special cases of frequency multipliers or dividers. ●●

Proof to equation 4:

a) Insert equation 2 into equation 1:

$$x(t) = A * Sin(\omega_0 t) + n_x(t) * Cos(\omega_0 t) + n_y(t) * Sin(\omega_0 t)$$

b) Rewrite x(t) as:

$$x(t) = A * \left(\frac{n_x(t)}{A} * Cos(\omega_0 t) + Sin(\omega_0 t)\right) + n_y(t) * Sin(\omega_0 t)$$

c) Recall the following trigonometric identity:

$$Sin(\theta + \phi) = Sin(\phi) * Cos(\theta) + Cos(\phi) * Sin(\theta) = Cos(\phi) * (Tan(\phi) * Cos(\theta) + Sin(\theta))$$

d) Writing the bracketed part of the equation in step b into the trigonometric form of step c:

$$x(t) = A * \frac{Sin(\omega_0 t + \phi(t))}{Cos(\phi(t))} + n_y(t) * Sin(\omega_0 t)$$

where:

$$\phi(t) = ArcTan * \left(\frac{n_x(t)}{A}\right) \approx \frac{n_x(t)}{A} \qquad Cos(\phi(t)) \approx 1$$

e) Since $\phi(t)$ is a very small angular variation x(t) can be written as:

$$x(t) \approx A * Sin\left(\omega_0 t + \frac{n_x(t)}{A}\right) + n_y(t) * Sin(\omega_0 t) \qquad \text{Q.E.D}$$

3. This window shows the derivation of Eq. 4.

References

1. Stan Goldman, "Phase-Noise Leakage Through a Mixer," *MSN & CT*, November 1987, pp. 88-96.
2. Work performed by Joel Blumke, Raytheon, Tucson AZ, 1998.

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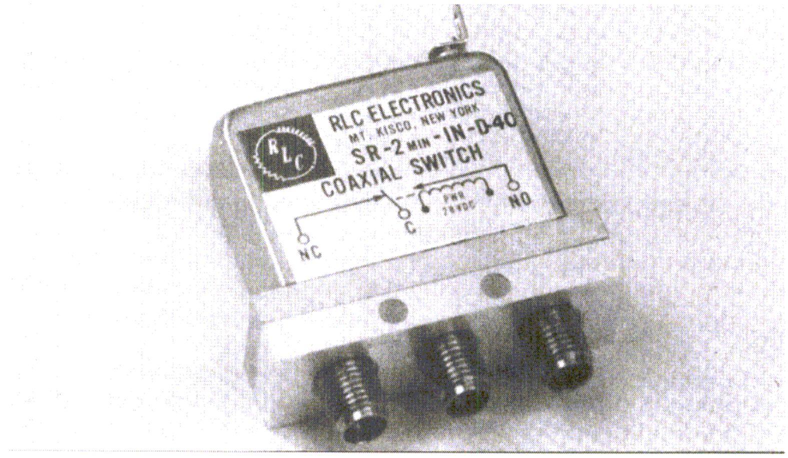

More than 14 years ago, the way was paved for coaxial millimeter-wave systems with the introduction of the model SR-2min-D-40 single-pole, double-throw (SPDT) switch from RLC Electronics (Mount Kisco, NY). Covering DC to 40 GHz, the switch exhibited an insertion loss of 0.9 dB at 40 GHz, with at least 45-dB isolation.

Microwaves & RF January Editorial Preview

Issue Theme: Semiconductors

News

No single process seems to be the solution for all wireless applications. For example, GaAs technology was once thought to be superior for applications above 2 GHz. Lately, however, silicon germanium (SiGe) and Si complementary-metal-oxide-semiconductor (CMOS) technologies have pushed into GaAs' former stronghold. For millimeter-wave frequencies, indium phosphide (InP) still seems to be the best choice. This Special Report will examine how high-frequency designers use different processes for different applications, and how the different processes compare.

Design Features

January begins the year with a strong line of contributed technical articles, including the design of a wide-ranging voltage-controlled oscillator (VCO) and notes on creating a voltage-controlled attenuator. Additional articles examine the effects of filter group delay on error-vector-magnitude performance in modulated systems, and guidelines for selecting a shielding supplier.

Product Technology

January's Product Technology section begins the year with a close look at a new wideband generator. This single instrument covers a range from 0.1 Hz to 40 GHz with single-sideband (SSB) phase noise that compares favorably to that of a crystal oscillator, even at microwave frequencies.