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FOR DESIGNERS AT HIGHER FREQUENCIES

Microwaves & RF

Communications Issue

NEWS
Scanning trends in communications

DESIGN FEATURE
Practical test methods for CDMA handsets

PRODUCT TECHNOLOGY
Diminutive OCXOs fit surface-mount designs

Fiber-optic link shines at 11 GHz

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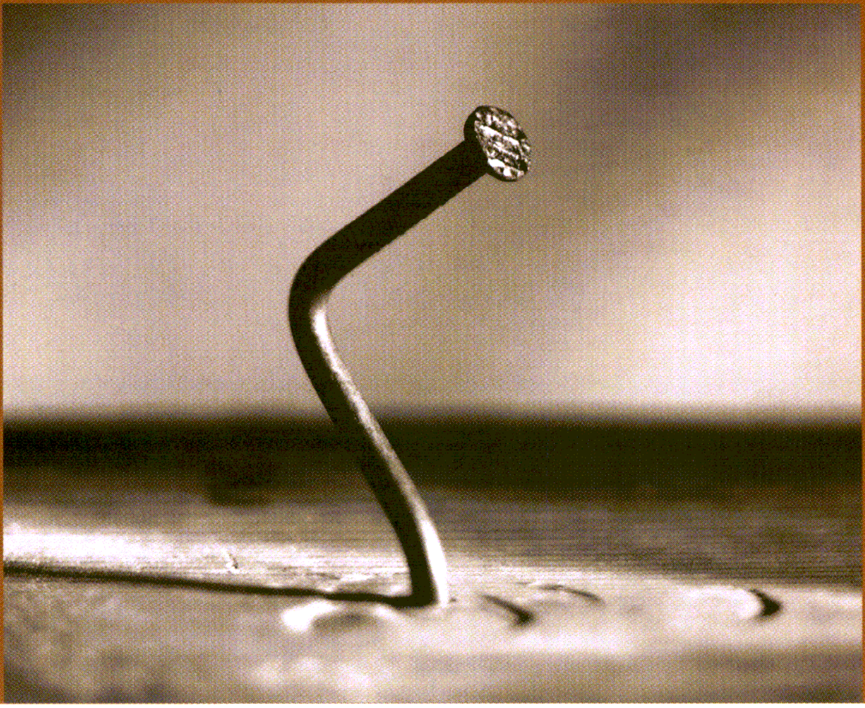
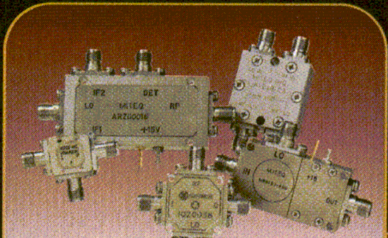


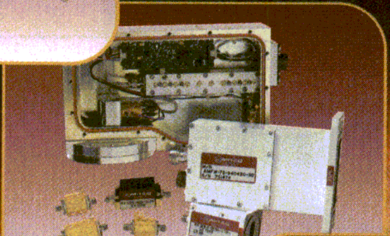
MITEQ

FROM COMPONENTS TO SYSTEMS



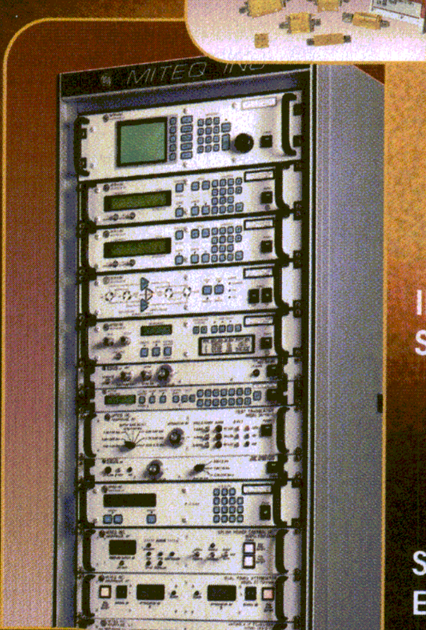
MIXERS TO 60 GHz

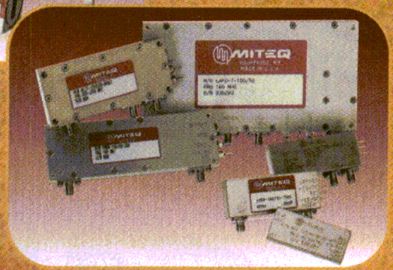
- Single-, double-, and triple-balanced
- Image rejection and I/Q
- Single-sideband, BPSK and QPSK modulators
- High dynamic range
- Active and passive frequency multipliers



AMPLIFIERS TO 60 GHz

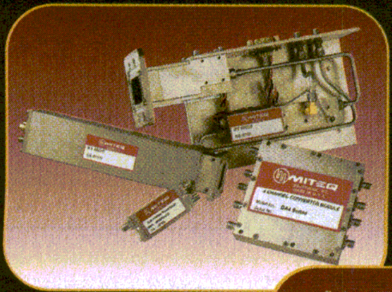
- Octave to ultra-broadband
- Noise figures from 0.35 dB
- Power to 10 watts
- Temperature compensated
- Cryogenic





INTEGRATED SUBASSEMBLIES TO 60 GHz

- Integrated up/downconverters
- Monopulse receiver front ends
- PIN diode switches
- Ultra-miniature switch matrices
- Missile receiver front ends
- Switched amplifier/filter assemblies



IF AND VIDEO SIGNAL PROCESSING

- Logarithmic amplifiers
- Constant phase-limiting amplifiers
- Frequency discriminators
- AGC/VGC amplifiers
- I/Q processors
- Digital DLVAs

SATCOM EARTH STATION EQUIPMENT TO Ka-BAND

- Synthesized up/downconverters
- Test translators
- LNA systems
- 1:N redundancy units
- INMARSAT products
- FM modems

FREQUENCY SOURCES TO 40 GHz

- Free-running VCOs/DROs
- Phase-locked cavity oscillators
- Phase-locked coaxial resonators
- Synthesizers for SATCOM
- Fast-tuning communication synthesizers

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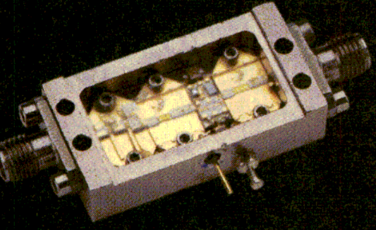
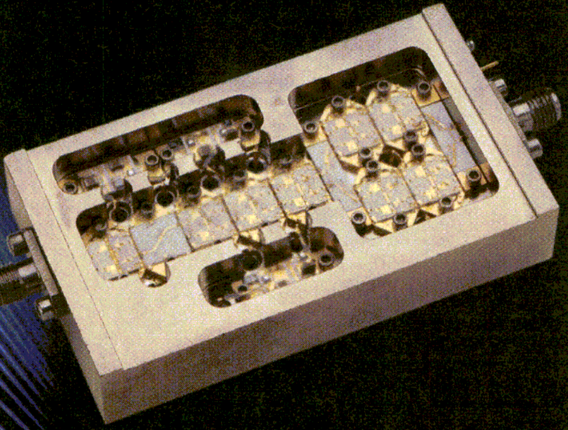
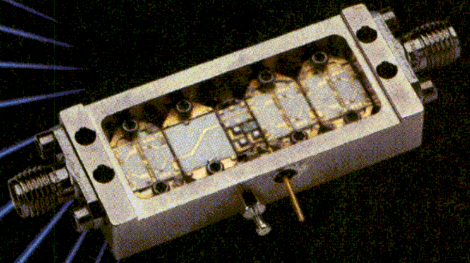
for every application







ULTRA BROAD BAND

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC 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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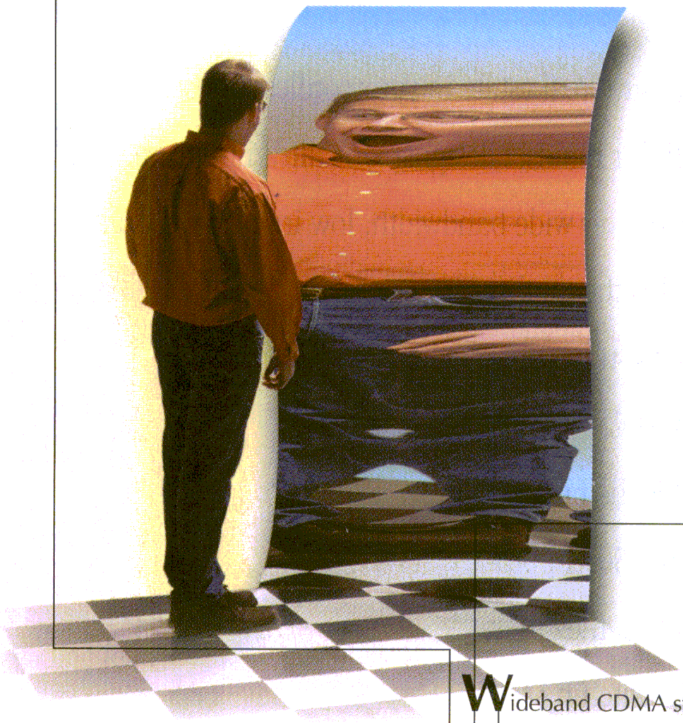

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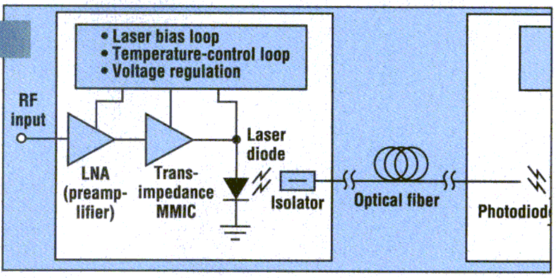

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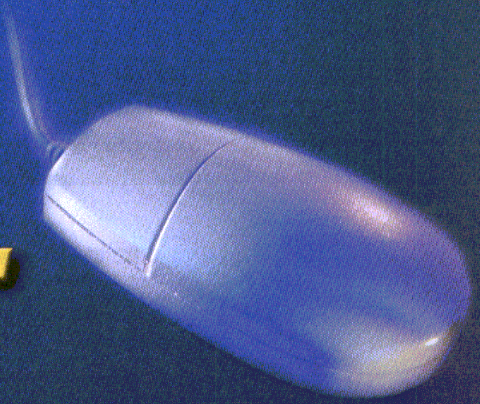
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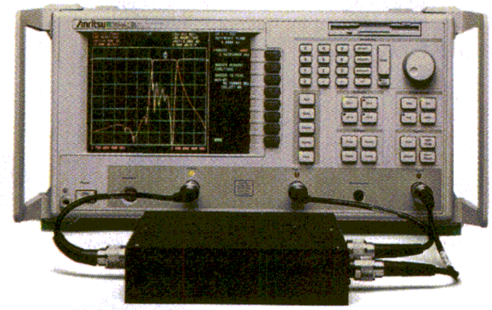

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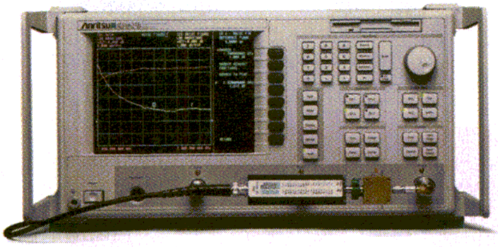

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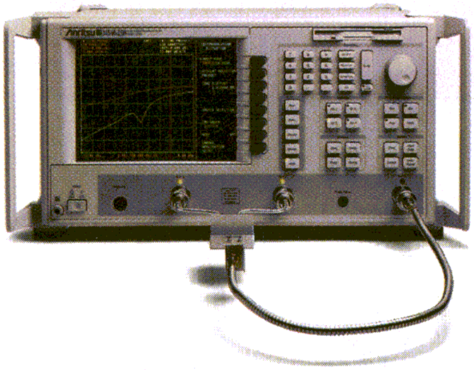

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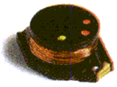
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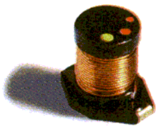
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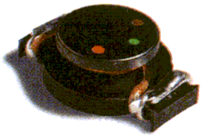
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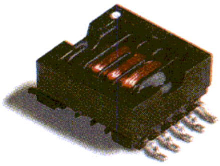
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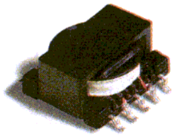
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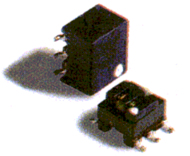
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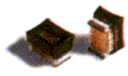
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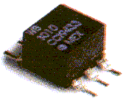
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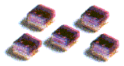
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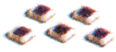
1008HS Chip Inductors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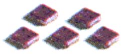
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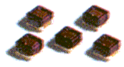
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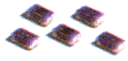
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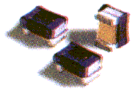
1812CS Chip Inductors


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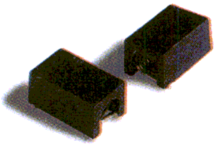
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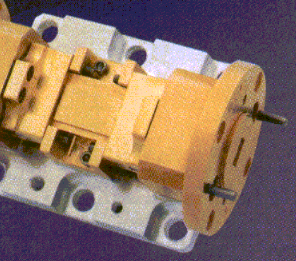
CIRCLE NO. 231

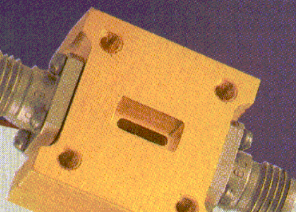
MILLIMETER WAVE
COMPONENTS
AMPLIFIERS • MIXERS • MULTIPLIERS



AMPLIFIERS

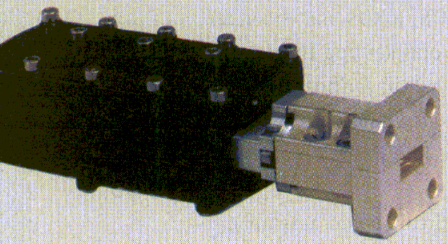
Model Number	Frequency (GHz)	Gain (dB, Min.)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	I/O VSWR (Max.)	Output Power at 1dB Comp.* (dBm, Typ.)
JSW4-18002600-18-5A	18-26	28	1.0	1.8	2.0:1/2.0:1	5
JSW4-26004000-25-5A	26-40	25	2.5	2.5	2.0:1/2.0:1	5
JSW4-18004000-32-8A	18-40	21	2.0	3.2	2.0:1/2.5:1	8
JSW4-30005000-45-5A	30-50	21	2.5	4.5	2.5:1/2.5:1	5
JSW4-40006000-65-0A	40-60	16	2.5	6.5	2.5:1/2.5:1	0

* Higher output power options available



MIXER/CONVERTER PRODUCTS

Model Number	Frequency (GHz) RF	LO	IF	Conversion Gain/Loss (dB, Typ.)	Noise Figure (dB, Typ.)	Image Rejection (dB, Typ.)	LO-RF Isolation (dB, Typ.)
LNB-1826-30	18-26	Internal	2-10	42	2.5	20	45
LNB-2640-40	26-40	Internal	2-16	42	3.5	20	45
ARE3436LC1	34-36	15.5-16.5	2.7-3.3	25	4	20	60
SBW3337LG2	33-37	33-37	DC-4	-7.5	8	N/A	25
TB0440LW1	4-40	4-42	.5-20	-10	10.5	N/A	20
DB0440LW1	4-40	4-40	DC-2	-9	9.5	N/A	25
SBE0440LW1	4-40	2-20	DC-1.5	-10	10.5	N/A	20



MULTIPLIERS

Model Number	Frequency (GHz) Input	Output	Input Level (dBm, min.)	Output Power* (dBm, min.)	Fundamental Feed Through Level (dBc, min.)	DC current @+15VDC (mA, nom.)
MAX2M260400	13-20	26-40	10	12	18	160
MAX2M200380	10-19	20-38	6	14	18	200
MAX2M300500	15-25	30-50	10	8	18	160
MAX4M400480	10-12	40-48	10	8	18	250
MAX3M300300	10	30	10	10	60	160
MAX2M360500	18-25	36-50	10	8	18	160
MAX2M200400	10-20	20-40	10	10	18	160
TD0040LA2	2-20	4-40	10	-3	30	N/A

* Higher output power options available

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CIRCLE NO. 290

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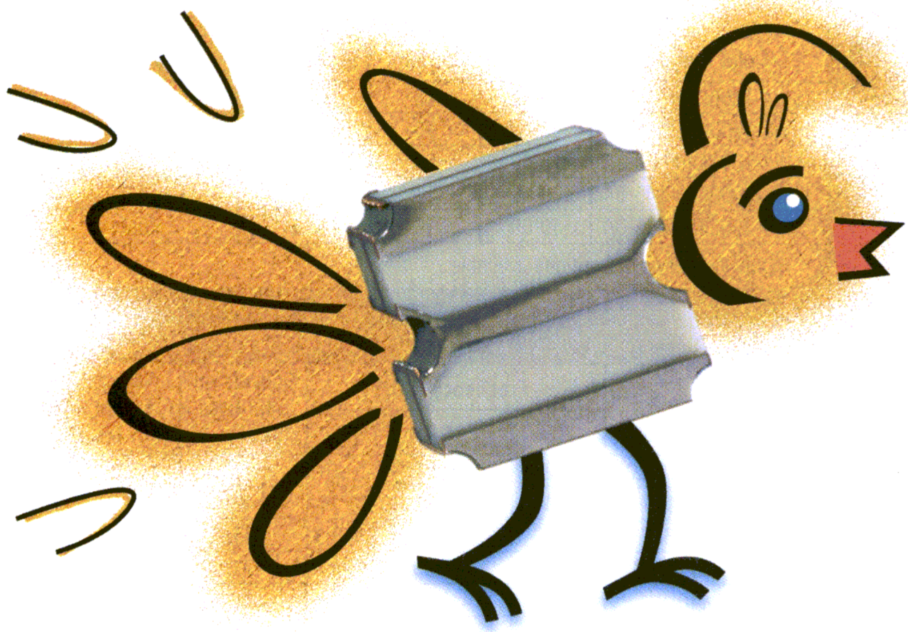

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CIRCLE NO. 317

PHONE RADIATION

To the editor:

In your February 2000 article "Studying Biomedical Issues Of High-Frequency Radiation" (p. 105), the author, Rajeev Bansal, has compared the power density from the sun to the microwave. This comparison is misleading for the cellular-phone user. Bansal has presented the radiation level of 0.3 mW/cm ^{2} inside a car from a mobile phone, but he did not write anything regarding a 600-mW cellular phone that is close to the user's head. Recently, George Carlow[1] told the *Boston Globe* that "we have scientific information now that suggests genetic damage and some increased risk of cancer. My current recommendation at this point has to do with moving the antenna away from your head" or use shielding.[2] Consumers should check the radiation level from a cellular phone/personal-communications-services (PCS) phone antenna to the user's head by using a low-cost radiation checker.[2] If you have an antenna right next to your head, you are going to have exposure.

Bansal did not use any recent biomedical/biological paper in his reference. Many biomedical scientists[3-6] have suggested that microwave radiation has some effect on DNA and human memory. Lai and Singh,[3] both at the University of Washington (Seattle, WA), contend that the Malyapa-Roti[7] work is flawed. "There is something seriously wrong with those experiments," Singh told *Microwave News.* [8]

In my opinion, cellular-phone users must safeguard themselves from the radiation that is close to their heads.

References

1. Patricia Wen of the *Boston Globe*, "Cell-Phone Alarm Sounded," *The Gazette*, Montreal, Section J8, October 9, 1999.

2. A. Kumar, "Shielding The Ill Effects Of EM Radiation," *Microwaves & RF*, Vol. 35, No. 13, December 1996, pp. 157-161.

3. H. Lai and N.P. Singh, "Single- And Double-Strand DNA Breaks In Rat Brain Cells Offer Acute Exposure To Radiofrequency Electromagnetic Radiation," Int. J. Radiation Biology, Vol. 69, No. 4, pp. 513-521, 1996.

4. J.L. Philips *et al.*, "DNA Damage In Molt-4 T-lymphoblastoid Cells Exposed To Cellular Telephone Radiofrequency Fields In Vitro," *Bioelectrochemistry and Bioenergetics*, Vol. 45, pp. 103-110, 1998.

5. M.H. Repacholi *et al.*, "Lymphomas In EU-Pimj Transgenetic Mice Exposed To Pulsed 900 MHz Electromagnetic Fields," *Radiat. Res.* Vol. 47, 1997, pp. 631-640.

6. A.W. Preece *et al.*, "Effect Of A 915-MHz Simulated Mobile Phone Signal On Cognitive Function In Man," *International J. Radiat. Biol.*, Vol. 75, 1999, pp. 447-456.

7. R.S. Malyapa *et al.*, Measurement Of DNA Damage After Exposure To Electromagnetic Radiation In Cellular Communications Frequency Band (835.62 and 847.74 MHz)," *Radiat. Res.*, Vol. 148, 1997, pp. 618-627.

8. *Microwave News* "Two Labs At Odds Over Microwaves And DNA Breaks," Vol. XVIII, No. 1, January/February 1998, p. 1.

A. Kumar
AK Electromagnetique, Inc.
Les Coteaux, Quebec, Canada

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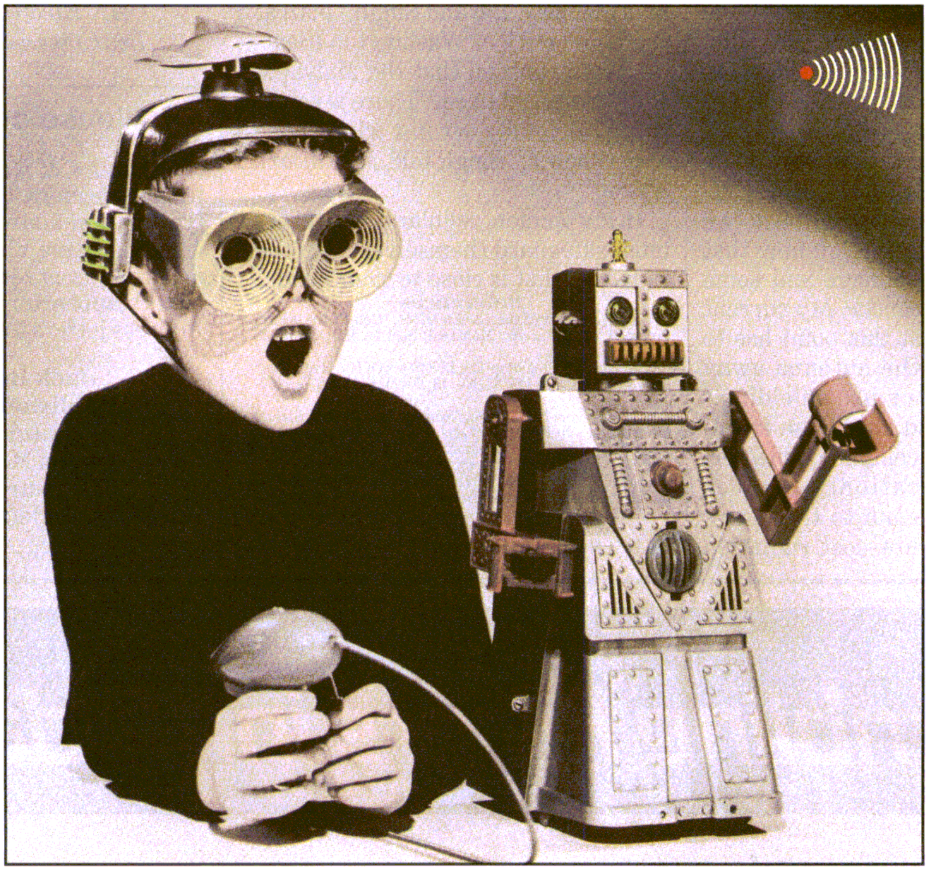
TECHNOLOGY



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CIRCLE NO. 348

NAVIGATING RF WEBSITES

Microwave and RF manufacturers have been slow to embrace the possibilities of the Internet compared to some other portions of the electronics industry. But they have made up for their initial equivocation with a flurry of website development in the past year. Many high-frequency manufacturers are learning that a properly maintained website can be a powerful business partner. Armed with the right information, the website cannot only become an extension of a company's sales force, but also an applications aid for customer engineers.

What makes a good website? Obviously, small firms with only a handful of specialized product lines cannot host a website with thousands of pages of product information. Such companies cannot hope to compete with sophisticated websites such as those maintained by Agilent Technologies (http://www.agilent.com) and Analog Devices (http://www.analog.com). Still, many small firms offer superb websites, sites that serve to enhance a company's technical credibility. An example is the site maintained by Philsar Semiconductor, Inc. (Nepean, Ontario, Canada) at http://www.philsar.com.

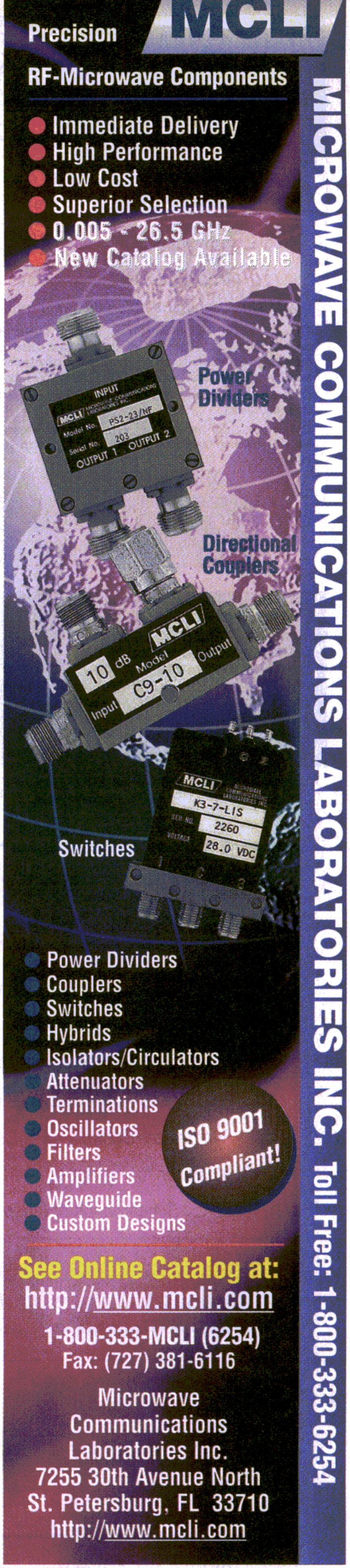
The site's home page is simple but effective: one small graphic element (a photograph) and just enough information to guide browsers to those sections that interest them. Key among these sections is the "RF Designer's Resource Center." At this part of the site, browsers are treated to an attractive collection of application notes and articles (in downloadable PDF form) on the company's specialties: Bluetooth integrated circuits (ICs), fractional-N frequency synthesizers, Global Positioning System (GPS) front-end design, and multipurpose RF transceivers. This small company has managed to supply visitors to its site with a wealth of information that is disproportionate to the size of the firm. Good sites are like this one: not just a product catalog but a design-engineering resource center.

Where does one learn more about such sites? Well, this magazine contains a section called WebWatch in which websites are reviewed and presented in generally one-page reports (see p. 121 for a review of the Philsar site). Special Projects Editor Alan "Pete" Conrad invests his time so that readers don't waste theirs. And if you feel your site should be the subject of a review, drop us an e-mail at jbrowne@penton.com and we'll take a look.

Editor's Note: Many readers will remember Ron Schneiderman for his years as the News Editor of *Microwaves & RF*. In recent years, Ron has stood at the helm of our sister publication, *Wireless Systems Design*, as that magazine's Chief Editor. With the April issue of *Wireless Systems Design*, Ron has chosen to leave this organization to pursue other opportunities. In the interim, I will be performing double duty as the Editor of both *Microwaves & RF* and *Wireless Systems Design*. For those who know and remember Ron, I hope you will join me in wishing him all the best in his future pursuits.

Jack Browne

Publisher/Editor



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Publisher/Editor Jack Browne—(201) 393-6293
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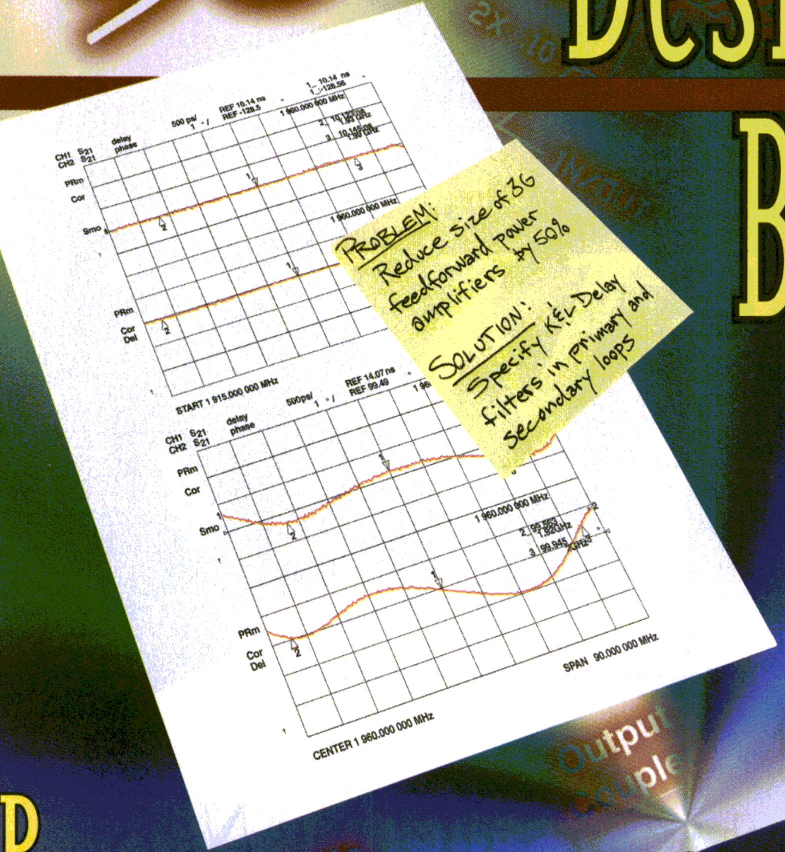

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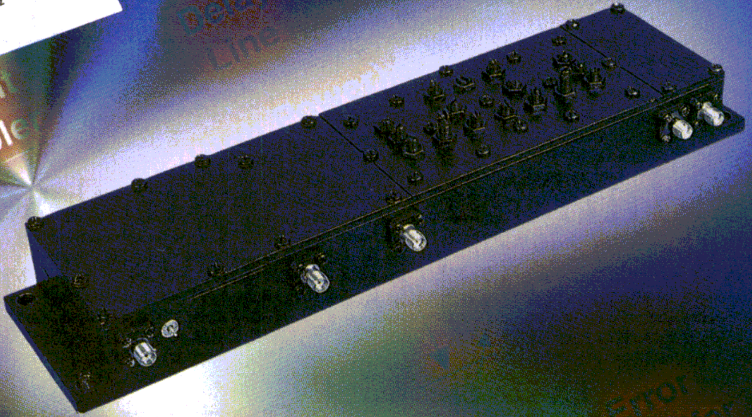

Primary loop delay filter assemblies integrate high power cavity delay filters, couplers and isolators into a single compact module for performance improvement, space savings and cost reduction.

Secondary loop miniature delay filters utilize a Patent Pending topology to provide delay equalization. The filters exhibit excellent delay and phase flatness in a miniature surface mount package. The 3G model measures a mere 1.5"L x 0.60"W x 0.4"H and can be mounted directly onto your PWB with pick and place machinery.

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CIRCLE NO. 262


FROM WATKINS-JOHNSON
NEW FETs

Mobile-Phone Giant To Offer Soccer Highlights On Their Phones

MANCHESTER, ENGLAND—Telecommunications firm Vodafone signed a four-year, 30 million pound (approximately $48.3 million US) sponsorship deal with English soccer club Manchester United on February 11. The deal, which is effective June 1, provides Vodafone with sponsorship of Manchester United jerseys, the right to use the Manchester United trademark in promotions and advertising, hospitality-area access, as well as advertising boards at all Manchester United home games (except for UEFA Champions League matches).

Perhaps the most intriguing part of Vodafone's sponsorship deal with Manchester United is that Vodafone will provide United fans with access to audio highlights of United matches as well as text messages regarding the club through the new Vodafone AirTouch Global Wireless Portal using wireless-application protocol (WAP). This wireless Internet service will be available to United fans starting with the 2000-2001 season.

"We are delighted to welcome Vodafone as our new principal sponsor," says Peter Kenyon, deputy chief executive of Manchester United. "Vodafone is one of the largest companies in the world. They will bring us the capability to provide our fans around the world with the best services giving them news and information about the team anywhere, anytime."

Peter Bamford, chief executive of Vodafone UK Ltd., comments, "This ground-breaking agreement goes beyond a pure shirt sponsorship and will bring a new range of mobile information services to a loyal massive supporter base. There is additional business potential in the bringing together of the world's largest telecommunications company and the world's best-known football club."

There will be an additional perk for United supporters in approximately three years' time according to Paul Donovan, commercial and marketing director of Vodafone, who says, "From the beginning of 2003/2004, fans will be able to look at highlights of matches and of goals that have been scored wherever they are in the world. People will also be able to receive broadcast messages from the club and they will be able to use their phones to buy shirts or tickets."

Third-generation (3G) mobile phones should be available beginning in 2003 and will make the viewing of archived soccer matches possible. Live games will not be viewed on cell phones at any time in the foreseeable future.

There are approximately 25 million mobile phones in the United Kingdom, which is more than double the number of personal computers (PCs). Vodafone is Britain's largest mobile-phone company, recently purchasing a controlling stake in German firm Mannesmann AG in a deal worth 114 billion pounds (approximately $183.54 billion US). Vodafone controls 33 percent of the UK cellular market, servicing approximately 8 million customers in the UK and has more international roaming agreements than any other UK mobile operator. Currently, Vodafone is able to offer its subscribers roaming with 220 networks in 104 countries. In addition to their sponsorship of Manchester United, Vodafone also sponsors the England cricket team and the Vodafone Derby horse race.

Next-Generation Telescope To Aid Search For Extra-Terrestrial Intelligence

LITTLE FERRY, NJ—The SETI League, Inc., an organization involved in the search for extra-terrestrial intelligence, has begun the design of Array2k, a new kind of radio telescope which will be taking shape over the next few years at a remote Northern New Jersey location. The telescope's name refers not to the year 2000, but rather to the instrument's more than 2000 sq. ft. of collecting area. This is equivalent to a single dish antenna of more than 50 ft. in diameter, at approximately a tenth of the cost.

The Array2k design combines 16 standard satellite TV antennas into a single powerful radio telescope. The SETI League, Inc. pioneered the use of backyard satellite TV dishes for SETI research four years ago, with the launch of its *Project Argus* all-sky survey. The concept has been embraced by other scientific organizations, including the SETI Institute in California, which earlier this year announced its One Hectare Telescope (1HT) project to combine 500 of these dishes into a grand SETI array.

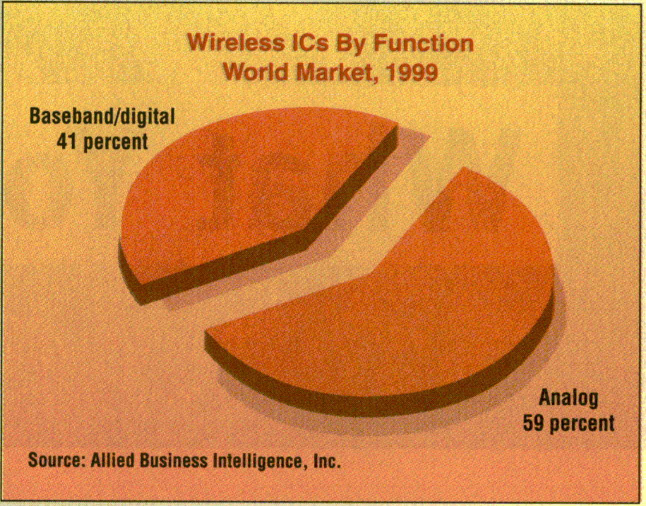
The SETI League's more modest design will support the individual efforts of its 1100 members worldwide as a follow-up detection device to help confirm their observations. It will also be used for direct astronomical research, and serve as a test bed for SETI League engineers to develop the technologies which will someday allow them to unite thousands of members' small backyard telescopes into a huge planetary array.

Wireless IC Market To More Than Double In Value

OYSTER BAY, NY—As the wireless revolution continues to progress worldwide, chip manufacturers can expect to see the multibillion dollar market more than double over the next five years, according to a study from Allied Business Intelligence, Inc. (ABI). Movement in the wireless phone market has been strongly augmented by new growth in the millimeter-wave market as frequencies above 2 GHz continue to be used throughout the world.

As reported in *Communications Integrated Circuits 1999—Embedded Electronic Solutions for Wireless Communications*, the integrated-circuit (IC) market for wireless applications is expected to grow from $5.2 billion in 1999 to $11.3 billion in 2004. The study assesses the market for ICs in four key wireless applications—cellular/personal communications services (PCS), Global Positioning System (GPS), local multichannel distribution system (LMDS), and wireless local-area network (WLAN). The study pays close attention to the competition between chip-set modules, boards, and the migration to systems solutions.

Different materials may fare better in some sectors when compared to others. For example, gallium-arsenide (GaAs) ICs account for 13 percent of the total market value in 1999 and only 3 percent of the GPS IC market. However, GaAs is considerably more popular in the cellular/PCS market where it is used in power amplifiers (PAs), low-noise amplifiers (LNAs), and mixers. Heterojunction-bipolar-transistor (HBT) GaAs ICs alone account for 4 percent of the cellular IC market.



Source: Allied Business Intelligence, Inc.

Although the progression toward greater functionality and systems solutions continues, chip-set solutions are gaining ground from boards and modules in the GPS and WLAN sectors. For example, modules and board solutions accounted for 41 percent and 23 percent of the market in 1999 (see figure) but both are expected to fall in share due to the use of GPS chip sets in embedded applications. The antithesis is evident in the cellular/PCS market where second- and third-tier phone builders are looking to IC makers for complete reference designs and board solutions. This is especially true in the digital cellular market, particularly code-division multiple access (CDMA).

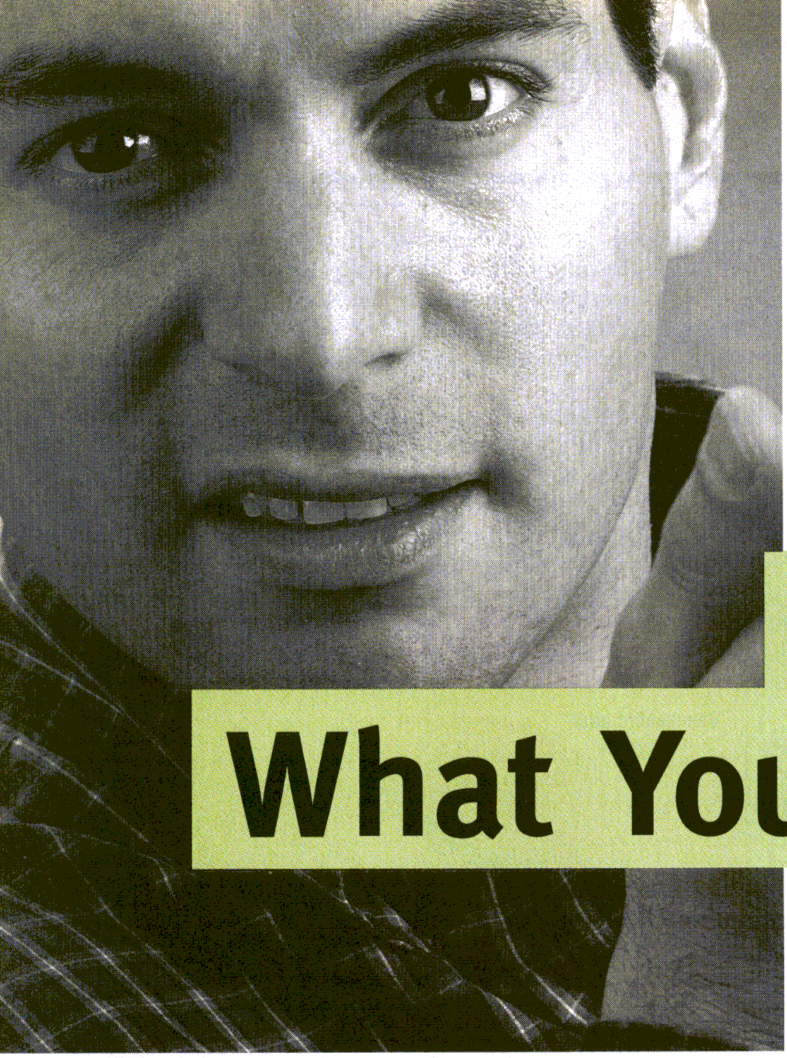
Researchers Develop Miniature Power Source For Electronic Devices

SCHAUMBURG, IL—Scientists at Motorola Labs and Los Alamos National Laboratory have developed a new miniature fuel cell that may one day replace the traditional batteries that now power everything from cellular phones and laptop computers to portable cameras and electronic games.

The energy density of these new fuel cells is 10 times that of conventional rechargeable batteries. At the same time, they will be significantly lighter in weight and less expensive to purchase.

The new fuel cells, each measuring approximately 1 in.^{2} (2.54 cm^2) and less than one-tenth of an inch in thickness, are powered by liquid methanol (wood alcohol) and can easily be installed into numerous existing and future electronic devices. Use of fuel cells, for example, could safely power a cellular phone for more than a month and eliminate the need for battery chargers and AC adapters.

"Manufacturers are constantly developing new features for portable electronic equipment that require more power and longer operating life," says Bill Ooms, director of Motorola's Material, Device, and Energy Research. "These fuel cells have an amazing ability to produce energy for longer periods of time while weighing far less than conventional batteries."



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Increase Seen For Fiber-Optic Coupler Market By 2008

SAN MATEO, CA—The global consumption of fiber-optic couplers in 1999 was $394.1 million according to ElectroniCast Corp.'s *Fiber Optic Coupler Global Market Forecast.* The consumption value will increase to $1.75 billion by 2008, supported by rising quantity growth, however, partially offset by a continuing decline of average prices.

Global coupler consumption will be driven by the accelerating demand for high-capacity transport systems (optical-fiber amplifiers, optical add/drop multiplexers, etc.). "Couplers, in various forms, are enabling components used in a wide array of applications such as long-haul submarine networks, subscriber-loop networks, cable-television (CATV) networks, test instruments, and sensors. The main use of couplers is for splitting or combining signals in today's capacity-hungry networks and will remain so in the foreseeable future," says Stephen Montgomery, president of ElectroniCast.

North America led in global coupler consumption with 38 percent, or $149.7 million, in 1999. North American consumption will expand in value to $664.3 million by 2008. Europe ranked second in usage of fiber-optic couplers with 27.6 percent, or $108.9 million, in 1999, growing in value to $491.8 million by 2008. The leading European countries in fiber-optic coupler deployment were Germany, the United Kingdom, France, and Italy.

Wireless-Location Business Is Sold In $1 Billion Deal

SAN DIEGO, CA—Qualcomm recently announced that it has acquired SnapTrack, Inc., a company involved in wireless position-location technology. Combining SnapTrack's technology with Qualcomm's gpsOne technology will accelerate the introduction of powerful Assisted Global Positioning System (GPS) technology. Qualcomm paid $1 billion in stock for the acquisition of SnapTrack. The agreement was completed last month.

The combined Qualcomm and SnapTrack position-location technology targets wireless applications worldwide. It will be designed and is patented to operate in existing code-division-multiple-access (CDMA), Personal Digital Cellular (PDC), Global System for Mobile Communications (GSM), time-division-multiple-access (TDMA) and integrated-dispatch-enhanced-network (iDEN), and new third-generation (3G) CDMA systems. Qualcomm is incorporating gpsOne technology in its chip-set and software solutions for wireless voice and data products.

The combined technology will enable the design of smart phones, personal digital assistants (PDAs), and pagers that will help find wireless 911 callers for emergency purposes, or provide customized location-specific services either directly to the user or through wireless Internet applications and services. The location technology is air interface independent and functions in any wireless standard. SnapTrack's Location on Demand feature will ensure a caller's privacy—putting location information in the hands of the user, not the network. Qualcomm will provide a low-cost, robust solution to the Federal Communications Commission's (FCC's) mandate that wireless carriers provide for the location of wireless phones for 911 applications.

SnapTrack has 50 patents, either issued or pending, that concern the deployment of wireless-assisted GPS. SnapTrack has focused on integrating GPS and two-way wireless technologies for the past five years. It pioneered the client/server-assisted GPS technology known as Wireless Assisted GPS that uses the US government's GPS satellites to pinpoint wireless devices to within an average of 5 to 20 m, including buildings where conventional GPS does not operate.

Kudos

RF Micro Devices, Inc. announced that it has shipped its 50 millionth code-division-multiple-access (CDMA) product...Murata Electronics announced that its State College, PA manufacturing facility is certified to the ISO 14001 Environmental Management Standard...Intelligent Information, Inc. has been named to Deloitte & Touche's "Fast 500" program, a ranking of the 500 fastest-growing US technology companies...RF Monolithics, Inc. is the recipient of the Delphi Automotive Systems Division Delphi-Delco Absolute Zero Defect Award. This award is presented by Delphi-Delco to those vendors who have zero failures or defects during the previous year. RFM is one of only eight vendors out of 671 suppliers who received this award...Marconi Communications, along with only 10 other companies nationwide, is the first to receive the new TL-9000 quality certification from the QuEST (Quality Excellence for Suppliers of Telecommunications) Forum. The TL-9000 program is based on the ISO-9000 program, but with the telecommunications-specific metrics added.

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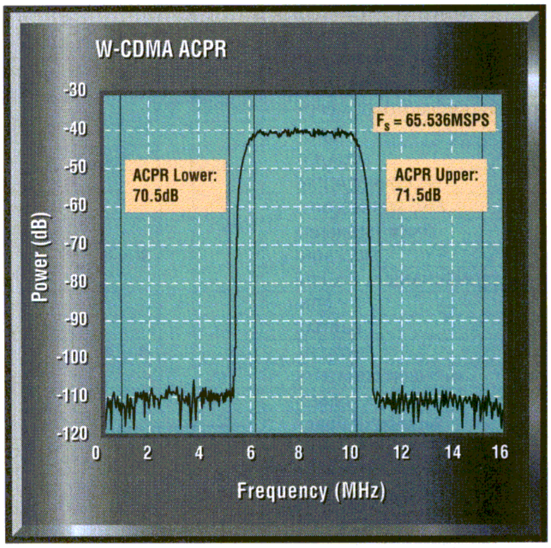

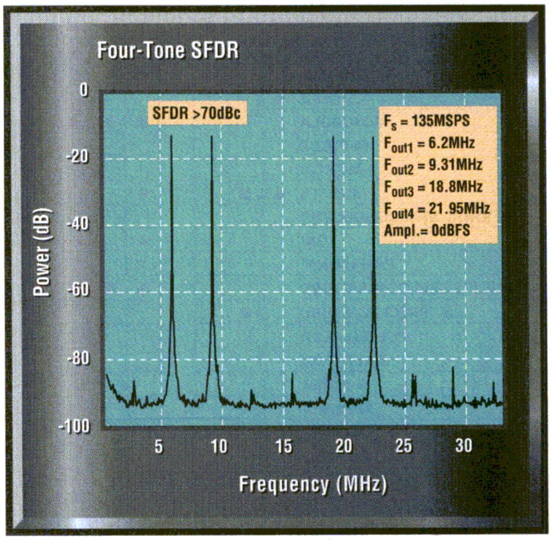

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Broadband and narrowband data technologies are two of the trends making strong bids to grab the headlines in today's fast-paced wireless communications industry.

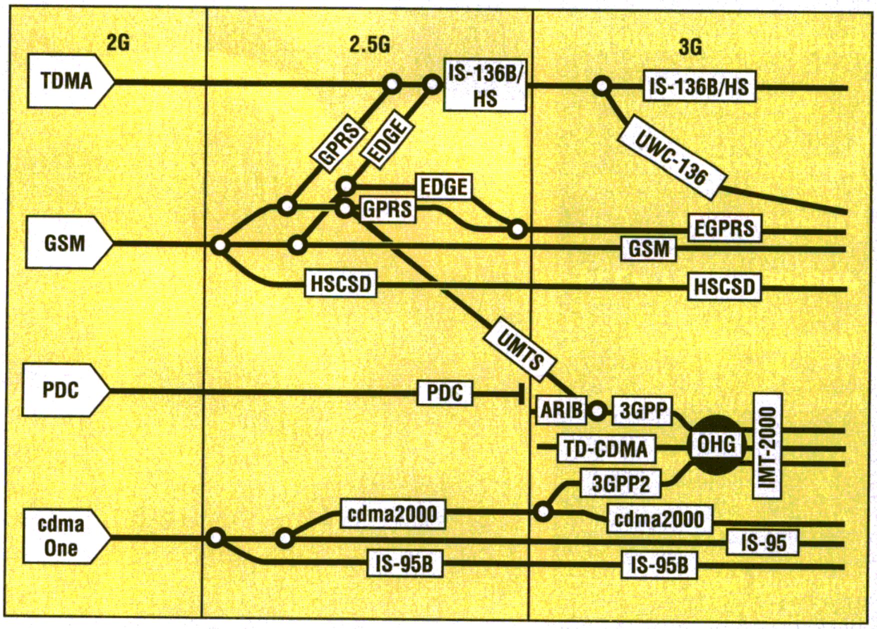
Wireless Up-And-Comers Head For The Spotlight

GENE HEFTMAN
Senior Editor

WITH the mass of media attention focused on developments in portable phones (IMT-2000 or 3G) and Bluetooth connectivity, it is easy to overlook allied technologies that will have major impacts on the future wireless world. Probably the most important trend in wireless communications is the beginning of its transformation from a voice-centric to a data-centric technology. Already, manufacturers of phones are moving to equip up to 50 percent of their handsets with WWW surfing capability by next year. And that is only the beginning as the digital worlds of wireless, computers, and the Internet race headlong down a road where all three will converge. The trend is clearly under way as wireless services transition from 2.5 G to 3G (Fig. 1).

Within the Global Systems for Mobile Communications (GSM) and cdma2000 standards, data protocols such high-speed circuit switched data (HSCSD), enhanced data rate for global evolution (EDGE) and others are coming online. A little farther out on the radar screen, however, are wireless local area networks (WLAN) and Broadband Wireless Access (BWA), two technologies that could change the way data are handled within companies and delivered to the home. The WLAN market is predicted to undergo explosive growth over the next few years—more than seven times its present size by one estimate. BWA in the form of local multipoint distribution system (LMDS) and multichannel multipoint distribution systems (MMDS)—also known as Metropolitan Area Networks (MANs)—may require more nuturing but standardization efforts are underway to bring the large bandwidths of these systems into the wireless mainstream.

The IEEE802.11 specification for 2.4-GHz WLANs is on the verge of a breakout into higher data-rate territory that is expected to greatly expand its range of applications and user base. The original 802.11 working group was established in 1990, but it took until 1997 to get approval of the first standards covering frequency-hopping spread spectrum (FHSS) and direct-sequence spread spectrum (DSSS) as the physical-layer (PHY) standards (IEEE 802.11-1997). These first WLAN sys-



1. Data services are an important aspect of 2.5G wireless phone technology, and will be in the future, as shown in this projected path to 3G envisioned by Tektronix, Inc. The blocks marked GPRS, EGPRS, EDGE, and HSCSD are data-handling protocols.

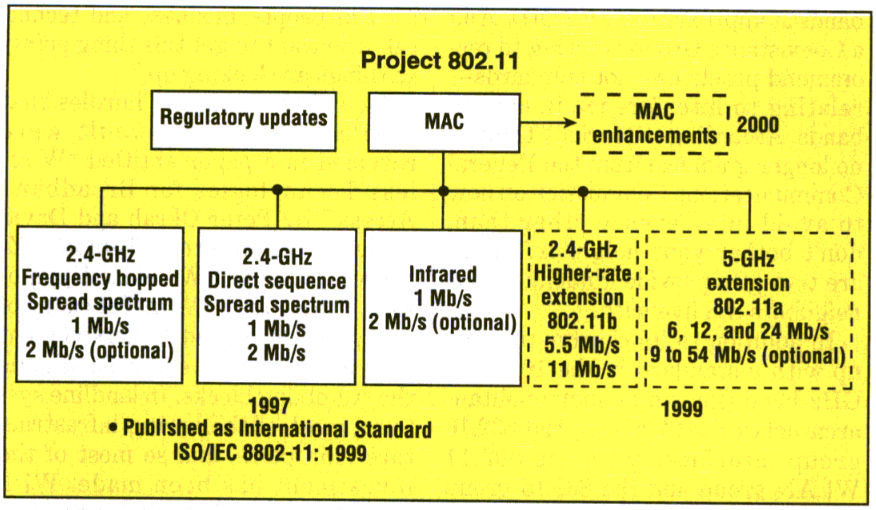
tems ran at data rates from 1 to 2 Mb/s and were aimed primarily at vertical applications such as inventory control, bar-code reading, etc.

To compete against higher data-rate wired LANs, changes had to be made. "Wireless LANs weren't going anywhere until the data-rate issue was solved," says Al Petrick, Director of Marketing and Business Development at ParkerVision, Inc. (Jacksonville, FL) and Vice Chairman of the IEEEP802.11 committee. In order to augment a wired Ethernet LAN, higher data rates were needed and work began in 1997 on higher data-rate extensions to the first standard. These higher rates, according to Petrick, "could serve more users and also be used for voice, isochronous, and video-stream applications." This is a change in emphasis from the original specification, which was always more data oriented.

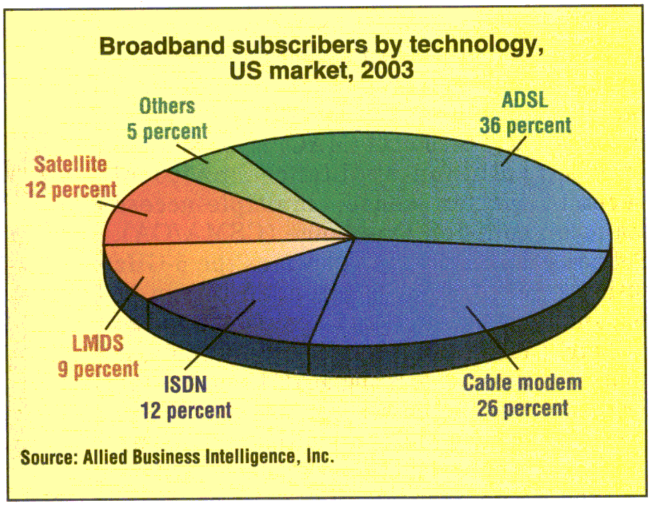
The catch to going to higher data rates was how to do it without creating a new standard. Proposals from WLAN hardware makers Harris Semiconductor (now Intersil) and Lucent Technologies led to the conclusion that the original standard could operate up to a 11-Mb/s data rate. Thus, two new extensions, 802.11a and 802.11b, were born (Fig. 2).

IEEE802.11b is known as the 2.4-GHz high-rate extension and can operate at 11 Mb/s until the distance between transmitter and receiver grows too large—somewhere around 100 feet indoors—at which point the data rate drops back to 5.5 Mb/s. It uses the existing 802.11 medium-access-control (MAC) layer and the collision-avoidance protocol carrier sense, multiple-access collision avoidance (CSMA/CA). IEEE802.11a, known as the 5-GHz extension, is intended to run at mandatory data rates of 6, 12, and 24 Mb/s. Similar to its 11-b cousin, it uses the existing MAC layer, but the modulation scheme, orthogonal frequency-division multiplex (OFDM), is different [11a uses complementary code keying (CCK)].

In Petrick's view, the near term goal for the extensions is to get worldwide adoption so that one system can be used anyplace in the world, perhaps using a computer equipped with a PC card [a personal-computer memory-card international association (PCMCIA) card]. This avoids dealing with various standards that could be in effect in different places. Also on the agenda is obtaining ISO approval for the extensions, something considered very probable. A new goal is called the interactive access-point protocol, which would allow access points to talk to each other, creating a more efficient network structure. Under current WLAN configurations, access points (a transceiver connected to the network) does not know what other points are doing. The



2. IEEE802.11a and 11b are high-rate extensions to the original 802.11 standard adopted in 1997. The higher data rates of the extensions open up new applications in enterprise and consumer markets.



Source: Allied Business Intelligence, Inc.

3. This projection of the broadband wireless and wired markets from Allied Business Intelligence indicates that LMDS services will lag well behind other access means until 2003.

group also wants to establish wireless quality-of-service (QOS) standards for voice and Voice over Internet protocol (VoIP), a technique that permits voice and data to travel simultaneously over a single network line, providing users with more effective phone and fax service.

Ultimately, the higher data rates becoming available will enable WLANs to match the rates of the majority of wired LANs. At 11 Mb/s, 802.11b systems can be considered a direct alternative to 10- Mb/s wired LANs such as 10base-T Ethernet. Not only that, falling prices for WLAN equipment are making it more cost-effective for small and medium-size enterprises to purchase the technology. A recent market study performed by Intex Management Services Ltd. of the United Kingdom puts today's worldwide market for WLANs at 1.07 million units (network-interface connections, access points, and building-to-building bridges.) By 2003, the report states that the number will increase to more than 8.14 million units, and medium to long-term growth will be the result of penetration into the home/consumer market.

802.16 MAKES A BID

Ever since the Federal Communications Commission (FCC) auctioned off a chunk of bandwidth in the 28-to-31-GHz range in the winter of 1998 to 104 bidders, the broadband wireless service called LMDS has shown more promise than progress. But change may be in the offing as the IEEE802.16 Working Group on BWA takes on the task of developing transmission standards that will produce a working foundation for system developers and hardware providers. Recent activity in the working group has centered around developing technical standards for the PHY and MAC layers and whittling down the dozen proposals in the hopper to a few that show the most promise.

The original charter of the 802.16 group was to look into broadband services spanning the frequency range of 10 to 66 GHz, but that range has been expanded to cover frequencies below 10 GHz. According to Dr. Roger Marks of the US National Institute of Standards and Technology, and a member of the 802.15 Group, there are a number of studies and projects underway. In addition to developing an air-interface standard for fixed BWA in the 10-to-66-GHz range, one subgroup is investigating an air-interface standard for unlicensed bands between 2 and 11 GHz. A study group called the Wireless Human Project has been formed to examine unlicensed frequency bands at approximately 5.8 GHz. And a Coexistance Group is trying to recommend practices—not standards—relating to interference in closely bands. According to Marks, "There is no longer guidance from the Federal Communications Commission on how to avoid interference other than, don't bother your neighbor." They are trying to provide guidelines that neighbors can live with.

In addition to its charter to come up with a standard in the 10-to-66-GHz band [known as metropolitan-area networks (MANs)], the 802.16 group interfaces with the 802.11 WLAN group and the 802.15 group which focuses on personal-area networks (PANs). A PAN is a network that is smaller than an LAN. Marks also states that another goal is to turn the Bluetooth specification into an IEEE standard, and work is underway in that area.

Under current technology, broadband access to businesses and residences for services such as high-speed Internet, video and data comes in primarily through the wired infrastructure. Two examples of this type of access are cable modems and digital subscriber line (DSL). The wireless alternatives to these technologies are LMDS and MMDS. LMDS is a two-way point-to-multipoint system that operates in three bands: 27.5 to 28.35 GHz, 29.10 to 29.25 GHz and 31.075 to 31.225 GHz for a total bandwidth of 1.15 GHz. Another auction is planned for this year to sell off an additional 1.4 GHz in the 39-GHz range. The success, or lack of it, should send a signal as to the prospects for the future of LMDS development.

One prediction comes from Allied Business Intelligence (Oyster Bay, NY) which sees the technology trailing well behind the wired DSL and cable-modem access three years down the road (Fig. 3). But Marks takes an opposing view. He says, "LMDS will be growing and coming on very strong. At a recent broadband wireless conference, there were a lot of people, business and technical, who want to get this thing going, so things are looking up."

Two of the technical hurdles that LMDS will have to vault were revealed in a paper entitled "Wireless Technologies for Broadband Access," by Peter Okrah and David Anderson of Motorola (Tempe, AZ) presented at the Wireless Symposium in San Jose, CA in February of this year. Okrah and Anderson point to deployment cost and reliability as the stumbling blocks. In landline systems, most of the wiring infrastructure is in place, and so most of the investment has been made. With LMDS, cost is a factor because some skeptics question whether the cost of the required radio technology will

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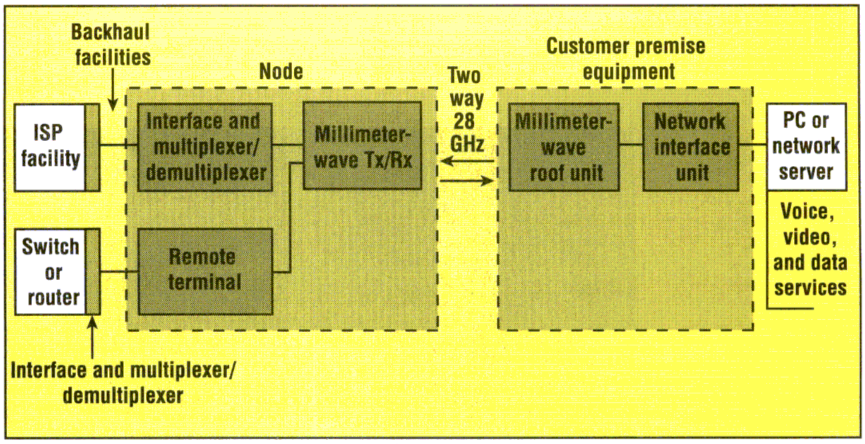


4. A basic LMDS system is a 2-way broadband communications channel running at around 28 GHz. Its extremely wide bandwidth (1 GHz) allows it to support an almost unlimited variety of voice, video, and data services.

come down sufficient to make the technology practical. The radio portion [RF and intermediate frequency (IF)] of the transceivers is a major cost factor, and to compete with DSL and cable modem, the installation and service costs to the consumer must be comparable (Fig. 4).

The second factor, claim the authors, is that LMDS's operation in the millimeter-wave band makes the service vulnerable to environmental conditions such as trees, water vapor, fog, gasses, etc. That is, such conditions can cause signal attenuation that will render the service inoperable. Thus, the equipment would have to be installed under line-of-sight (LOS) conditions, and in non LOS areas, with repeaters, both of which could add cost to the systems.

UMTS IN THE AIR

In all the reportage on the Universal Mobile Telecommunications System (UMTS) and the push toward 3G, the subject of the satellite component receives little mention. In another paper offered at the Wireless Symposium entitled "Satellite UMTS (S-UMTS) Visions and Realities," by Santanu Dutta and Peter D. Karabinis of Ericsson (Research Triange Park, NC), the authors claim that a satellite component of UMTS is essential: "If UMTS is to be truly 'UMTS,' it must encompass a satellite component. This component must be a synergistic derivative of the terrestrial UMTS standard and technology, otherwise it will not be able to afford the economies of scale which are so essential for the end-user product." S-UMTS is defined as any system that will satisfy the requirement of IMT-2000, meaning that it must provide multimedia packet data services of up to 384 kb/s in a mobile environment and address TDMA and CDMA solutions.

The authors offer a basic vision for a mobile-satellite standard (MSS) that must include terminals (handsets) that offer cellular-like size, weight, battery life, and cost. These can be created by aligning the air interface closely with a mainstream terrestrial interface, down to the physical layer. This facilitates the maximum use of cellular components, which enjoy low cost through high-volume manufacturing.

Satellite technology embedded in a phone should not mean bigger, heavier, or significantly more cost for the product. It should mean added value for slightly more cost. The product should remain a consumer (mass-market) product.

This said, the authors offer a view of the technological challenges that stand in the way of making S-UMTS a reality that fulfills the goals mentioned previously. And they are not too optimistic that the challenges can be over come in the near future. The reality, they claim, is approximately ten years off and it will take a combination of working out the standards and technical details to deliver the vision of a truly "universal" system.

The actual hardware or radio equipment that will implement satellite communications and the space technology that will get it up there is close to reality in the view of G. Della Monica and P. Barretto of Alcatel Space Industries (Toulouse, France). In their paper, "Next Generation Architecture Of Satellite Radio Equipment Using Very Latest Wireless Solutions," given at the September 1999 Wireless Symposium in New Orleans, LA. The technology for building satellite is already there, they claim, stating that satellites can be produced on assembly lines in mass-production like quantities. One of the design considerations that has lead to a standoff between different factions is the debate over the reliability level of the components needed for space flight.

Veterans of the satellite business cling to the notion that space demands devices that meet the old "class S" requirements of military systems to ensure the highest reliability. If this is true say the authors, it will be difficult or impossible to build the modern, low-cost electronic architectures that will allow S-UMTS to succeed. Thus, the industry must find a way to produce electronic devices that can meet the military-like requirements of civilian space applications but at commercial price levels. Particularly difficult are the radiation-hardening requirements that any device placed in space must operate with a high degree of reliability over a long period of years.

NEW MODELS

For wireless technology to forge ahead with enterprising projects such as 3G, BWA, WLANs, and others, hardware designers will need tools that can speed up the current design turnaround process to meet time-to-market demands. This means improving the design automation tools used to model amplifiers, mixers, oscillators, and other circuit elements that are the foundation of many RF transmitter/receiver systems. These circuits are growing more difficult to design due to factors such as the need for complex modulation schemes in digital cellular to increase channel capacity, handle data traffic, and receive messages with greater accuracy in the presence of noise and distortion. An important concept behind faster and more accurate design tools is neural networks (NNs).

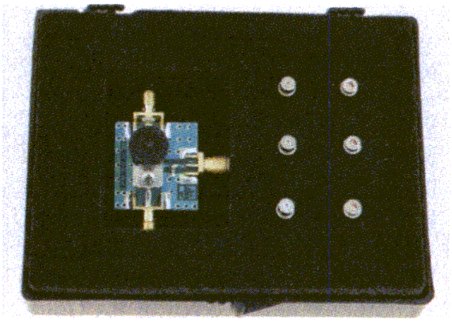
At the conceptual level, NNs are systems composed of a large number of single processing units interconnected by communications channels. Units operate on small pieces of data which then can be processed in parallel to produce results much faster than with serial processing methods. At the practical level, Xpedion Design Systems (Santa Clara, CA) is a company using NNs in its GoldenGate Model Compiler to not only speed up circuit simulations but to give designers more accurate results than can be obtained with conventional modeling.

The standard way to model an individual device or a circuit/subsystem is by writing a complicated equation that describes its behavior over several different bias points, temperatures, or other input variables. The problem is that the more parameters accounted for, the greater the amount of data required or the more complicated the equation becomes. "With NNs," says Jake Goldstein, customer support manager at Xpedion, "you build a model based on data, either from an RF circuit simulator or from measured data. The model can be parameterized at different bias points and is not simulator specific." NNs are known for allowing the creation of numerically efficient models drawn from large input-data bases. Techniques such as table look-up, curve fitting, and polynomial fitting become difficult to handle as the amount of input data gets larger.

According to Richard Curtin, Senior Vice President of Sales and Marketing at Xpedion, "The GoldenGate Model Compiler's capabilities turned out to be more robust than anticipated. So we decided to extend it to device modeling, in addition to circuit and subsystem modeling. By taking NN down to the transistor level, the more accurate the final design will be." This is known as bottom-up design and it permits very complex devices to be modeled accurately.●●

Kits evaluate transimpedance amps

Evaluation kits are available to gauge the performance of the company's integrated detector/preamplifier-transimpedance amplifiers (IDP-TIAs) used in fiber-optic receivers for Gigabit Ethernet and Fibre Channel applications. Each kit includes six IDP-TIAs, one of which is mounted on an evaluation board that provides SMA connectors to the differential outputs. The kit also includes an application note that describes how to achieve optimal performance of the IDP-TIA in a receiver design. Evaluation kits are available for the company's three IDP-TIA models currently in production: AMT121302, AMT128502, and 128503. Model AMT121302 is designed for 1300-nm systems and employs a positive-intrinsic-negative (PIN) diode. Models AMT128503 and AMT128502 are designed for 850-nm systems and employ metal-semiconductor-metal (MSM) diodes. **ANADIGICS, 35 Technology Dr., Warren, NJ 07059; (908) 668-5000, FAX: (908) 668-5132, Internet: http://www.anadigics.com**



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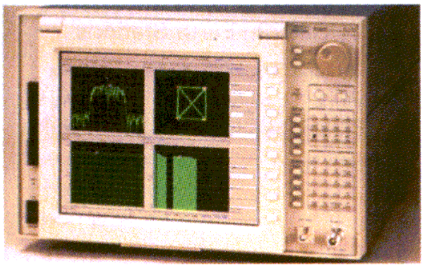

Spectrum-analyzer options serve 3G

Two new options for the model 3086 real-time spectrum analyzer allow it to measure code-domain power and perform analyses of complementary cumulative-distribution functions (CCDFs). These options can assist engineers with the design of third-generation (3G) wireless devices and systems. The code-domain power option, designated Option 16, allows the analyzer to quantify a base station's response to instructions from the network. Option 16 permits measurements that conform to the published specifications for wideband code-division-multiple-access (WCDMA) experimental version 1.1. The CCDF option, designated Option 20, is particularly useful to designers for evaluating the distortion performance of their products. **Tektronix Measurement Group, P.O. Box 3960, Portland, OR 97208-3960; (800) 426-2200 request code 1176, FAX: (503) 222-1542, Internet: http://www.tektronix.com/measurement.**

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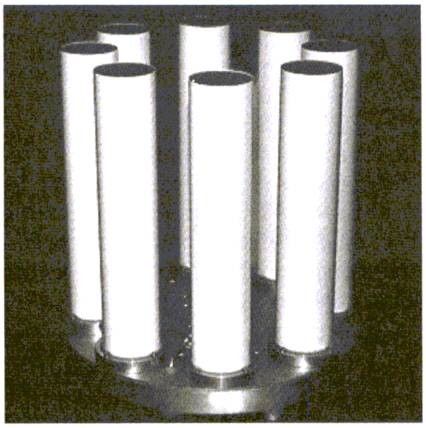

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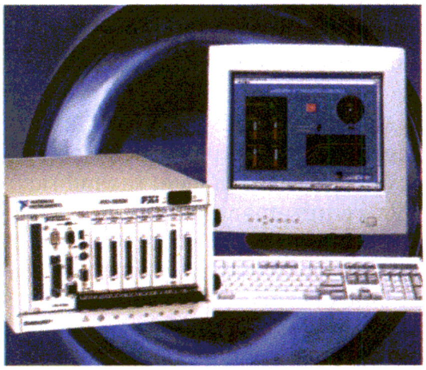
LabVIEW RT software helps engineers and scientists develop real-time application programs for high-speed data acquisition (DAQ), control, test, and process control. It is designed to be used in conjunction with the company's RT series of DAQ hardware. The software's graphical programming environment allows engineers and scientists to develop Windows-based applications without extensive knowledge of traditional text-based programming languages. LabVIEW RT automatically communicates with the RT engine on the RT target hardware, which can be a plug-in DAQ device or a PXI/Compact PCI controller connected through Ethernet. **National Instruments, Inc., 11500 N. Mopac Expwy., Austin, TX 78759-3504; (512) 683-0100, FAX: (512) 794-8411, Internet: http://www.ni.com.**



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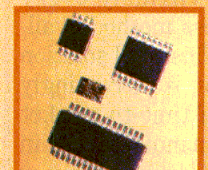
Shape your form factors

with fewer components and smaller batteries



Empowering wireless telecom RF-IC solutions

TEMIC Semiconductors offers SiGe ICs, such as U7006B, that feature extremely high integration. With fewer components, you design smaller, lighter phones. High efficiency and low supply voltage (e.g. T0930: PAE > 50%, $V_s = 1.8$ V) mean they are also lower in power consumption. This lets you both slim down bulky batteries and extend talk-time. Our SiGe products deliver high gain and low noise figures (e.g. U7006B: $G_p = 19$ dB, NF = 1.6 dB @ 2 GHz), enabling higher sensitivity at low supply current. Available now, benefit from our full SiGe range being manufactured in high volume.

	P/N	Description	Application
✓	U7004B/ U7006B	1.9-GHz PA + LNA	DECT RF Front End
✓	T0930	900-MHz PA	2-way pager
✓	TST0950	900-MHz LNA	GSM, ISM
✓	TST0912	900-MHz PA	GSM

PA: Power Amplifier *LNA: Low Noise Amplifier*

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CIRCLE NO. 254

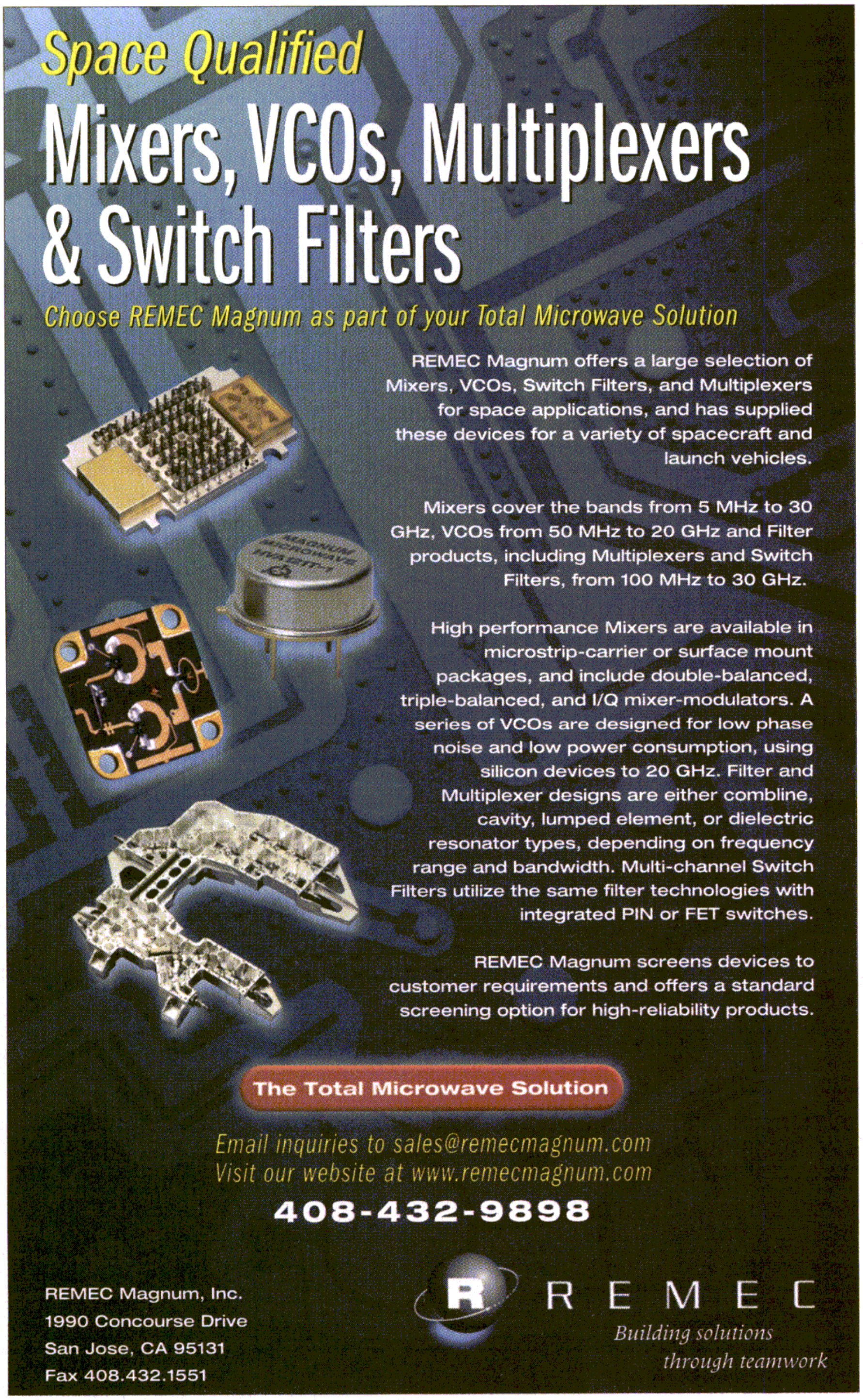
Top Tuner Makers Team Up

Two companies with expertise in developing innovative integrated circuits (ICs) for TV- and radio-broadcasting applications have merged. Microtune, Inc. (Plano, TX) and Temic Telefunken Hochfrequenztechnik GmbH (Ingolstadt, Germany) joined forces in January with the deal being engineered by Hicks, Muse, Tate & Furst, Inc., a Dallas, TX investment house. Microtune acquired the technology, personnel, and assets of Temic, including manufacturing facilities and operations in the US, Germany, and the Philippines. The company will conduct business under the Microtune, Inc. name. Financial details are sketchy, except that Hicks, Muse invested $75 million in the two companies shortly before the merger, and bought out the German company a few weeks prior to the deal.

Microtune's technological achievement is its patented MicroTuner 2000, a single-chip broadband TV tuner that has applications in a wide range of TVs, set-top boxes, cable modems, multimedia personal computers (PCs) and other information-receiving products that are considered vital to the upcoming digital media/communications era. The IC is a breakthrough in tuner technology since it can replace conventional board-type tuners, which are larger and not as versatile. It incorporates an all-silicon (Si) RF architecture that works with various types of broadband networks, operates on the established analog and new digital systems, and handles video/audio information as well as digital data. Microtune recently announced new families of chip and modular products aimed at specific markets such as cable set-top boxes, cable modems, PC/TVs, and digital TVs. These products serve as broadband gateways for bringing audio, video, and data from information providers to information users.

Temic is a manufacturer of tuner ICs used in automobiles and multimedia computers, and has focused on the emerging broadband marketplace. Its customer base includes auto and communications manufacturers such as DiamlerChrysler Corp., Cisco Systems, and Ericsson USA.

The link of the two companies was well-received by financial analysts and industry watchers. Microtune is viewed as an Si company while Temic has a reputation as a systems house. Most pundits believe the marriage puts Microtune in a position to offer its customers a one-stop shopping solution for a complete solid-state RF front end covering virtually every communications access method available or on the way. This total solution for the tuner function is increasingly important because of time-to-market pressures faced by manufacturers in the fast-growing digital consumer electronics and information appliance markets. The merger also gives Microtune entrée into the expanding automotive tuner market.●●



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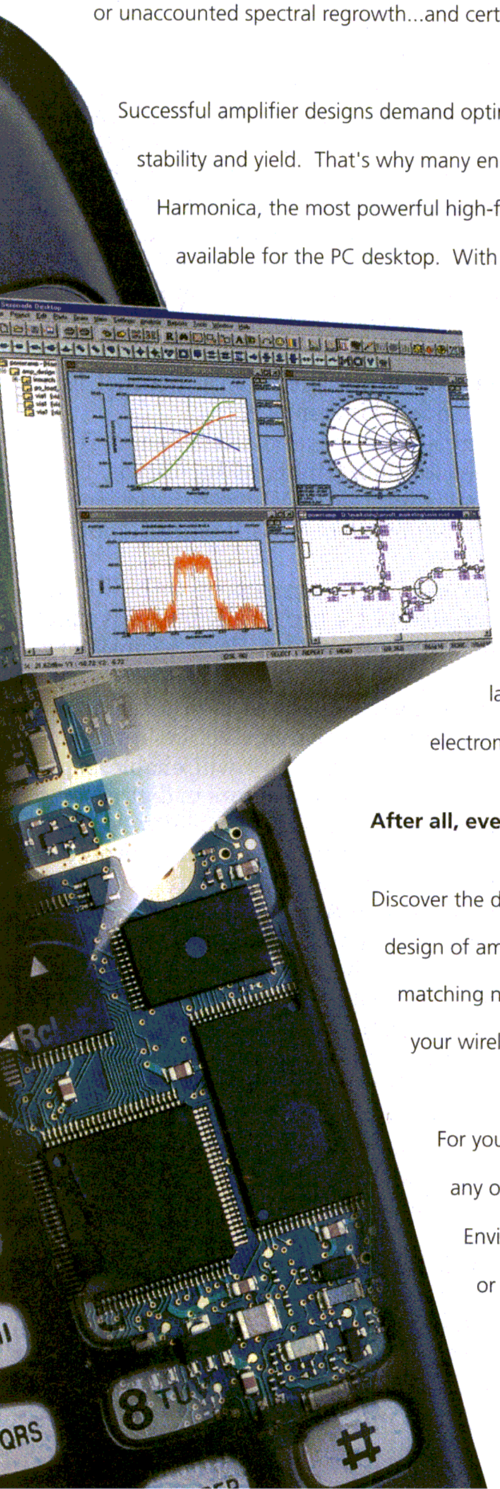
CIRCLE NO. 270



Contracts

Ghana Telecommunication Co. Ltd.—Awarded a $41.5 million contract to Motorola, Inc. for the supply and deployment of its Global System for Mobile Communications (GSM) digital cellular network.

IFR Systems, Inc.—Was awarded a contract from British Telecommunications (BT) valued at $8.1 million over three years to supply calibration and maintenance services for BT's electronic test equipment used in field and laboratory applications throughout the UK.

Sanders—Has received a $7 million Foreign Military Sales contract from the US Army to provide missile-warning systems (MWS) for the Greek armed forces.

LCC International, Inc. and Pinnacle Holdings, Inc.—Have entered into a definitive agreement for LCC's tower subsidiary, Microcell Management, Inc., to sell up to 197 communication tower sites to Pinnacle Towers, Inc., a wholly owned subsidiary of Pinnacle Holdings. The deal is valued at approximately $80 million.

Intermec Technologies' Amtech Systems Division—Has been awarded a multimillion-dollar China Ministry of Railways (MOR) contract to provide RF-identification (RFID) equipment for the Chinese railway network, the fourth largest in the world.

Telespree Communications—Received $6 million in funding from leading wireless venture capital firms to introduce a new category of prepaid wireless communications for the mass market.

Robinson Nugent, Inc.—Has been awarded the contract for the backplane connector for the newly released MAX TNT switch. The MAX TNT is a multiprotocol wireless-area-network (WAN)-access switch that enables carriers, Internet service providers (ISPs), corporations, and major network providers to offer a variety of access services such as analog, integrated-services digital network (ISDN), leased T1/E1, and frame relay.

HTE, Inc.—Was awarded a contract worth $1,037,570 to provide a comprehensive public-safety software solution to the Wisconsin State Patrol. Under the contract, mobile software will be integrated with HTE's dispatching software, CAD V™, so that officers can receive dispatch information, update their status, and run queries from computers in their vehicles.

Glenayre Technologies—Announced that it has received a $5.6 million, three-year contract to provide its enhanced-services solution to Urban Media, an on-site service provider (OSP) delivering integrated broadband communications services to small and mid-sized businesses.

Fresh Starts

Signal Technology Corp.—Acquired the assets of Advanced Frequency Products (AFP) of Andover, MA. AFP is a provider of high-frequency millimeter-wave and microwave transceivers for the broadband wireless communications infrastructure marketplace.

Wavetek Wandel Goltermann—Sold its Precision Measurement Division in Norwich, UK and its Test Tools product line based in San Diego, CA to the Fluke Corp. of Everett, WA.

Silicon Wave, Inc.—Announced the completion of its third round of financing where it raised $35 million. The round included new investors Intel Capital, Seligman Technology Group, TDK Corp., and Velocity Capital Management, as well as existing investors Sevin Rosen Funds, Amepersand Ventures, Signal Lake Ventures, The Benaroya Co., and Japan Asia Investment Co. Ltd. The financing round allows Silicon Wave to continue with the design and delivery of small-power, low-cost radio solutions including the company's recently announced SiW015™ radio-modem integrated circuit (IC).

Alpha Industries—Announced a significant increase in capacity with its new high-throughput i-line stepper, now being used in full production. The stepper has expanded Alpha's capacity with the ability to produce sub-half-micron RF integrated circuits (RF ICs) in high-volume production. Alpha received a second ASML 5500/100 stepper in January, which added even more capacity.

RF Monolithics, Inc.—Has relocated its European sales office to England. The England sales office joins existing North American sales offices in CA, GA, and MN.

Spectrian Corp.—Has entered into an agreement with Metricom, Inc. to provide ultra-linear power amplifiers (PAs) in the 2.3-GHz wireless-communications-service (WCS) band in support of Metricom's Ricochet 128-kb/s launch scheduled for this summer.

Microtune, Inc.—Has merged with Temic Telefunken Hochfrequenztechnik GmbH of Ingolstadt, Germany, a supplier and marketer of RF system solutions to the cable, personal-computer (PC), and automotive industries.

M/A-COM—Has reached an agreement with ITT Industries, Inc. to acquire ITT's GaAsTEK business unit. GaAsTEK will operate as part of M/A-COM, a subsidiary of Tyco Electronics.

Agilent Technologies—Has signed a licensing agreement with SynthSys Research, Inc. for its error-analysis technology. This technology will enable engineers to uncover the causes behind errors in digital components and system hardware. Agilent will develop and globally market bit-error-ratio products that incorporate SynthSys' BitAlyzer technology.

Anaren Microwave and Avnet Electronics Marketing—Announced the signing of an enhanced distribution agreement. Under the agreement, Avnet Electronics will directly distribute Anaren Wireless Group's entire list of surface-mount products to Asia, enabling customers in the Far East to purchase a variety of wireless components locally from a single source.

Analog Devices—Announced that Novatel Wireless, Inc. of San Diego, CA has selected their respective technologies for the development of Global System for Mobile Communications (GSM)/general-packet-radio-switch (GPRS) networks.

TRW, Inc. and Endgate Corp.—Signed a definitive agreement to merge Endgate and TRW Milliwave, Inc., a wholly owned TRW subsidiary, to create a new company, Endwave Corp.

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SPECIFICATIONS

SIZE	DIMENSIONS	ESR	SERIES RESONANCE
A CASE	.055 X .055	10MΩ(1)	3 GHZ(1)
B CASE	.110 X .110	85MΩ(1)	2 GHZ(1)
C CASE	.250 X .250	40MΩ(2)	150 MHZ(2)
E CASE	.380 X .380	70MΩ(2)	120 MHZ(2)

(1) 10 PF, 1 GHZ ESR

(2) 1000 PF, 30 MHZ ESR

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AMT—Pete Manno to president and CEO; formerly executive vice president of Powerwave. Also, John Carollo to vice president and general manager of AMT's Wireless Business Unit; formerly director of marketing at Hewlett-Packard's power-amplifier (PA) division.

Anaren Microwave—David Eastwood to Eastern regional sales manager; formerly Southeastern regional sales manager for a manufacturer of industrial controls and systems.


EASTWOOD


McCAULEY

ANADIGICS—Kenneth W. McCauley to director of field sales; formerly director of sales in telecommunications and wireless applications for Lucent Technologies.

Tekra Film and Adhesive Products—Mark Norton to technical market specialist for the Western US; formerly account executive for contract manufacturing with Key Tronic, Inc.

Current Technology, Inc.—Dean W. Datre to national sales manager; formerly employed in management positions with Square D/EPE Technologies.

The CIT Group/Equipment Financing—James V. O'Halloran to vice president; formerly treasurer of FSI International, Inc.

MYDATA Automation—Pierre Martin to president of MYDATA Japan; formerly president of MYDATA France. Also, Joel Girard to managing director of MYDATA France; formerly sales manager of MYDATA France. In addition, Cheng Chong Foo to managing director of MYDATA Asia; formerly agent support manager at Universal Instruments.

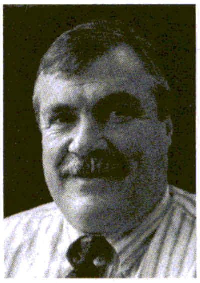
Nextec RF & Microwave, Inc.—David Kim to executive vice president; formerly vice president in engineering at CPI.

Quad Systems Corp.—Elmer O'Brien to vice president of technical services and support; formerly director of field service. Also, Matt Stackhouse to senior director of technical services; formerly director of technical services. In addition, Edward Conson to service manager for the Eastern region of the US; formerly field service engineer.

RLC Electronics, Inc.—Robert DeBrecht to general manager; formerly vice president of engineering at General Microwave Corp.

Microwave Power Devices, Inc.—Alfred Weber to president, chief executive officer, and chairman of the board; formerly employed as president, chief executive officer, and chairman of C&D Technologies, Inc.

Microwave Instrumentation Technologies, LLC—Douglas Kremer to regional sales manager for the north central states; formerly systems integration specialist.


KREMER


TAYLOR

Alpha Industries—W. Thomas Taylor to director of sales for North and South America; formerly Eastern regional sales manager for Murata Electronics.

Andrew Corp.—James A. Yard to vice president of the broadband wireless systems group; formerly employed in wireless network-development work at Sprint.

CTS Corp.—Bernie Cairns to materials director for CTS' interconnect systems business; formerly planning and procurement manager for the high-performance systems business at Digital Equipment Corp. (DEC).

Leitch Technology Corp.—Terry A. Canning to vice president of marketing; formerly president of Bell Gateways.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e-mail: valence@mead.ch or usmead@cmug.com

Advanced Topics for Operating Cellular and PCS Wireless Systems
May 9-12 (Madison, WI)
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University of Wisconsin-Madison
432 North Lake St.
Madison, WI 53706
Katie Peterson
(800) 462-0876, FAX: (608) 263-3160
e-mail: Custserv@epd.engr.wisc.edu
Internet: http://epd.engr.wisc.edu.

Compression for Digital TV
May 10-12 (Los Angeles, CA)
UCLA Extension, Department of Engineering, Information Systems and Technical Management, Short Courses
10995 Le Conte Ave., Suite 542
Los Angeles, CA 90024
(310) 825-3344, FAX: (310) 206-2815
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Internet: http://www.uclaextension.org/shortcourses

Telecom Trends: Markets & Technologies
May 11-12 (Sheraton Austin Hotel, Austin, TX)
Technology Futures, Inc.
13740 Research Blvd., Suite C-1
Austin, TX 78750-1859
Kirsten Palumbo
(800) TEK-FUTR, (512) 258-8898
FAX: (512) 258-0087
e-mail: seminar@tfi.com

CMOS Analog Integrated Circuits
May 15-19 (Milpitas CA)
Continuing Education
Georgia Institute of Technology
Atlanta, GA 30332-3502
(404) 385-3502, FAX: (404) 894-7398
e-mail: conted@gatech.edu

Antennas: Principles, Design, and Measurement
May 22-25 (Orlando, FL)
Northeast Consortium for Engineering Education (NCEE)
Kelly Brown
1101 Massachusetts Ave.
St. Cloud, FL 34769
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e-mail: stcloudofl@aol.com
Internet: http://www.usit.com/antenna

Meetings

International Conference and Exhibition on High Density and Systems Packaging
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Reston, VA 20191-1517
(888) 464-6277, FAX: (703) 758-1066
e-mail: imaps@imaps.org

2000 International Conference on Gallium-Arsenide Manufacturing Technology
May 1-4 (Omni Shoreham Hotel, Washington, DC)
Wes Mickanin, Publicity Chair
TriQuint Semiconductor
Hillsboro, OR 97124
(503) 615-9253, FAX: (503) 615-8903
e-mail: wesm@tqs.com

Wireless Partnering International
May 16-18 (Desert Inn, Las Vegas, NV)
Cellular Telecommunications Industry Association (CTIA)
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Internet: http://www.WOW-COM.com

IEEE International Conference on Phased Array Systems & Technology
May 20-26 (Dana Point, CA)
The IEEE Antennas and Propagation Society
Dr. Michael Thorburn
The Aerospace Corp.
Los Angeles, CA 90009-2957
(310) 336-2197, FAX: (310) 336-6225
e-mail: m.a.thorburn@ieee.org

24th Workshop on Compound Semiconductor Devices and Integrated Circuits (WOCSDICE)
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Dr. Andreas Eisenbach, Workshop Secretary
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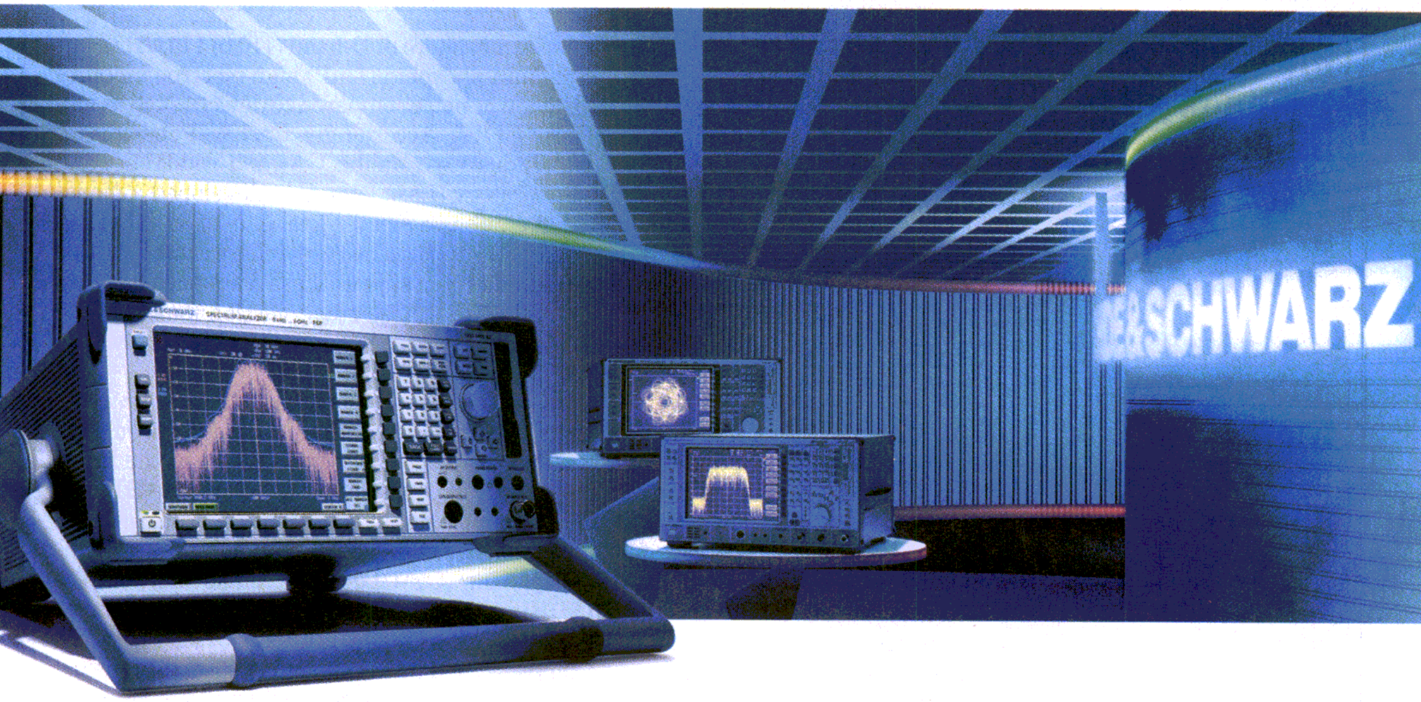
DE&SCHWARZ

High-gain amplifier stars in D-band

Few designers get to work in the rarefied atmosphere of D-band (110 to 170 GHz), but for those who do, they should know that indium-phosphide (InP) high-electron mobility transistors (HEMTs) provide higher gain at lower noise compared to devices such as gallium-arsenide field-effect transistors (GaAs FETs). Accordingly, Carl W. Pobanz *et al.* of the Microelectronics Laboratory of HRL Industries (Malibu, CA), and Todd Gaier and Lorene Samoska of the Jet Propulsion Laboratory (Pasadena, CA) developed a monolithic three-stage InP HEMT amplifier that exhibits a small-signal gain of 30 dB at 140 GHz, and a gain of more than 10 dB from 129 to 157 GHz. The researchers claim that this is highest gain per stage for a transistor amplifier working at these frequencies. A single-stage amplifier occupies only 0.9 mm^2 while the three-stage version measures 2.0 mm^2. See "A High Gain Monolithic D-band InP HEMT Amplifier," *IEEE Journal of Solid-State Circuits,* September 1999, Vol. 34, No. 9, p. 1219.

Digital broadcasting goes optical

Optical-fiber systems will be a cornerstone of the next generation of high-speed communications systems that will deliver consumer and business services such as the Internet, multimedia broadcasting, videoconferencing, and high-definition television (HDTV). Jian-Guo Zhang of the School of Advanced Technologies at the Asian Institute of Technology (Pathumthani, Thailand) claims that the transmission medium for these systems should be optical-fiber code-division multiplexing (OF-CDM). He thinks that an integrated-services-digital-broadcasting (ISDB) system based on OF-CDM offers a number of advantages over wavelength-division-multiplexing (WDM) systems, which can be difficult to control when the user base becomes large. The broadband system design that the author presents can multiplex various types of digital signals with multiple bit rates in ISDB applications. See "Design of Integrated Services Digital Broadcasting Systems Using Multirate Optical Fiber Code-Division Multiplexing," *IEEE Transactions on Broadcasting,* September 1999, Vol. 45, No. 3, p. 283.

E-commerce represents the shape of things to come

Although it is barely three years old, E-commerce (electronic commerce or EC) has already been anointed as the fuel of the economic growth engine of the new millennium. Described simply by Roberto Aaron, Muarizio Dècina, and Riccardo Skillen of the Dumas Institut National des Packeteers, it is about building better relationships among customers, producers, and suppliers. On a detailed level, EC is complex, but its major enablers are the Internet, the World Wide Web (WWW), and electronic mail (e-mail). The authors offer an extremely optimistic and bright forecast for the future of EC: "It is a precocious infant seeking fluent Internet protocols (IP) and spreading its influence everywhere." Their conservative prediction for global EC goods and services (G&S) by 2003 is $2 trillion and a total of approximately $5 trillion over the 1999-2003 time period. The authors attribute a statement by Andy Grove, chairman of microprocessor giant Intel Corp., that projects, "In five years' time there won't be any Internet companies. All companies will be Internet companies or they will be dead." See "Electronic Commerce: Enablers and Implications," *IEEE Communications Magazine,* September 1999, Vol. 37, No. 9, p. 47.

Scope rise-time errors explained

Engineers who test circuits and equipment depend on rules of thumb about equipment such as oscilloscopes that are ubiquitous in the laboratory. For example, Cristoph Mittermayer and Andreas Steininger of the Department of Measurement Technology at the Vienna University of Technology (Vienna, Austria) point out the most common is the widely used relationship between bandwidth and rise time (the rise-time-bandwidth product of 0.35). But this may not always hold true because the rise-time measurement on the scope does not only depend only on the rise time of the input signal and the instrument's frequency response, but also on the shape of the input. A commonly used error-estimation formula is not useful for error correction, and applying it can lead to a greater error than otherwise. Rise-time error varies widely with signal shape, and the best way to estimate it is to know the actual signal shape. The dynamic influence of the scope can be understood only by digital-signal-processing (DSP) analysis. See "On the Determination of Dynamic Errors for Rise Time Measurement with an Oscilloscope," *IEEE Transactions on Instrumentation and Measurement,* December 1999, Vol. 48, No. 6, p. 1103.

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Already designed into several major CDMA handsets, the MGA-72543 LNA's integral switch allows you to bypass the amplifier, reducing system current needs. The ATF-34143 FET with its low noise figure and excellent linearity at 4V, is perfect for base station LNA applications. The ATF-35143 FET offers economical low noise performance for portable applications.

Add it all up and you'd have a hard time finding a more consistent bunch of parts anywhere.

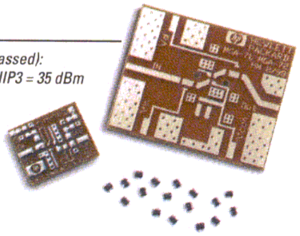
For more product information, technical literature, samples, demo boards and participating distributors, please visit our website.

www.agilent.com/view/consistent

Typical performance @ 2 GHz

Part Number	**Bias**	**NF** (dB)	**Gain** (dB)	**IP3** (dBm)
MGA-72543* (input)	3V, 5-60 mA	1.5	14.4	3.5-14.8
ATF-34143 (output)	4V, 60 mA	0.5	17.5	31.5
ATF-35143 (output)	2V, 15 mA	0.4	18.0	21.0
ATF-38143 (output) *coming soon*	2V, 10 mA	0.5	16.0	22.0

** as a switch (amp bypassed): insertion loss = 2.5 dB, IIP3 = 35 dBm*



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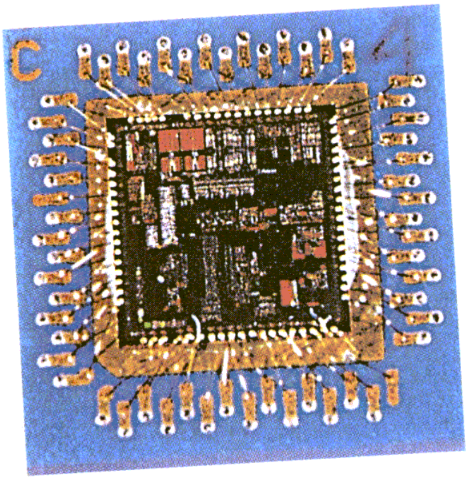
CIRCLE NO. 249

PL47R-11/99

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 wirebonding 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.

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Making EMI-Radiated Emissions Measurements

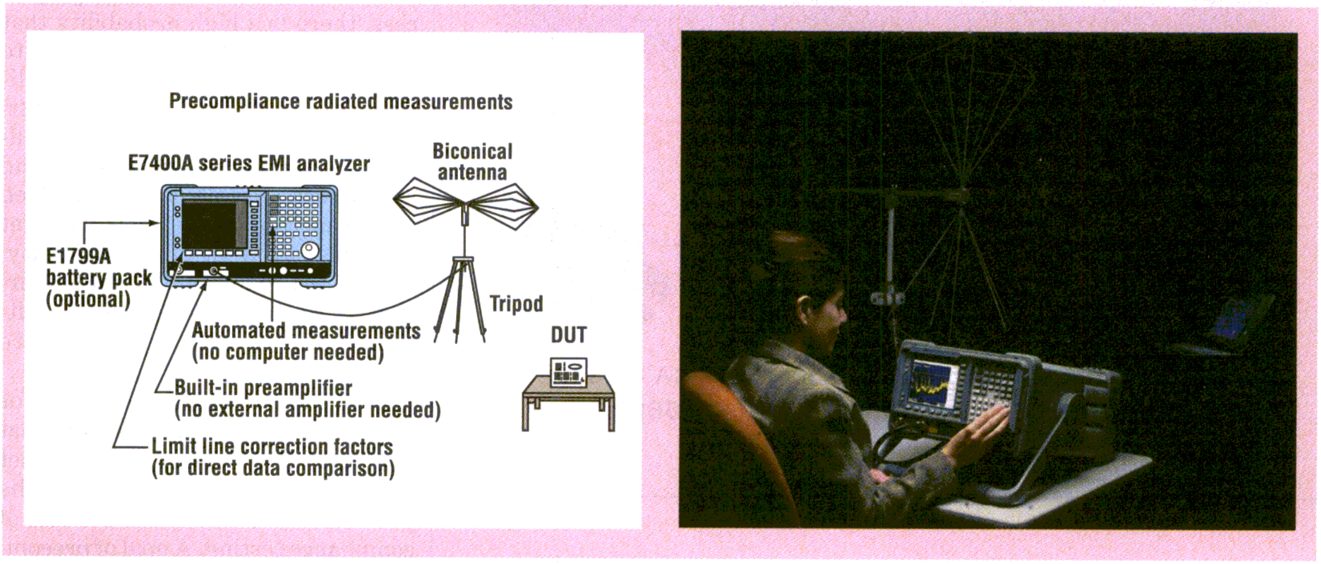
Radiated emissions measurements provide information on a product's ability to operate effectively in a real-world environment.

Dennis Handlon
Applications Engineer
Agilent Technologies, 1400 Fountain Grove Pkwy., Santa Rosa, CA 94501; (707) 577-1400, FAX: (707) 577-4527, Internet: http://www.agilent.com.

FREQUENCY management has two different meanings to cellular communications equipment suppliers. Within a working cell site, it is the sharing of a limited number of frequencies by a large number of users. Perhaps more important, however, it is the need to prevent unwanted signals emanating from one electronic product from interfering with the operation of a second electronic device. Measurements of electromagnetic-interference (EMI)-radiated emissions can gauge the levels of energy "transmitted" by a device and prevent interference from ever occurring.

Measurements of radiated EM emissions can take two forms—compliance testing and precompliance testing. Compliance testing is usually performed at the end of a product design cycle, in a calibrated test laboratory. The test time is expensive and, when a product is found to exceed government regulations for radiated emissions, can be devastating to a sales and marketing team by delaying the introduction and sales "shelf" life of a product while redesigns are performed to correct the EM radiation problem.

Precompliance testing represents a more practical approach to evaluate a product for radiated EM emissions. Precompliance testing of a product's radiated emissions offers a good first



1. A basic EMI precompliance measurement system for radiated emissions testing consists of an EMC analyzer or spectrum analyzer, antennas, close-field probes, and measurement software.

look at the EM radiation given off by an electronic device and helps to isolate and control the individual sources for the EM radiation within a product. Unlike compliance testing, which is performed in a carefully controlled, calibrated environment, precompliance testing is usually performed within a manufacturer's own facility under less tightly controlled conditions, although the measurement equipment to perform the two types of tests may be similar.

The traditional approach to EMI testing is to perform a precompliance test on a prototype unit, hoping that its radiated emissions levels fall below the regulatory limits. Compliance testing can be expensive: every day a product spends at an independent test laboratory for compliance testing can cost $2000 or more, not to mention the lost time to market and additional product-development costs to correct an EM radiation problem.

Compliance testing is performed according to specifications established by regulatory groups, such as the Federal Communications Commission (FCC) in the US and CISPR (Comite International Speciale des Perturbations Radioelectriques) in Geneva, Switzerland. Precompliance testing can follow the same guidelines for radiated emissions in order to isolate and correct problems that are closer to the prototype stage, and prior when a product is ready for the production line. Especially as clock frequencies increase in computers and other microprocessor-driven electronic devices, the potential for undesirable emissions at higher frequencies increases. For example, the FCC now requires testing to 2 GHz if the highest frequency generated or used in the equipment under test (EUT) is in the range of 108 to 500 MHz (the fifth harmonic). If the EUT generates or uses signals in the range of 500 to 1000 MHz, radiated emissions testing must be performed to 5 GHz. Testing is based on analyzing the levels of the fifth harmonic signal of the highest fundamental operating tone or 40 GHz, whichever is lower.

Since compliance testing begins at the end of the traditional design process, there is a high probability that the final product design will fail to meet the electromagnetic-compliance (EMC) objectives during first-time testing while requiring additional engineering resources and components. Problems may be solved easily, such as the addition of gasket material, or with great difficulty, such as the redesign of a printed-circuit board (PCB) to re-route circuit-board traces that act similar to antennas.

Precompliance testing is useful for evaluating electronic equipment that does not fall under the guidelines set by regulatory agencies, and can be performed at a fraction of the cost of compliance testing. A goal of precompliance testing is to achieve the highest accuracy possible in order to

closely approximate the performance of a compliance test system. A typical precompliance test system (Fig. 1) for evaluating radiated emissions consists of an EMC receiver or spectrum analyzer, broadband antennas, near-field probes, and measurement software. Optionally, low-noise amplifiers (LNAs) may be added to increase receiver/analyzer sensitivity. In addition, a line-impedance stabilization network (LISN) will be required for conducted emissions testing. The LISN filters incoming power from the AC mains, prevents line-conducted noise from reaching the EUT, and routes conducted emissions from the EUT to the measurement receiver.

The measurement antenna converts incident electric- or magnetic-field strength into a voltage that can be measured by the receiver. The ratio of the field strength to the voltage at the antenna output terminal is known as the antenna factor. By adding the antenna factor (in dB/m) to the receiver reading (in dBμV), the result is electric-field strength (in dB μV/m) as measured at the antenna elements.

Selection of antennas for EMI testing involves a compromise between antenna gain and bandwidth. High antenna gain, which yields high measurement sensitivity, is possible only for limited bandwidths. As a result, traditionally two antennas are used for EMI measurements: a biconical antenna for frequencies from 30 to 300 MHz and a log-periodic antenna for frequencies from 200 to 1000 MHz. A single antenna can provide coverage from 30 to 1000 MHz, although these designs tend to be more expensive than the combined price of a biconical antenna and a log-periodic antenna.

Since antenna movement relative to the EUT is important for the detection of worst-case emissions, EMI test antennas that are used in a shielded room must be mounted in a way so that a certain degree of rotation to change polarization (usually 90 deg.) is allowed. In a shielded enclosure, the antenna should be raised above the enclosure's ground plane. The height should be adjustable from 1 to 4 m in order to innovation #5

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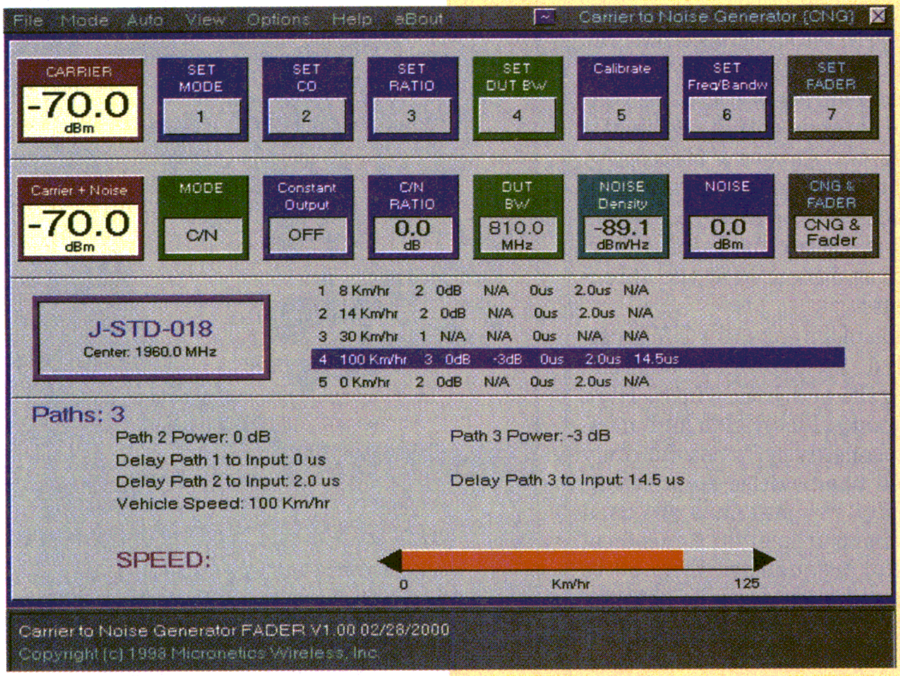

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Paths: 3

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comply with the requirements of major EMI regulations such as those from CISPR. The test antennas should also operate with vertical and horizontal polarizations in order to facilitate detection of worst-case EMI signals.

In addition to antennas, close-field probes may be used for diagnostic purposes when attempting to isolate and identify EM radiation sources in the EUT. As the name suggests, close-field probes are used often within inches of the EUT to detect high field levels. Close-field probes are calibrated in magnetic-field-strength units of dBμA/m/μV at specific frequencies. They can also be used to evaluate EMI immunity and the screening effectiveness of packaging and enclosures. Examples of close-field probes include the 11941A from Agilent Technologies for use from 9 kHz to 30 MHz and the 11940A from Agilent Technologies for use from 30 MHz to 1 GHz.

One of the most critical parts of an EMI precompliance test system for radiated emissions is the measurement receiver or spectrum analyzer (Fig. 2). EMI measurement receivers display voltage as a function of frequency. The measurements are normally provided in logarithmic values in order to show a wide dynamic range, normalized to 1 μV, as dBμV. An EMC analyzer is essentially a radio receiver with filters and detectors as required by appropriate EMC regulatory bodies. An EMI receiver is usually tuned to a fixed frequency or adjusted in frequency steps, where it is usually known as fixed-tuned or stepping receiver. A spectrum analyzer with the proper filters and detector can also perform EMC measurements. Spectrum analyzers, which are also known as swept-frequency receivers, can produce fast analog sweeps across wide spans of frequencies.

Both EMI receivers and spectrum analyzers employ a superheterodyne architecture. In this type of configuration, frequency translation—from high-frequency input signals to lower intermediate frequencies (IFs)—occurs by mixing input signals with signals from a precision local oscillator (LO) within the receiver or analyzer. The fixed-tuned approach lacks the speed of the swept receiver.

EMI receivers for compliance testing in Europe must meet CISPR Publication 16-1 requirements. The receiver must have sufficient frequency range, adequate sensitivity for low-level testing, and enough dynamic range to handle high-level signals without distortion. Filter bandwidths and detection methods are specified so that measurements made on a particular EUT under a given set of conditions with one CISPR-16 EMI receiver will conform with measurements made on the same EUT with another CISPR-16 EMI receiver under a similar set of conditions.

A good spectrum analyzer can have CISPR filters and detectors added without a major increase in cost. The filters must fit the masks specified by CISPR 16. The required filters are 9 to 150 kHz with a fit mask bandwidth of 200 Hz for CISPR band A, 150 kHz to 30 MHz with 6-dB bandwidth of 9 kHz for CISPR band B, and 30 MHz to 1 GHz with 6-dB bandwidth of 120 kHz for CISPR band C/D. Without EMC-based firmware, however, the spectrum analyzer must send measured data to an external computer to properly plot limit lines and account for antenna factors.

To prevent overload and to accurately measure signals according to CISPR requirements, an EMI receiver should have some form of preselector. A preselector is a series of fixed or tunable filters prior to the receiver's front-end mixers. The bandwidths of the preselector filters are wide compared to the resolution-bandwidth filters used in the EMI receiver or spectrum analyzer.

As the receiver tunes across a frequency range, the preselector tunes to the same instantaneous frequency. By tracking the receiver's frequency, the preselector suppresses that part of the frequency spectrum that the receiver is not measuring to reach the mixer at any time. Preselection increases broadband sensitivity by reducing the total energy of the pulsed signals present at the mixer (bandlimiting the harmonics of these signals), and supporting the use of

less input attenuation.

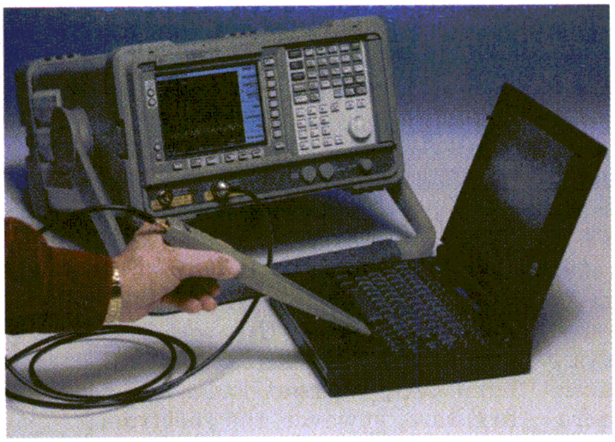
The 8546A/8542E series of instruments from Agilent Technologies is an example of EMI measurement receivers. They operate at frequency ranges to 2.9 and 6.5 GHz while meeting CISPR 16-1 requirements, with ±2-dB absolute amplitude accuracy to 2.9 GHz. The analyzers feature low noise levels of typically –4 dBμV in CISPR band C/D for quasi-peak measurements. A split-screen display allows broad scans and narrow scans to be shown simultaneously.

Detectors are an integral part of a CISPR-compliant receiver. Peak, quasi-peak, and average detection are used to perform radiated and conducted emissions measurements. Some requirements involve quasi-peak and average measurement limits. When peak detection is used, the detector's time constant allows it to follow the fastest changes of an IF sine wave's signal envelope, but not the instantaneous value of the IF sine wave. A peak detector provides the best measurement speed of the three types of detection methods, and offers a worst-case reading of the EUT's radiated emissions. If EUT emissions are below a particular limit when measured with peak detection, the EUT will certainly pass a given test when measured with quasi-peak or average detection, where the measured signals appear at lower levels.

The output levels of a quasi-peak detector vary according to the impulse rate of the measured signal. Quasi-peak detectors are defined by specific time constants. At low repetition rates, a quasi-peak detector has adequate time to discharge the incident energy, resulting in a lower output-voltage reading. At higher repetition rates, the detector can no longer discharge enough of the incident energy and the detector's output voltage reading is higher. Eventually, the reading from a quasi-peak detector reading approaches that of a peak detector, as the repetition rate of an incident signal approaches that of a continuous-wave (CW) signal.

While quasi-peak detectors appear to offer more benefits than peak detectors, their response time is considerably slower than that of a peak detector, and the use of quasi-peak detection can increase measurement times by two to three orders of magnitude compared to the use of peak detection.

Average-value detectors help to measure narrowband EMI signals that may be obscured by a broadband disturbance. For average detection, a peak-detected signal must pass through a filter with bandwidth that is much less than that of the analyzer's resolution-bandwidth filter. The filter integrates or averages the higher-frequency signal components, such as noise, at the output of the envelope detector.



2. The EMI receiver or spectrum analyzer is a critical part of an EMI precompliance test system.

A CISPR receiver is essentially an amplitude-modulation (AM) receiver where input signals are weighted by quasi-peak detection. The receiver includes preselection to filter out nonlinear signal effects. An EMI receiver can be verified to meet CISPR Publication 16 requirements by performing quasi-peak measurement using a pulse generator to create test signals with CISPR-specified pulse widths, repetition frequencies, and amplitude levels.

For example, in the CISPR band B range from 150 kHz to 30 MHz, a pulse with an amplitude level of +13 VDC and a pulse width of 12 ns provides the reference test signal at the input of an EMI receiver. The pulse repetition frequency (PRF) ranges from an isolated pulse to 1000 pulses per second (1000 Hz). Correct EMI-receiver amplitude readings for this test pulse can be seen. For example, for CISPR band B requirements, a 100-Hz PRF pulse should result in a displayed amplitude of 60 dBμV on the EMC receiver. If a 1-Hz PRF is used, a pulse amplitude of 22.5 dB higher would be needed for the same 60-dBμV reading.

Another critical part of the EMI measurement system is the measurement software. With the proper instrument drivers, it can be used to program and control the receiver, perform automated tuning and data capture, and even adjust the position of the EUT (on a rotating table) and the measurement antennas. The software should provide full automated data capture and manipulation to simplify the tasks of logging problem signals and generating practical EMI reports that an engineer can use to correct any radiated emissions problems. The E7415A EMI measurement software from Agilent Technologies, for example, provides a wide range of factory-programmed test setups. A user can also define custom measurement routines.

Once an EMI measurement system has been assembled, the choice of test site must be established. Precompliance measurements of EMI can be performed in numerous different locations, including shielded enclosures, semi-shielded enclosures, and an open-area test site (OATS). A shielded enclosure is a chamber made with conductive walls, floors, and ceilings. Typically, shielded rooms are made of welded or bolted sections of steel, although they can also be made of wire mesh or even conductive wallpaper. The EUT is generally placed insider the enclosure with the test antenna, while the remaining test equipment is located outside of the chamber, with access points for test cables and power lines well-shielded to minimize interference.

Shielded enclosures provide an ambient-free environment and protection from the weather for moderate cost. Since the surfaces are conductive, however, signals from a

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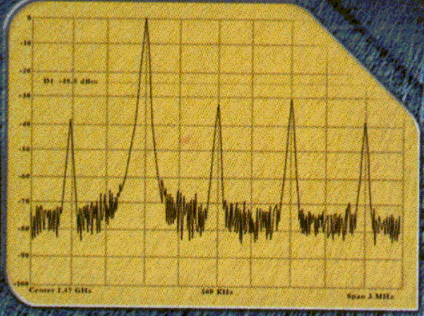

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EUT can exhibit multiple reflections within the chamber and set up standing waves. These reflections can cause large variations in the amplitude of the measured signals, depending upon the size of the room and the location of the EUT and test antenna.

An OATS does not suffer from the reflections of shielded enclosures. It uses a metallic ground plane to emulate the EUT in normal use to ensure that measurements will be repeatable from site to site. However, since measurements are made outdoors, ambient signals will be present and picked up by the test antenna and the EMI receiver. As a result, the test operator must make decisions on which signals should be measured and those signals that can be ignored. In an OATS, large ambient signal sources, such as those emanating from broadcast stations, may mask the emissions from the EUT and potentially cause overload of the EMC receiver. For year-round testing in an OATS, electromagnetically transparent materials must be used for protection from adverse weather conditions.

Successful open-site testing requires attention to many details. The open site must meet the requirements of the applicable EMC standards. The ambient signal environment must be well-characterized to efficiently identify the suspect signals from the EUT. After maximizing the signal amplitudes by locating the worst-case EUT orientation, they are compared to the test limit.

A semi-anechoic chamber is a type of shielded enclosure that attempts to emulate an OATS. To eliminate the multiple reflections of a standard anechoic chamber, electromagnetically absorptive material is added to the walls and ceiling, while the floor is left as a conducting surface. In some areas, such as low-frequency performance, this type of chamber will have difficulty matching the performance of an OATS. For a semi-anechoic chamber to approach the good low-frequency performance of an OATS, especially in the 30-to-100-MHz range, a large amount of absorbing material, either in the form of long absorbing cones or ferrite tiles, must be used.

What difference can absorbing materials make on an EMI test site? In tests performed on a chamber with and without absorbing materials, the unshielded room showed variations as large as 30 dB, indicating standing waves and reflections. When shielding material was added, the room's response behaves much better, although some reflections still exist in the range of 30 to 80 MHz. This is because the small size of the chamber limited the size of the absorbing cones that could be used to reduce these reflections. Cones of approximately 3 m are needed to reduce reflections at low frequencies.

The performance of an OATS can be verified through a site attenuation test, as outlined in ANSI C63.4. In this test, a signal source of known amplitude drives a transmitting antenna located 1 m above the ground plane, positioned where the EUT would normally be placed. The receiving antenna varies in height from 1 to 4 m until the position yielding the maximum receiver reading is found. The signal amplitudes are recorded for each frequency and compared to amplitude readings when the transmit (Tx) and receive (Rx) antenna cables are connected together. For acceptable open-site performance, the site attenuation measurements should fall within ±4 dB of the theoretical response.

If a test site is not an OATS, such as a semi-anechoic chamber, multiple normalized-site-attenuation (NSA) tests must be performed over a test volume that is traced out by the largest equipment or system to be tested. The Tx antenna is placed in the center and the four orthogonal edges of the test volume. Hence, five measurements are performed for vertical and horizontal antenna polarizations.

The measured normalized site attenuation (A_N) can be found from the following equation:

$A_N = V_{DIR} - V_{SITE} - A_{TX} - A_{TR}$ $-\Delta AF_{TOT}$ =the mutual impedance correction factor.

where:

V_{DIR} = the antenna factor of the transmitting antenna,

V_{SITE} = the maximized measurement of the transmitted signal at the receiving antenna,

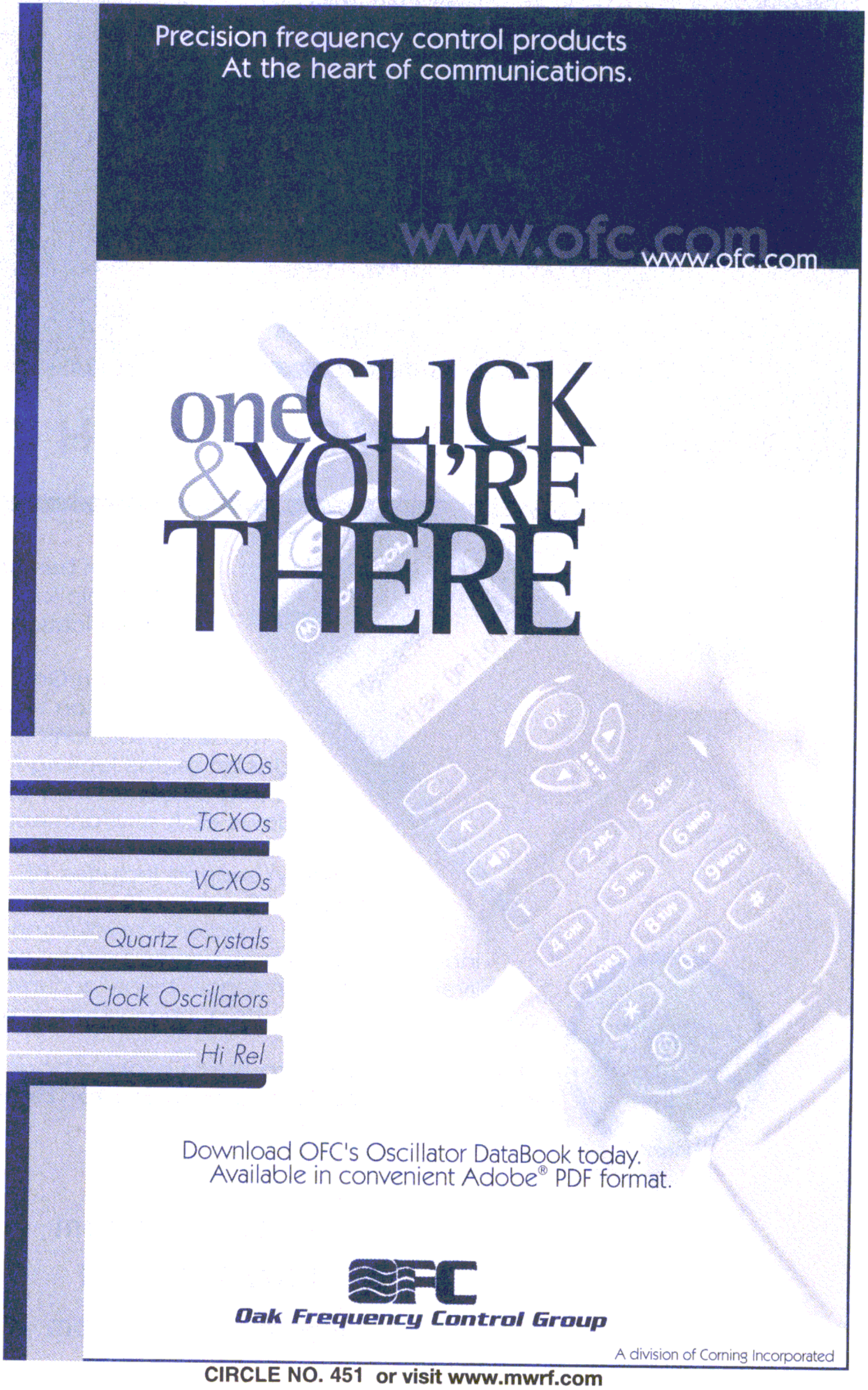
A_{TX} = the antenna factor of the transmitting antenna,

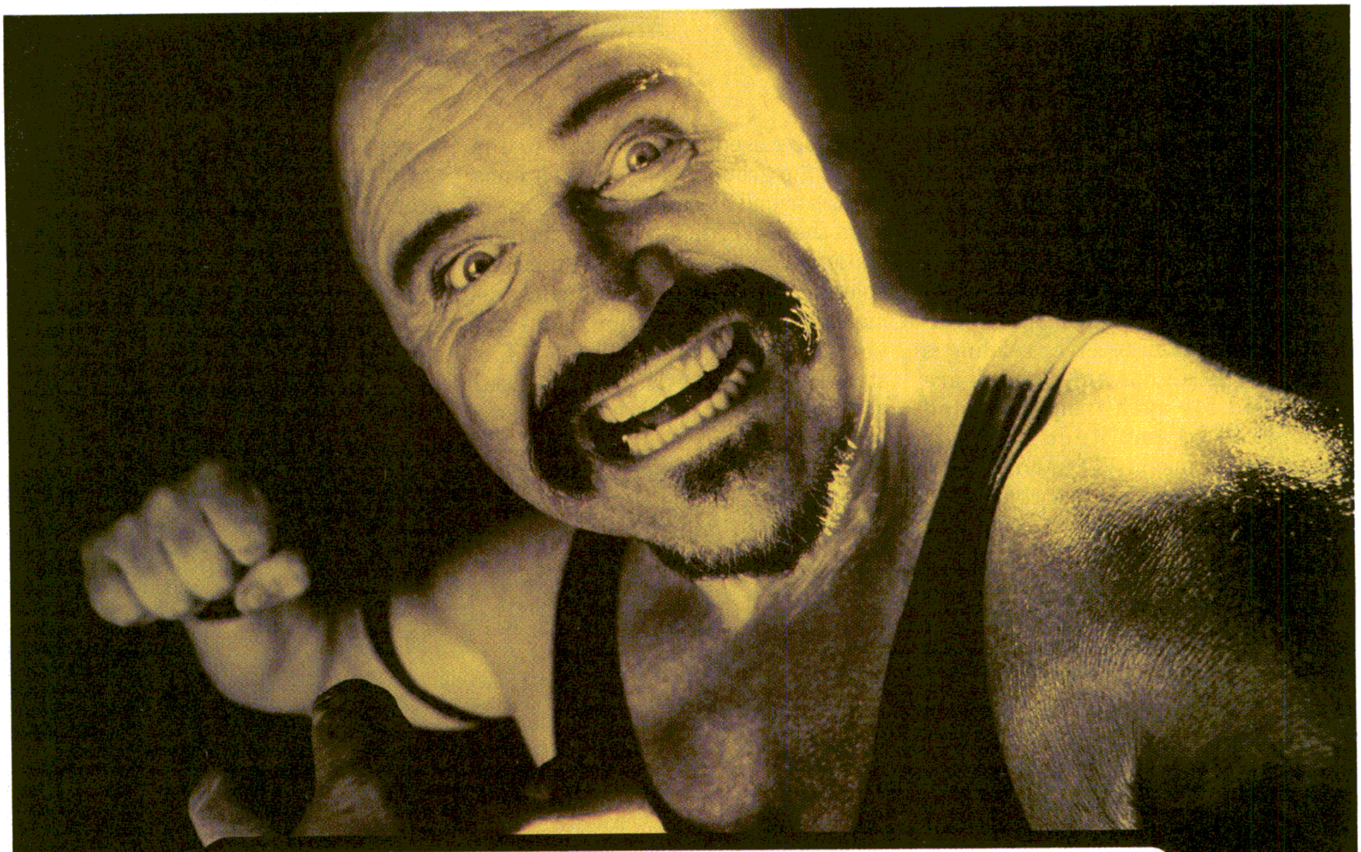
A_{TR} = the antenna factor of the receiving antenna, and

μAF_{TOT} = the mutual impedance correction factor.

NSA measurements must be performed with the antennas in the horizontal and vertical antenna polarizations. In the vertical polarization, the end of the antenna must be at least 25 cm above the ground plane.

For CISPR-based radiated emissions testing, the equipment is placed on an 80-cm-high nonconductive table that can be rotated 360 deg. The antenna is mounted on a mast so that it can be raised and lowered 1 to 4 m above the ground plane. This antenna mast is usually located 3 or 10 m away from the EUT, depending on the regulation. The antenna mount must be able to rotate 90 deg. so that measurements can be made in horizontal and vertical polarization. The EUT is attached to peripherals normally used with the product, and is exercised in a way that is representative of its typical use. The frequency range is scanned and signals must be identified as either ambient or suspect signals from the EUT. The worst-case configuration must be found for each suspect signal by rotating the EUT, raising and lowering the antenna, and changing the polarization until the largest amplitude is found. ••




PLAYS WELL WITH OTHERS

Enhance GMSK Performance With Two-Point Modulation

Two-point modulation can be used to eliminate synthesizer problems in communications systems employing DC-coupled GMSK modulators.

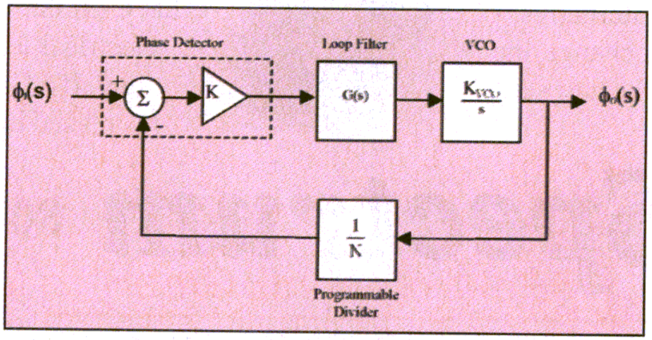
Ron Hunter and Fred Kostedt

MX-COM, Inc., 4800 Bethania Station Rd., Winston-Salem, NC 27105; (336) 744-5050, FAX: (336) 744-5054, e-mail: rhunter@mxcom.com and fkostedt@mxcom.com, Internet: http://www.mxcom.com.

DATA-COMMUNICATIONS systems that employ modulation techniques requiring good low-frequency response place unique demands on system signal sources, usually a phase-locked-loop (PLL) frequency synthesizer. For example, Gaussian minimum-shift-keying (GMSK) and four-level frequency-shift-keying (FSK) modulation schemes require modulation response extending to DC, an attribute that is not easily accommodated by many modulators. This article will discuss the problems encountered when designing GMSK modulators with respect to the characteristics of PLL frequency synthesizers, and show how two-point modulation can be used to solve these problems.

The PLL frequency synthesizer presents a unique problem when designing an effective GMSK modulator. Data patterns consisting of long strings of ones or zeros have a spectral response that extends to DC. Most frequency synthesizers do not respond to this low-frequency signal due to their inherent highpass-filter characteristic when modulated at the voltage-controlled oscillator (VCO). The two-point modulation technique circumvents this problem by splitting the Gaussian filter signal, sending one portion to the VCO modulation input, and the other to the PLL master oscillator. Since the master oscillator is not in the frequency-control feedback loop, it can be modulated by the low-frequency portion of the signal. Modulation at this point, combined with modulation of the VCO, produces a composite signal with a spectral response extending down to DC.

This two-point modulation technique results in an essentially constant modulation sensitivity without regard to the loop bandwidth. The loop bandwidth, which now has little effect on the modulation, may be used for other requirements, such as a wide-loop bandwidth for increased switching speed.



1. This block diagram shows a typical PLL used in frequency synthesizers.

In short, two-point modulation is an effective way to serve the needs of systems that require a modulation frequency response extending to DC. While it is not the only tech-

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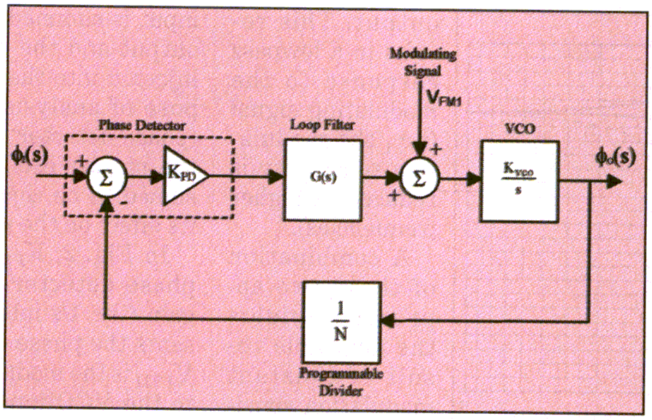
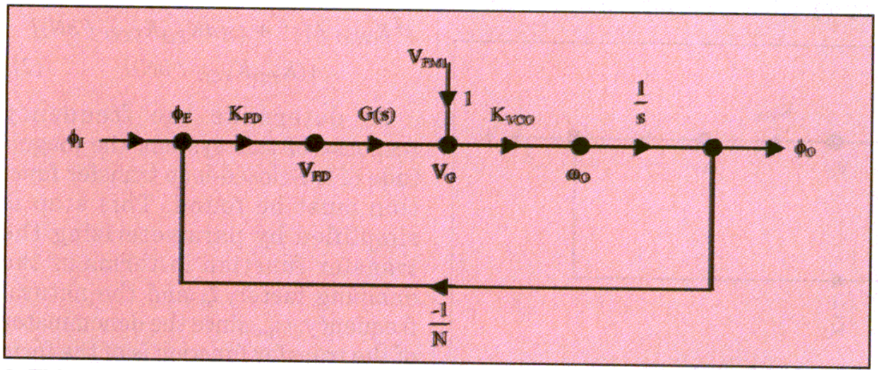


2. In this diagram, modulation is achieved through injection into the VCO.

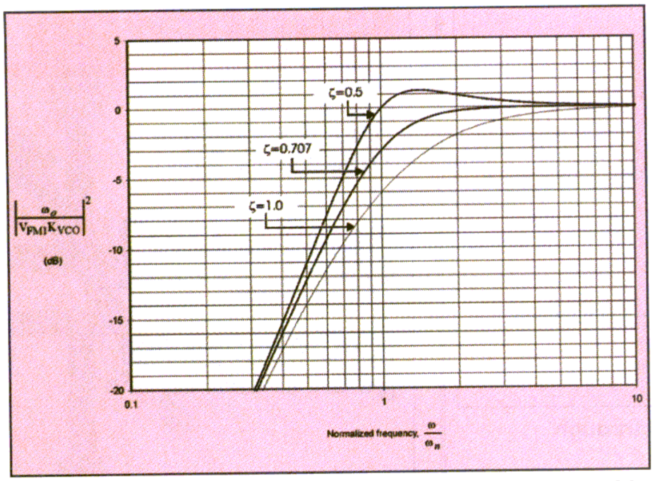
nique that can circumvent the problems inherent in designing low-frequency-response systems, it has been used successfully in several types of communication systems for many years. Once understood, two-point modulation is reasonably easy to translate into highly efficient modulators that meet the requirements of data-communications systems in applications ranging from telemetry to wireless local-area networks (WLANs).

The PLL, the typical platform for frequency synthesizers, is depicted in Fig. 1. Its purpose is to allow the phase of one signal to precisely track the phase of another signal. The phase detector compares the phase of the input signal to the phase of a divided-down VCO output signal, and converts any difference between the phases into an error-voltage signal. This signal is then applied to the loop filter, and the filtered output signal is used to modulate the VCO. When the PLL is in "lock," the output of the VCO is phase-locked to the input signal and changes in the input signal phase will be developed at the VCO output. A PLL can be designed in many different ways depending on system-design objectives. Phase-detector gain, loop-filter response, and VCO gain can all be set independently for a particular application. Many applications do not have stringent requirements for modulator frequency response. However, certain data-oriented schemes, such as GMSK and four-level FSK, require high-quality, low-frequency response. The frequency content of the modulating signal is determined by the pattern of the data string to be transmitted. Due to the inherently variable nature of the data signal, good frequency response for high-frequency and low-frequency content is required for optimal data transmission [i.e., with very low bit-error rates (BERs)].

Modulation can be applied to different points within the PLL, such as at the VCO input and at the master oscillator.[1] When modulation is applied to the input of the VCO, high-frequency content above the loop-filter bandwidth of the modulating signal is developed at the VCO output. Low-frequency content that falls within the loop-filter bandwidth is compensated by the PLL and is not present at the output of the VCO. This provides the PLL with a high-



3. This signal-flow graph helps simplify the derivation of the closed-loop transfer function.



4. This plot shows the highpass modulation response with VCO injection for normalized frequency.

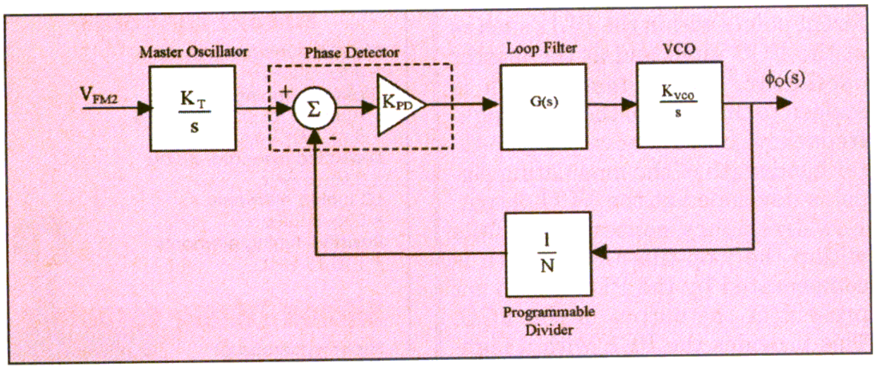
pass characteristic with respect to the modulating signal, and modulation sensitivity is reduced at lower frequencies.^{2}

The master oscillator is another potential injection point for the modulating signal.^{1} The oscillator must, however, be capable of being modulated by a voltage signal. When the modulating signal is applied to the master oscillator, only the frequency content that is within the loop-filter bandwidth is presented at the VCO output. This results in a lowpass response to the modulating signal (i.e., the modulation sensitivity is reduced at higher frequencies).^{1}

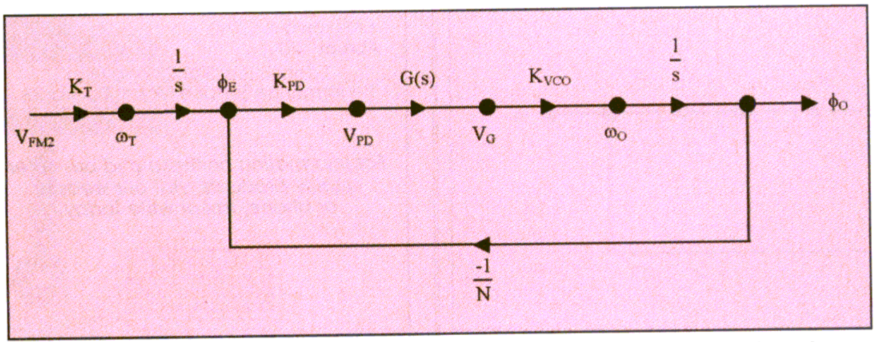
A combination of these two approaches yields the desirable result of constant modulation sensitivity without regard to loop bandwidth. This is readily achievable by applying modulation at two points within the PLL, an approach known as "two-point modulation."^{1}

To demonstrate how two-point modulation achieves the desired high and low frequency response, it is helpful to describe each modulation injection point along with its frequency response, and compare it to two-point modulation. The use of superposition simplifies the analysis and is used in the discussion.

In this scenario, the modulation input is summed with the loop-filter output and the composite signal is injected into the VCO. For the purpose of analysis, the second input (phase-detector input) representing the master oscillator signal is presumed to be constant, which causes its effect on the system to be zero.^{3}



5. In this system, modulation is achieved by injection at the master oscillator.



6. This signal-flow graph helps simplify the derivation of the transfer function for the system with modulation injection at the master oscillator.

In Fig. 2, K_{PD} is the gain of the phase detector, K_{VCO} is the VCO gain (the 1/s integrator term represents the phase of the VCO output), V_{FM1} is the modulating signal applied to the VCO input, N is the divider constant, ϕ_i is the phase of the input signal, ϕ_0 is the phase of the output signal, and G(s) is the loop-filter transfer function. The signal-flow graph of this system (Fig. 3) simplifies the derivation of the closed-loop transfer function.

In the signal-flow graph, ϕ is the phase of the error signal, V_{PD} is the voltage signal at the output of the phase detector, V_G is the voltage input to the VCO, and ω_O is the VCO output represented as a frequency.

The closed-loop transfer function for this system is:

$$\omega_O / V_{FM1} = K_{VCO} / \{1 + [K_{PD}K_{VCO}G(s)] / sN\} \quad (1)$$

Since second-order loops are the most popular in common design practice,^{5} a second-order, type-2 PLL is used for analysis. Since active loop filters are the norm today,^{5} an active filter will also be used for analytical purposes.

Setting G(s)=(1 + sa)/sb, where a and b represent resistive-capacitive (RC) time constants, and simplifying yields:

$$\omega_O / V_{FM1} = s^2K_{VCO} / \{s^2 + [s(aK_{PD}K_{VCO} / bN)] + (K_{PD}K_{VCO} / bN)\} \quad (2)$$

To determine the frequency response of this system, the magnitude of the closed-loop transfer function must be found. This step is simplified by parameterizing the transfer function in terms of the damping factor, ζ, and the natural frequency, ω_n. Since the denominator of the transfer function is of the form $s^2 + 2\zeta\omega_n s + \omega_n^2$, the transfer function can be parameterized once values of ζ

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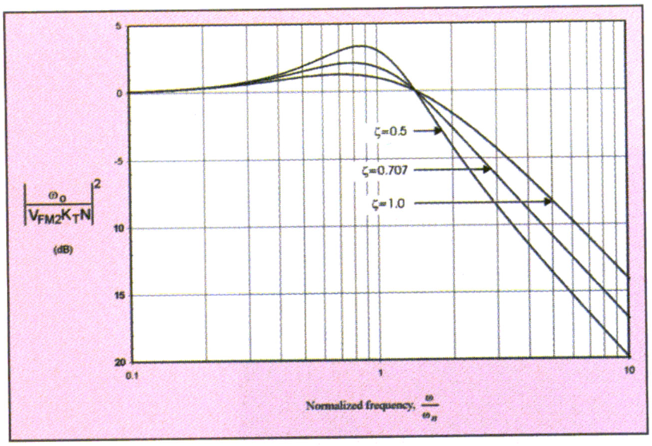


7. This plot shows the lowpass modulation response for the system with master-oscillator modulation injection.

and ω_n are known.

$$\zeta = (a/2)(K_{PD}K_{VCO}/bN)^{0.5} = (a/2)\omega_n \qquad (3)$$

$$\omega_n = (K_{PD}K_{VCO}/bN)^{0.5} \qquad (4)$$

Rewriting the transfer function in terms of ζ and ω_n yields:

$$\omega_0/V_{FM1} = K_{VCO}s^2/(s^2 + s2\zeta\omega_n + \omega_n^2) \qquad (5)$$

Substituting $j\omega$ for s constitutes the next step in determining the magnitude of the transfer function. Next, the numerator and denominator must be multiplied by their complex conjugates (for any complex number C, $CC^* = |C^2|$).[6] The transfer function can then be simplified by multiplying numerator and denominator by $1/\omega_n^4$.

The final answer is:

$$|\omega_0/V_{FM1}K_{VCO}|^2 = (\omega/\omega_n)^4/\{(\omega/\omega_n)^4 - 2(\omega/\omega_n)^2 + 4\zeta^2(\omega/\omega_n)^2 + 1\} \qquad (6)$$

The highpass modulation response of this system is shown in Fig. 4. In this configuration, the modulation input is applied to the master oscillator, and the modulation input to the VCO has been set to zero (Fig. 5). While there are a variety of oscillators to choose from, the master oscillator that is used in this system must be capable of being modulated by a voltage signal. That is, the oscillator must have some type of voltage-controlled characteristic. In Fig. 5, V_{FM2} is the modulation signal injected into the master oscillator and K_T is the gain term of the master oscillator (the 1/s integrator term represents the master-oscillator output in terms of phase).

The signal-flow graph for this system is shown in Fig. 6, where ω_T is the master-oscillator output expressed as a frequency.

The closed-loop transfer function of this system is:

$$\omega_0/V_{FM2} = [(K_T/s)K_{PD}K_{VCO}G(s)]/\{1 + [K_{PD}K_{VCO}G(s)]/sN\} \qquad (7)$$

Setting G(s) to (1 + sa)/(sb) and simplifying yields:

$$\omega_0/V_{FM2} = [(K_TK_{PD}K_{VCO}/bN)(1 + sa)]/\{[s^2 + s(aK_{PD}K_{VCO})/bN] + (K_{PD}K_{VCO}/bN)\} \qquad (8)$$

This equation can be written in terms of ζ and ω_n as follows:

$$\omega_0/V_{FM2} = [K_TN(\omega_n^2 + s2\zeta\omega_n)]/(s^2 + s2\zeta\omega_n + \omega_n^2) \qquad (9)$$

The frequency response (amplitude) of the system can be found as before:

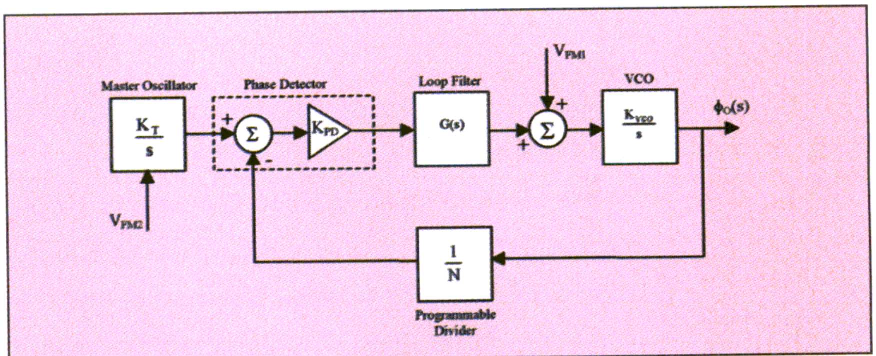
$$|\omega_0/V_{FM2}K_TN|^2 = [1 + 4\zeta^2(\omega/\omega_n)^2]/[(\omega/\omega_n)^4 - 2(\omega/\omega_n)^2 + 4\zeta^2(\omega/\omega_n)^2 + 1] \qquad (10)$$

The lowpass modulation response of the system is shown in Fig. 7. In this case, the modulated signal is injected simultaneously into the master oscillator and the input of the VCO. A diagram of the configuration is shown in Fig. 8. The signal-flow graph for this combination approach is shown in Fig. 9.

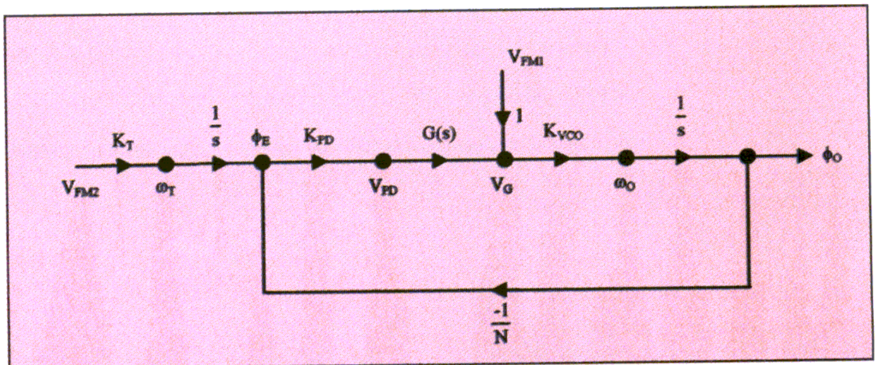
Using superposition and the previously determined transfer functions yields:

$$\omega_0/V_{FM} = (\omega_0/V_{FM1}) + (\omega_0/V_{FM2}) \qquad (11)$$

This can be simplified in terms of ζ and ω_n to:



8. In this synthesizer diagram, the modulated signal is injected simultaneously into the master oscillator and the input of the VCO.



9. This signal-flow graph helps to visualize and simplify the derivation of the dual modulation-injection approach of Fig. 8.

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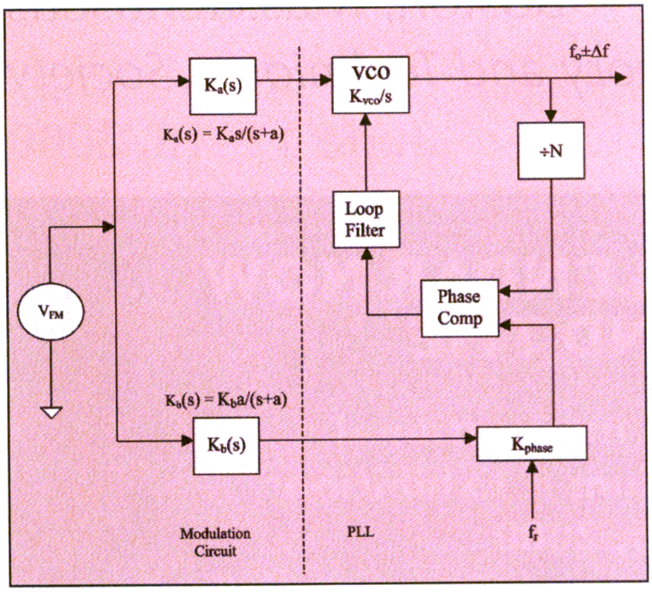
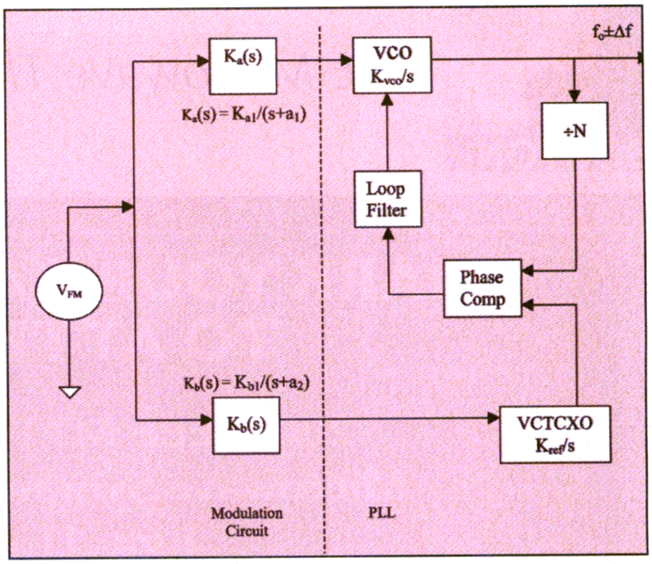


10. This complementary filter modulation circuit employs highpass and lowpass filters to realize a near-perfect integrator.



11. This voltage-controlled-temperature-compensated-crystal-oscillator (VCTCXO) modulation circuit achieves the perfect integrator needed for the two-point modulation scheme.

$$\omega_0 / V_{FM} = [s^2 K_{VCO} + K_T N(\omega_n^2 + s2\zeta\omega_n)] / (s^2 + s2\zeta\omega_n + \omega_n^2) \qquad (12)$$

Using the method described previously, the magnitude of the combined transfer function can be expressed as:

$$|\omega_0 / V_{FM}|^2 = [(\omega / \omega_n)^4 K_{VCO}{}^2 - 2(\omega / \omega_n)^2 K_{VCO} K_T N + 4\zeta^2(\omega / \omega_n)^2 K_T^2 N^2 + K_T^2 N^2] / [(\omega / \omega_n)^4 - 2(\omega / \omega_n)^2 + 4\zeta^2(\omega / \omega_n)^2 + 1] \qquad (13)$$

As ω approaches 0 in this equation, the value of the combined magnitude function approaches $K_T N$. As ω approaches infinity, the value of the combined magnitude function approaches K_{VCO}. In order to achieve a uniform frequency response that equals K_{VCO}, K_T can be manipulated as follows:

$$K_T N = K_{VCO} \qquad (14)$$

$$K_T = K_{VCO} / N \qquad (15)$$

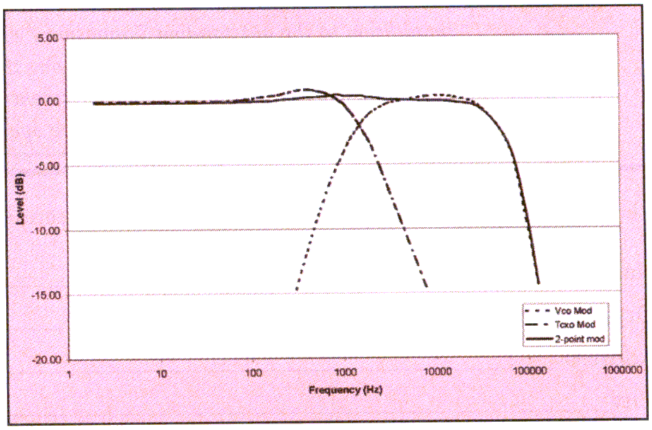
With proper selection of K_T, the modulation response will be flat across all frequencies.

As can be seen from the previous discussion, modulation at two points improves the frequency response of a synthesized modulator. Modulation at either input of the phase comparator requires not only amplitude matching through its path to the phase comparator but also a conversion of the frequency-modulating signal of the VCO to a phase-modulating signal.

PERFECT INTEGRATOR

Two methods have been suggested in the literature to realize the perfect integrator required to convert the frequency modulating signal to a phase-modulating signal. The highpass/lowpass complementary filters suggested by Underhill[1] and Brennan[3] nicely deliver a practical implementation of this conversion, as shown in Fig. 10. The resultant effective modulation is free from the highpass effect of the PLL and its loop filter. It still has a highpass characteristic due to the highpass filter used in the VCO modulation path. Grimmet[4] shows an alternate method of implementing a perfect integrator that is very inventive and impressive.

There is another possible solution for the frequency-to-phase-conversion requirement of the proposed two-point modulation scheme. For quite some time, designs have been using temperature-compensated crystal oscillators (TCXOs) as the reference signal for PLL synthesizers. The temperature compensation of these references appears as a signal that is inversely proportional to the change in frequency of the reference due to temperature. This temperature-compensating signal is a low-frequency modulation of the master oscillator. The integration



12. This plot shows the frequency response of a system using the topology shown in Fig. 11, with less than 1-dB ripple across the band.

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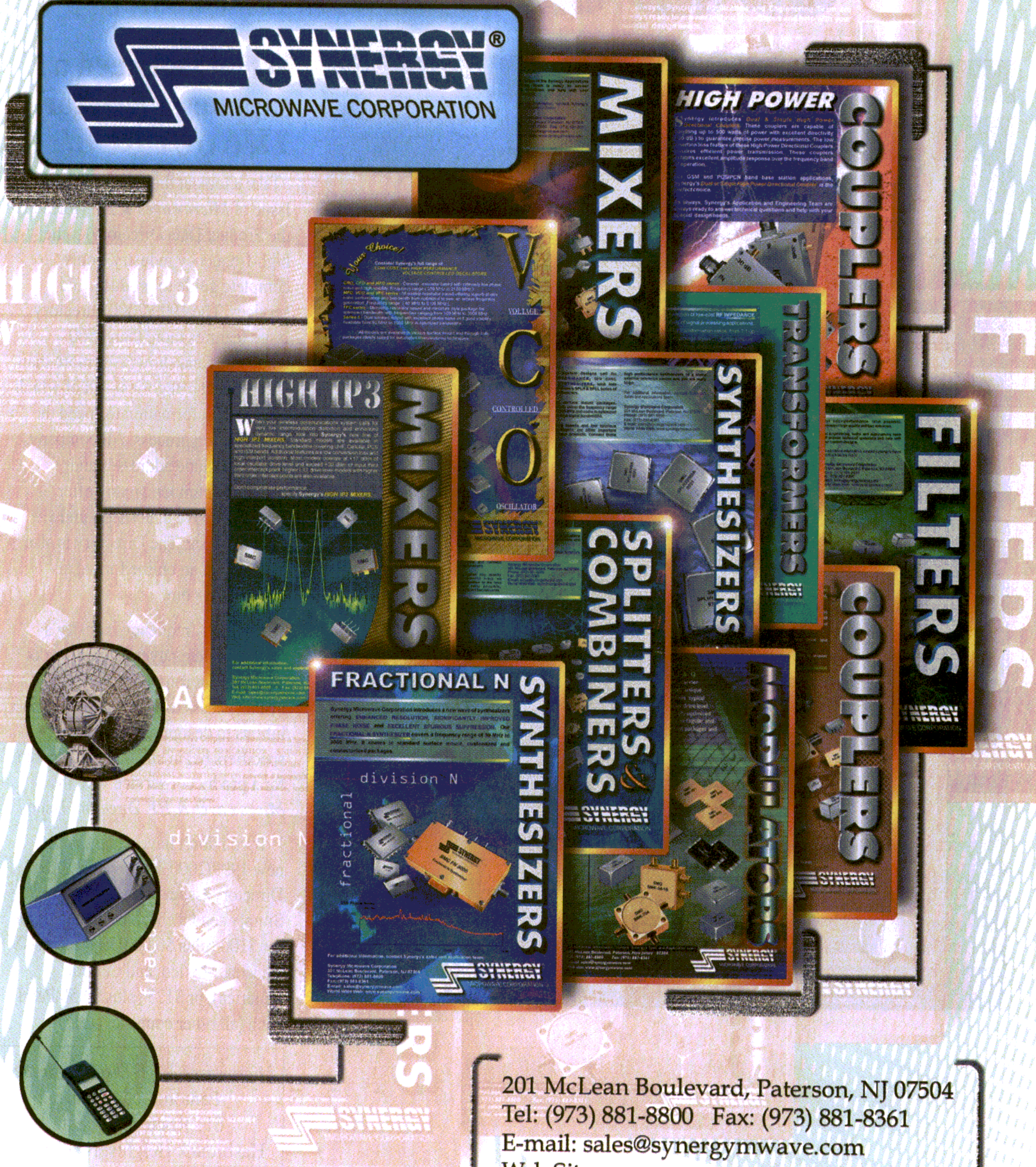

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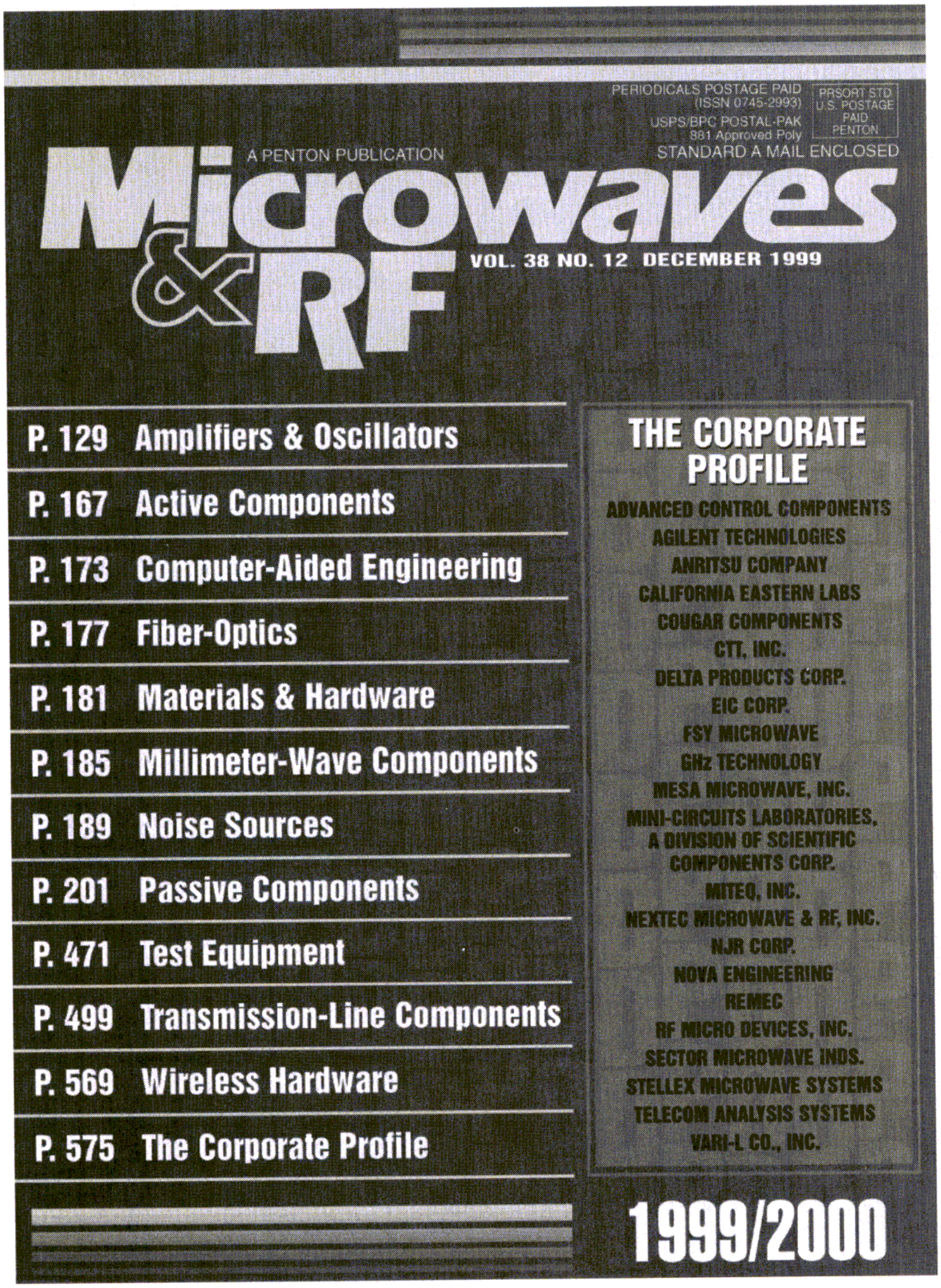

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inherent in a VCO transforms frequency modulation into phase modulation. As such, the voltage-controlled characteristic of the master oscillator transforms the frequency modulation of the temperature-compensating signal to the phase modulation required by the PLL at this injection point.

Modulation through the master oscillator, as shown in Fig. 11, has supplied the perfect integrator needed, and concern shifts from trying to realize a perfect integrator to ensuring that DC operating points, amplitudes, and frequency responses of the VCO are correct. Special attention should be paid to the damping factor of the loop filter. The more damped the loop is, the flatter the resultant composite frequency response will be.

FREQUENCY RESPONSE

Figure 12 shows the frequency response of a system using the topology shown in Fig. 11. The loop filter was first order with a damping factor of approximately 1 and a natural frequency of about 1 kHz. The three frequency responses that are shown represent modulation at the VCO, TCXO, and at both points together. The ripple across the band is less than 1 dB.

Many crystal manufacturers offer voltage-controlled TCXOs (VCTCXOs) that are appropriate for many systems. Of course, special system requirements may require an inhouse design solution. This type of two-point modulation is very effective and has been serving the needs of low frequency response systems for years. It is well worth considering as a solution for near-DC modulation requirements.●●

Acknowledgments

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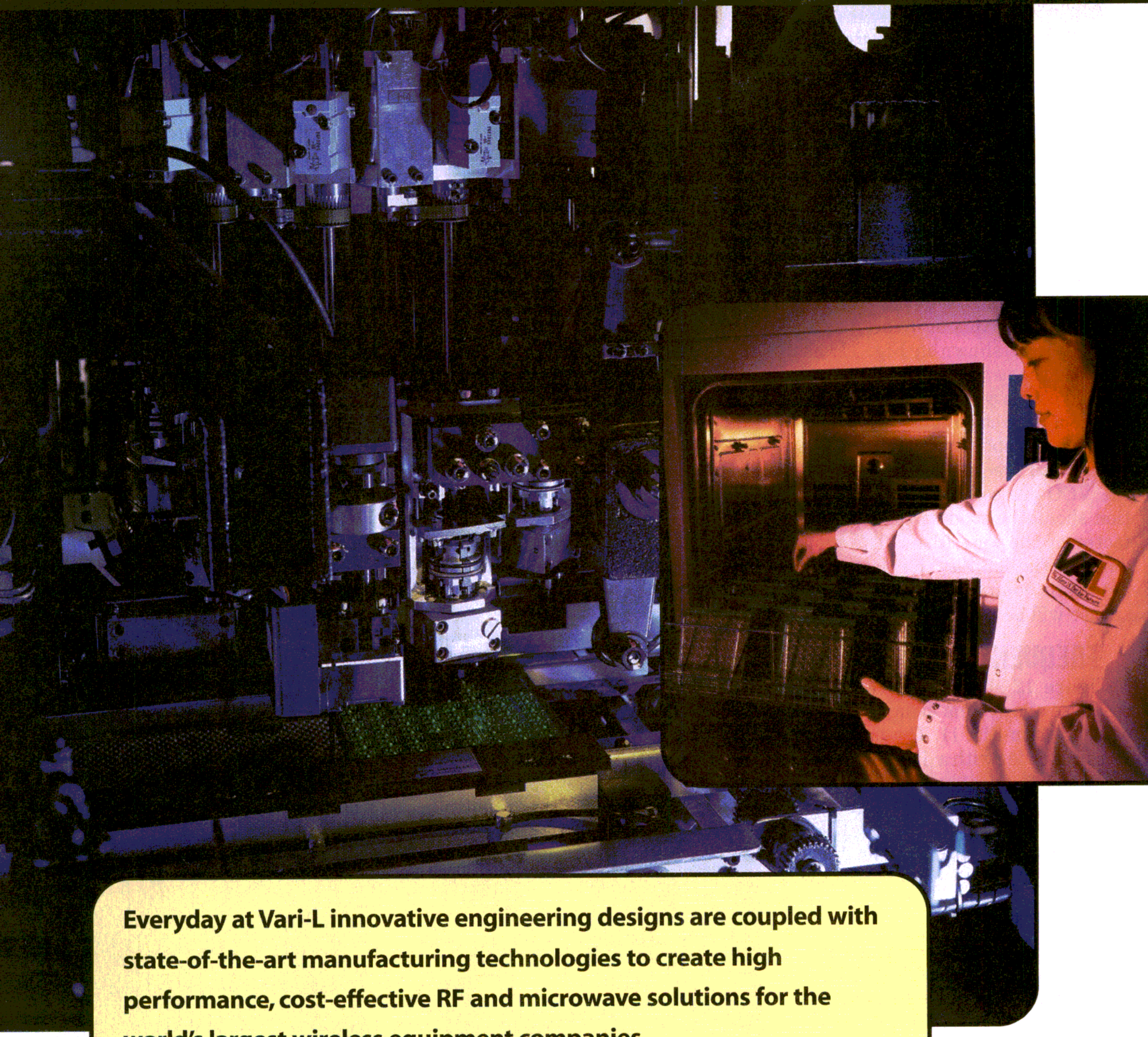
References

1. R.I.H. Scott and M.J. Underhill, "FM Modulation of Frequency Synthesizers," *IERE Conference on Land Mobile Radio*, Lancaster, England, September 1979.
2. P. Brennan and B. Murray, "Frequency Synthesizer Using LSI Devices," *Electronic Components and Applications*, Vol. 3, No. 1, November 1980.
3. P. Brennan, *Phase-Locked Loops: Principles and Practice*, McGraw-Hill, New York, 1996.
4. S. Grimmet, "Frequency Modulation In A Phase Lock Loop By Control of the Phase Inside the Loop," *RF Design*, Vol. 14, No. 6, June 1991.
5. Heinrich Meyr and Gerd Ascheld, *Synchronization in Digital Communications - Volume 1: Phase-Frequency-Locked Loops and Amplitude Control*, Wiley, New York, 1990.
6. Zoher Karu, *Signals and Systems Made Ridiculously Simple*, ZiZi Press, Huntsville, AL, 1999.



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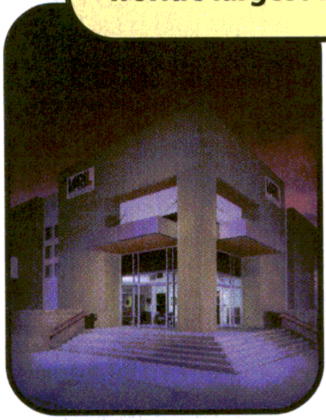

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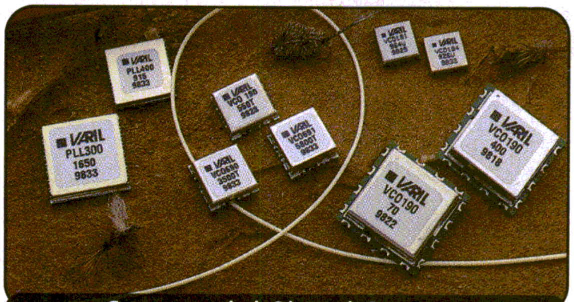

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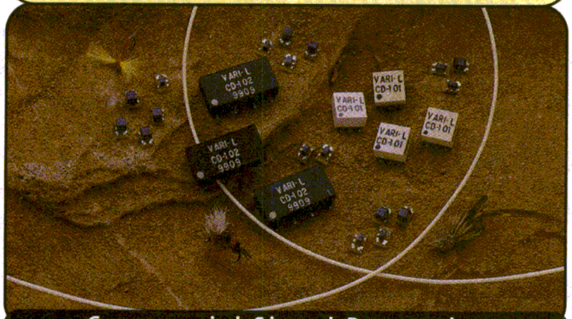

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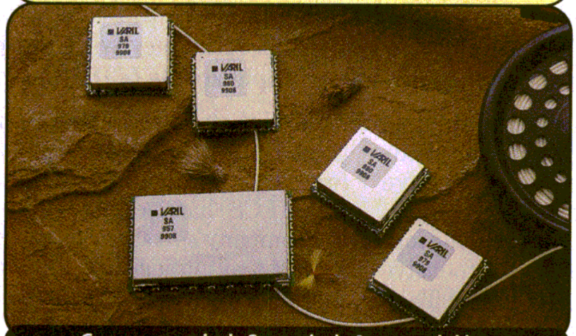

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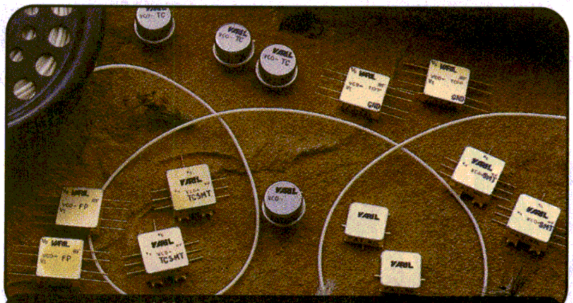

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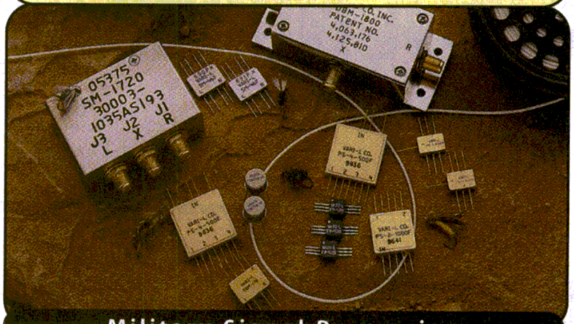

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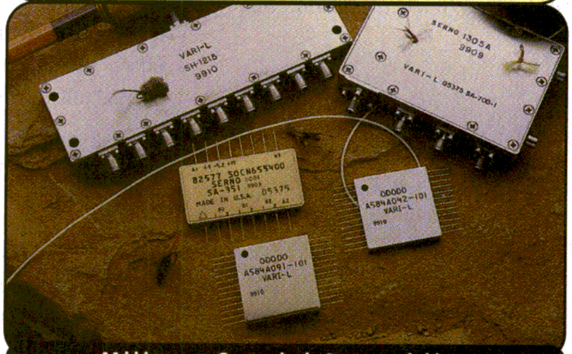

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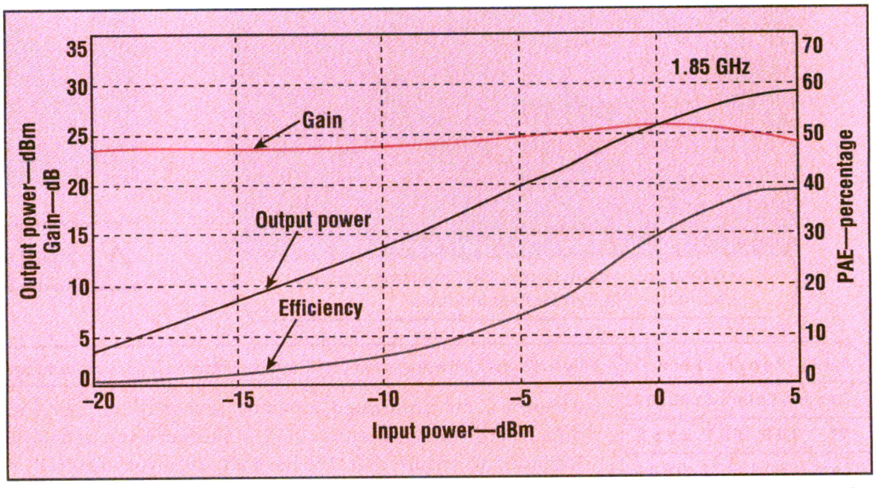
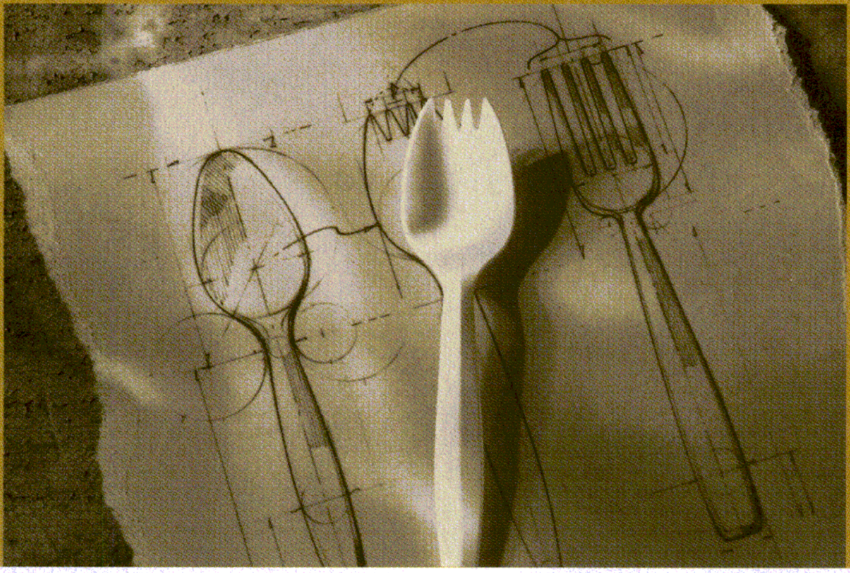
Engineers at Alpha Industries, pushed by handset designers' needs for decreasing cost targets, have managed to cost-effectively integrate high-performance depletion-mode technologies with inexpensive silicon (Si)-support circuitry.[1] They have also continued to develop components using technologies and techniques that eliminate the need for support circuitry altogether. In addition, the firm has also recently implemented their first CDMA design, in the form of the model AP126-89 PA for personal-communications-services (PCS) handsets. Not only was it the company's first series attempt at a CDMA amplifier design, it was also the company's first attempt at implementing HBT technology.

To reduce the time of the product-design cycle, and significantly increase the likelihood of success for the first design pass, the design cycle



1. The output power, gain, and PAE of the AP126-89 are plotted as functions of input power.



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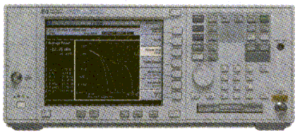

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Frequency (GHz)	DC-3.5	DC -3.0	DC-1.8
Gain (dB)	13.8	15.4	19.7
TOIP (dBm)	34.0	36.0	34.0
P1dB (dBm)	20.0	20.0	20.0
N.F. (dB)	3.9	3.8	2.9
Supply Voltage (Vdc)	4.2	5.0	5.2
Supply Current (mA)	75	80	75

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

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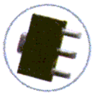

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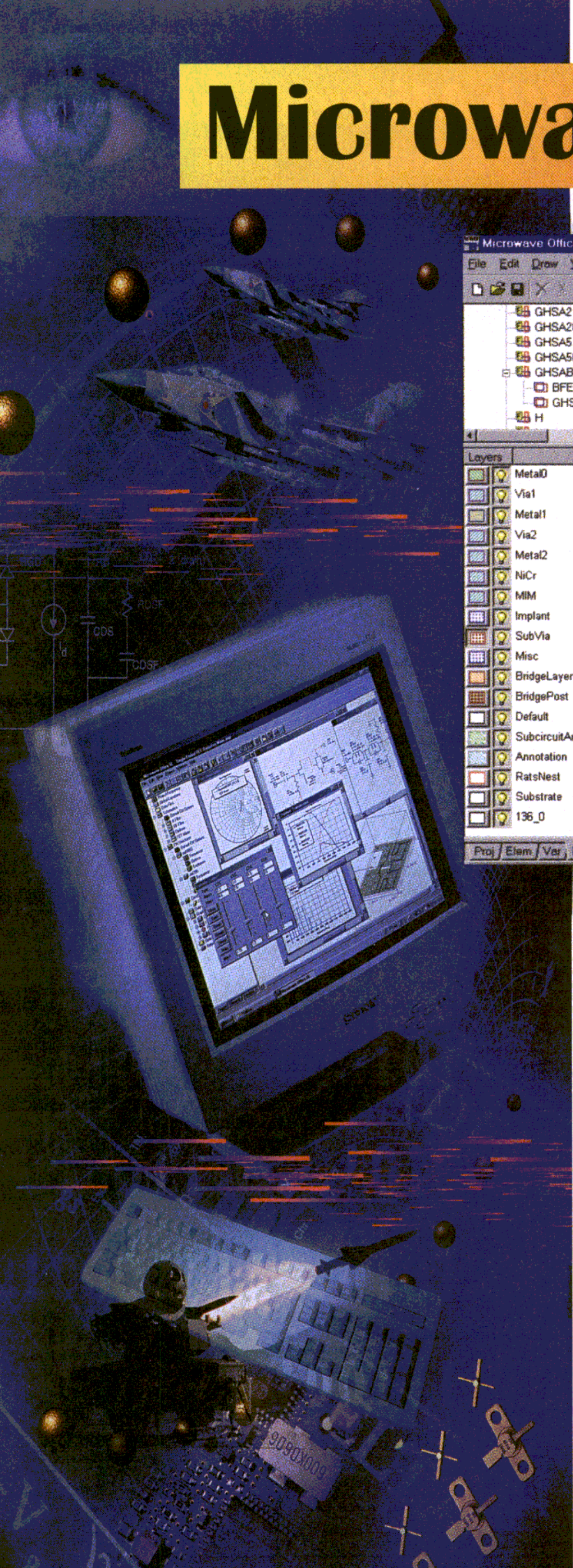
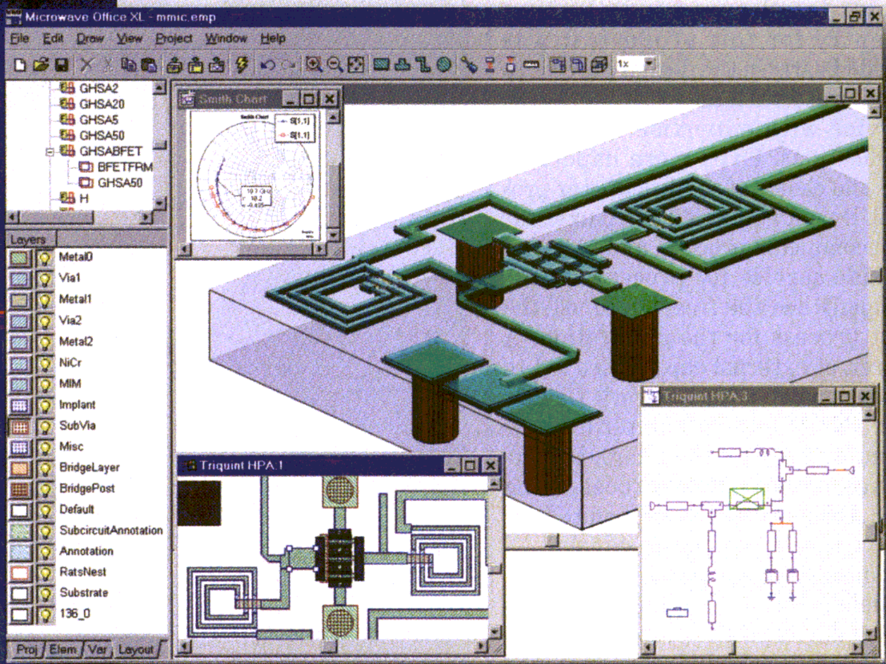
for the AP126-89 was approached differently than for previous design efforts. In order to minimize barriers to entry for this product, it was decided early in the design process to collaborate with an external design service with expertise in bipolar applications. Even more important was the choice of semiconductor process. By not being tied to a particular semiconductor process, and using an outside service for processing, the company had the freedom to use the best process for the application. A search of external capabilities led to a relationship with Network Device, Inc. (NDI) and the amplifier was manufactured on their high-performance AlGaAs HBT process. The NDI HBT process is well suited for PCS and cellular CDMA signals.

Considering the short design cycle, modeling was a very important part of the development process. Alpha's engineers worked closely with the design partner to create models for the NDI devices, specific to the device geometries and operating conditions. In addition to the modeling effort, Alpha measured a substantial amount of empirical data, including automated measurements of power, efficiency, and linearity contours, to address limitations in the models.

The model used for the design of the amplifier was a simple Gummel-Poon large-signal model created by curve fitting to DC and RF characterization data of measured HBT engineering devices. The subsequent model was used to predict the large-signal, unmodulated signal power and efficiency. Empirical data were used to find the optimum power loads and operating points for linear performance. New models are presently under development, which will allow designers to predict modulated performance as a function of temperature.

Based on the model and load contours, and the need to meet the gain requirements of the PCS band, a three-stage design was chosen. To simultaneously meet the gain, output power, and linearity requirements, a ratio of 1.0:4.5:3.6 was used for the three transistors. These three ratios provided the necessary gain and drive from the first two stages to the

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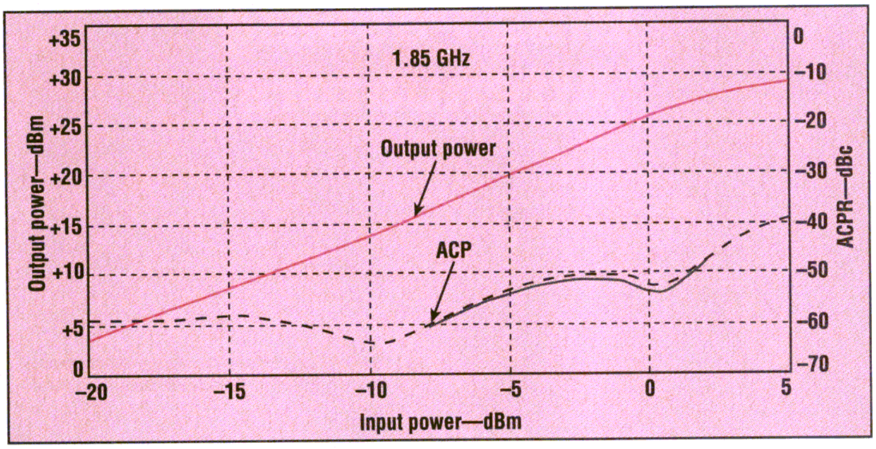
final stage, which was sized for a peak-to-average output power ratio of greater than 4:1.

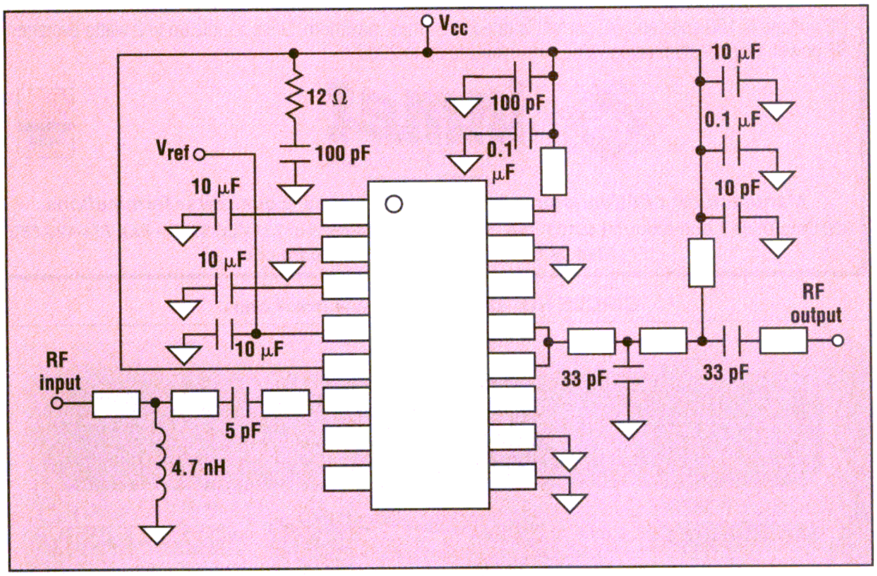
After device sizes were chosen, the next most important concern was the transistor layout. Although the layout of a MESFET or pseudomorphic HEMT (PHEMT) device is important and can affect its performance and reliability, it is absolutely critical for HBT thermal management. The first issues addressed were specific to meeting the output-power and efficiency requirements. Careful measurements were then made to study the thermal performance of the device and its impact on RF performance. The fundamental HBT cell dimension selection, unlike that of an FET technology, needs to take the impact of thermal effects into consideration. The cell's thermal resistance as well as the thermal coupling between device emitter fingers within the cell impact the onset of current "hogging" by one of the emitter fingers. If, however, too large a cell is used, a negative impact will take place on cost and RF performance. In this design, a 2 × 20-µm emitter-cell design was used. An emitter-ballast resistance was also used to delay current hogging to higher-current densities. The use of a dual-emitter finger per cell has the advantage of reducing the dimensions of the output stage while the relatively short 20-µm fingers minimize thermal issues.

In its first design iteration, the AP126-89 met the requirements for a handset CDMA PA. The amplifier delivers +28-dBm linear output power at 1.85 GHz with power-added efficiency (PAE) of 37 percent (Figs. 1 and 2). The AP126-89 is packaged in a high-power, exposed-pad SSOP-16 package with low electrical and thermal paths to ground.

As previously noted, a large percentage of the matching elements are fabricated on chip. However, the output-matching circuitry, a portion of the input-matching circuitry, and the RF bypassing circuitry were kept off chip to maximize the RF performance. Flexibility is a fundamental guideline of all PA designs at Alpha. By keeping the output-matching circuitry external to the package, it was



2. The linearity performance of the AP126-89 is shown here in terms of output power and adjacent-channel power (ACP).



3. For optimal performance, external matching and bypassing circuitry must be added to the AP126-89 HBT amplifier.

possible to account for multiband operation and differences in customers' handset architectures. They key to achieving the performance shown in Figs. 1 and 2 was a combination of optimizing the packaging, the bias ratio per stage, and finding a balanced linear/power load. Figure 3 shows the external matching and bypassing circuitry required for optimal performance.

One key advantage of HBT technology over MESFET or PHEMT is that high performance does not rely on submicron device geometries. Therefore, HBTs are easier to manufacture for a particular high-frequency product, and more producible. This does not alleviate the need for circuitry enhancements, however. CDMA transmitters, whether is handsets or in base stations, require precise control over the bias conditions to deliver the necessary linearity performance from part to part and over the full range of temperature and battery conditions. To meet these requirements, an on-chip active bias controller was used to consistently set proper bias condition. The first-generation bias controller was based on a traditional current mirror. The advantage of this approach is simplicity and temperature stability.

The AP126-89 is a first-generation product that met its intended performance targets. The next-generation design will continue and design and

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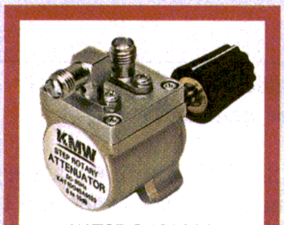

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Attenuation Step (dB)	0.2	1
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VSWR (Max.)	1.25:1	1.25:1	1.25:1
Attenuation Range (Min.)	13dB @ 2GHz		
Nominal Impedance	50 ohm		
I/O Port Connector	SMA(F) / SMA(F)		
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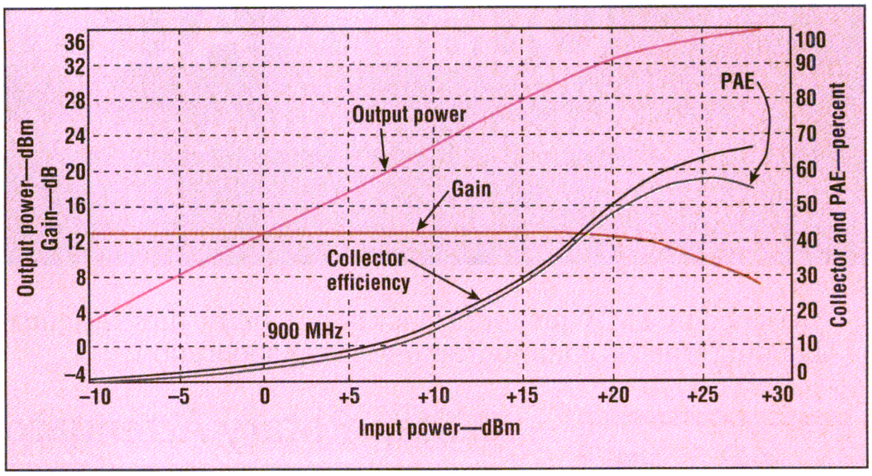
development philosophy applied to the AL126-90 while taking advantage of recent improvements in semiconductor and processing technology as well as design and model enhancements. In the redesign of the AP126-89, the design is being transferred to a more robust and significantly more reliable InGaP HBT process and simultaneously addressing issues that will improve the amplifier's RF and DC performance levels, thereby improving its manufacturability.



4. The performance of a single-stage amplifier fabricated with the InGaP HBT process is shown at 900 MHz in terms of output power, gain, and PAE.

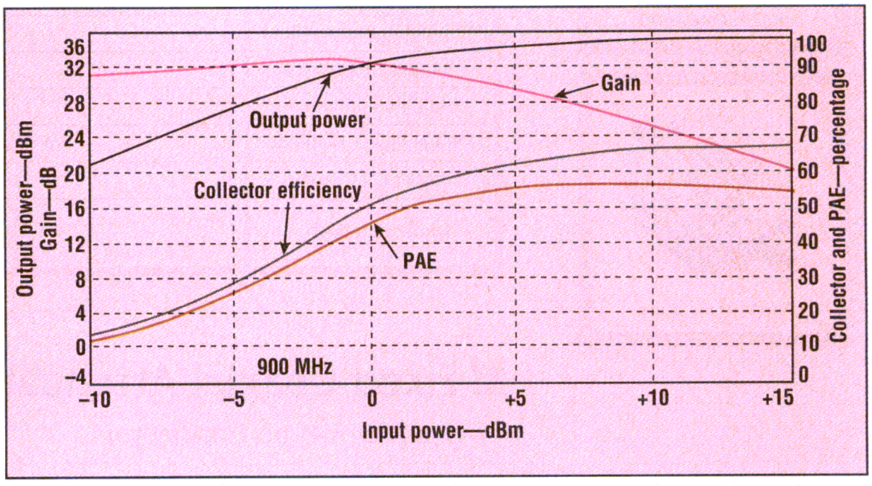
The majority of CDMA PAs manufactured today use AlGaAs HBT technology. The choice of technology makes sense due to HBT's excellent linearity and low quiescent current. Alpha, however, is looking at HBT technology to support all of its amplifier products. Recently published articles have addressed the inherently higher reliability and better performance of InGaP-based HBT amplifiers over AlGaAs-based amplifiers in higher-power applications.[2] The three most important benefits of InGaP HBTs are better thermal properties, improved long-term performance, and higher reliability. In addition to better electrical performance and higher reliability, InGaP-based transistors are also more manufacturable due to the higher etch selectivity which results in more uniform devices.[3] Since NDI offers both HBT technologies, and Alpha is not tied to any one technology for HBTs, the firm has chosen to move all HBT developments to the InGaP process. Selecting a single process for all HBT amplifiers will also reduce modeling efforts and design-cycle times.

As a proof of concept design for the first InGaP GSM PA, the engineers at Alpha recently breadboarded a two-stage PA. Figure 4 shows the characteristics of a single-stage power transistor while Fig. 5 shows the performance of the full two-stage PA with feedback and base ballasting. At +3.5 VDC, the single transistor delivers more than +35-dBm output power with associated PAE of 58 percent and collector efficiency approaching 68 percent. The amplifier also delivers +35-dBm output power at 57-percent PAE. These figures include matching losses.

To demonstrate the linearity capability of the InGaP process, several single-stage power amplifiers were also built. Figures 6 and 7 show the power, gain, PAE, and linearity performance of a 96-μm device tuned for CDMA performance. The device delivers +22-dBm linear output power at 39-percent PAE and 15-dB gain. To achieve the flat-gain curve and minimize gain expansion (as shown in Fig. 5), a 2-kA/cm^2 quiescent current was chosen. Lower quiescent currents reduce gain and increase gain expansion, while higher currents reduce PAE.

Most recent cellular handsets use a three-cell nickel-metal-hydride (NiMH) battery or a single-cell lithium-ion (Li-ion)battery, which generates a nominal voltage of +3.5 to +3.6 VDC. However, handset designers are now requesting PAs that operate with a +3.2-VDC nominal battery voltage to increase talk times and to account for temperature variations. Some applications are also requiring PAs to operate at temperatures higher than the typical high end of +85°C. Given these two design constraints, a redesign of the AP126-89 amplifier was initiated. The improvements in the design include adding backside via holes for improved thermal performance and reduced emitter parasitics, increased device area for all three stages to target higher output power levels and lower-voltage applications, and an enhanced active bias circuit to desensitize the variations in reference voltage and for reduced voltage operation.

The addition of the via holes is an approach that has been a very effective, highly manufacturable process



5. The performance of a two-stage HBT amplifier was evaluated at 900 MHz in terms of output power, gain, and PAE.

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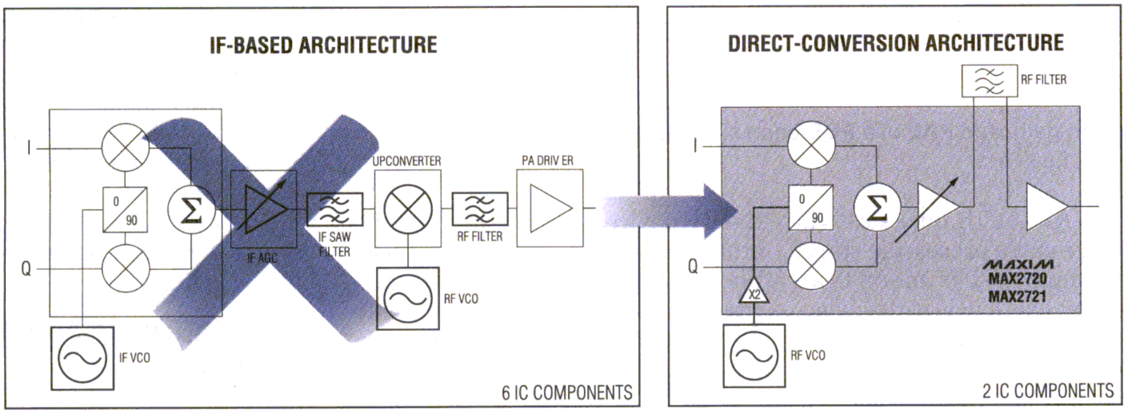

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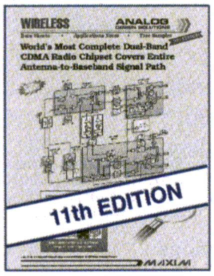
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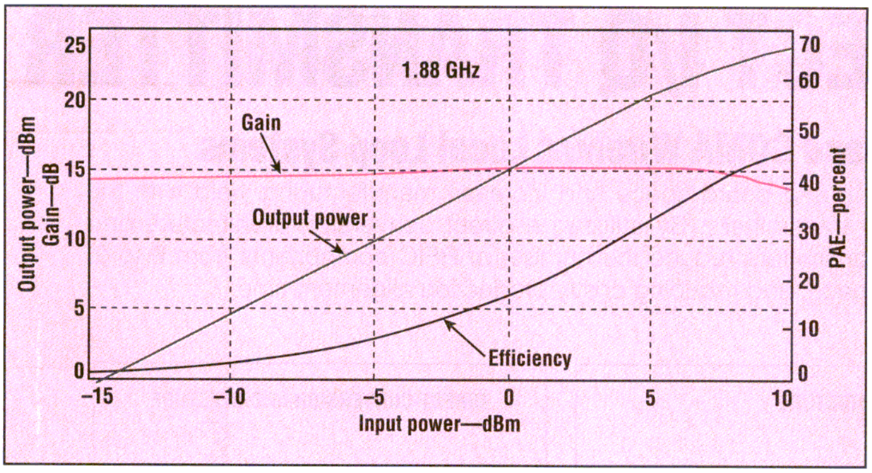
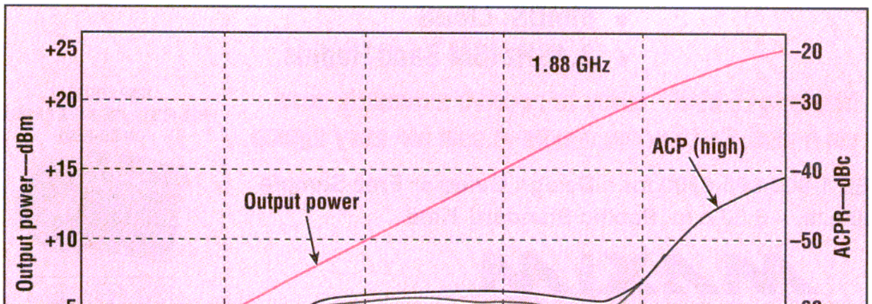


6. The power, gain, and PAE of a PCS-band single-stage HBT amplifier was evaluated at 1.88 GHz.

for Alpha. Although backside via holes require extra processing steps, the additional cost is more than recovered by the much higher electrical yields and reduced die area. The electrical benefits of via holes are obvious—the parasitic elements of a via hole are much less than that of bond wires and are nowhere near as sensitive to assembly-line variations. Via holes are much better thermal conductors than grounded bond wires and aid considerably in reducing topside temperatures.

A bipolar transistor is a current-controlled current source and, as such, is best controlled with a current source rather than a fixed voltage source. The purpose of the current mirror is to provide the necessary constant current to the RF device, thereby reducing the sensitivity of the RF device to processing, temperature, and power-supply variations.[4] The most basic type of current mirror consists of a device that is identical to the RF device, except in scale. However, this simple architecture is limited in its sensitivity to power-supply variations. As V_{ce} varies due to a change in the supply voltage, the collector current (I_c) changes due to the early voltage effect.

To improve the bias circuitry, a reference voltage is used to maintain current variations within ±5 percent over temperature and battery-voltage variations. The next-generation bias controller will be based on the current-mirror approach, but will include an emitter follower in the mirror's base-to-emitter path. This circuit supports a larger scaling ratio of the mirror transistor versus the RF amplifier transistor, which results in less die area being used for the bias controller and decreased sensitivity to voltage variations, due to the beta squared effect between the base supply (i.e., the mirror circuit) and the RF base. The one drawback of this circuit is the required headroom, since there are two base-to-emitter voltage (V_{be}) drops plus the voltage drop across the reference resistor. Present-day operating voltages support this approach, but as mobile telephone manufacturers try to lower the maximum supply reference voltage, this type of circuit will eventually not be viable. More sophisticated circuits which provide even more insulation to variations will be available, and operate at lower reference voltages, are being investigated.



7. The linearity performance of a PCS-band single-stage HBT amplifier was evaluated at 1.88 GHz in terms of output power and ACP.

DESIGN FLEXIBILITY

The requirements for handset CDMA PAs are fairly standard when it comes to output power, but there are certain differences between available amplifiers. The present generation design meets the lower-power requirements, but in order to make this amplifier more easily accepted by a wider audience, the output-power capability of the amplifier has been increased by scaling up the area of each transistor. The ratio that is used for the final two transistors will be preserved, since this was found to be an optimal combination for simultaneously achieving the necessary linearity and efficiency. Several experiments will also be run to reduce and/or eliminate external impedance-matching requirements where possible. The flexibility to address unique customer requirements dictates that some level of external matching and bypassing circuitry are maintained. ●●

Acknowledgments

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References

1. Rob McMorrow, Eric Olsen, and P. DiCarlo, "Integrating GaAs and Silicon Technologies for Power Amplifiers, Seventh Annual Wireless Symposium," February 22-26, 1999, San Jose, CA.
2. T.S. Low *et al.*, "Migration from an AlGaAs to an InGaP Emitter HBT IC Process for Improved Reliability," *1998 GaAs IC Symposium Technical Digest*, pp. 153-156.
3. "HP Chooses InGaP Emitters for First HBT Products," *HP Devices Newsletter*, Vol. 4, No. 9, 1998, pp. 4-5.
4. P.R. Gray and R.G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 3rd Ed., Wiley, New York, 1993.

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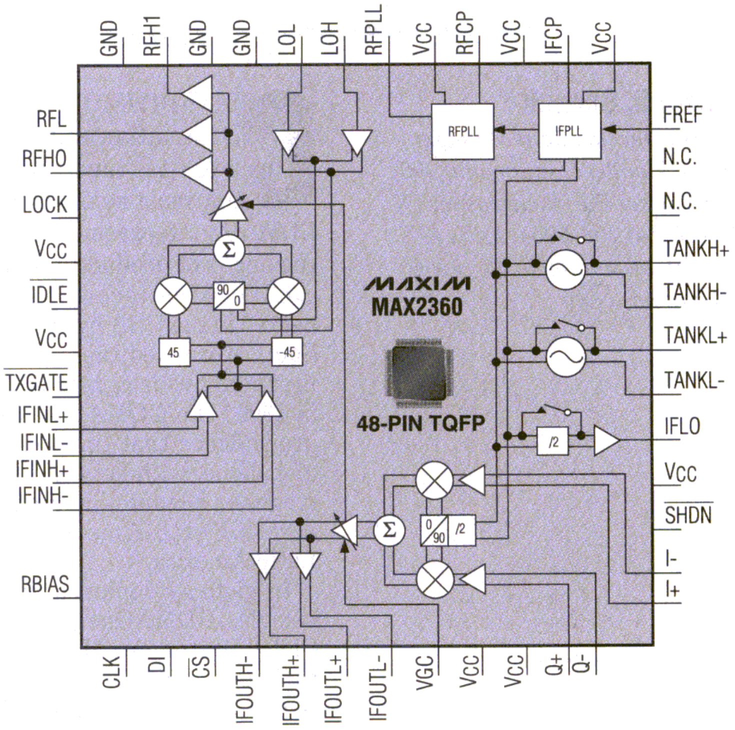

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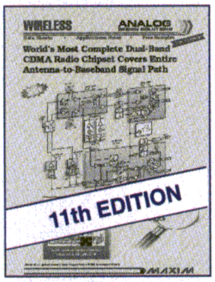
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CIRCLE NO. 243

Fine-Tuning Test Methods For CDMAOne Handsets

Methods of testing CDMAOne mobile-phone components and assembly processes during the manufacturing process can balance production volume, quality, and profit.

Michael D. Barrick
Business Development Manager
Wavetek Wandel Goltermann, 990 North Bowser Rd., Richardson, TX 75081; (214) 763-6064, FAX: (972) 231-3671, e-mail: mike.barrick@wwgsolutions.com.

CODE-DIVISION-MULTIPLE-ACCESS (CDMA) technology offers high information capacity over relatively narrow communication channels. It is the technology driving fast-growth, current-day standards and most next-generation designs. One of the key current standards, CDMAOne, represents a challenge for handset manufacturers to balance the needs of production-line testing for quantity, quality, and profitability.

CDMAOne technology was pioneered in the USA by Qualcomm, but South Korea led the world with the first nationwide network deployment in 1996. The CDMAOne market has grown since that time to be a truly global one, with networks in various stages of planning and deployment across North America, Asia, and Latin America.

In globally deployed digital technologies, CDMAOne is second only to Global System for Mobile Communications (GSM) for number of subscribers. At the end of 1998, there were 137 million GSM subscribers and 22 million CDMAOne subscribers.[1] The number of GSM subscribers is forecast to continue to exceed CDMAOne through 2003, but CDMAOne's rate of growth is forecast to exceed that of GSM in the same period. Approximately 100 million CDMAOne phones will be required in 2003, growing from 18 million in 1998. This rapid growth requires optimal testing concepts to allow mobile-phone supply to keep up with demand.

In mobile-phone manufacturing, testing must be used as a tool to check the components and assembly process used. It would be a waste of profits to conduct extensive parametric testing on every mobile phone produced at the functional test stage if failures are infrequent. On the other hand, if the product is shipped with too little testing, the resulting lack of quality would hurt the manufacturer's reputation. In the latter

1. The WWG MMP-4400M is an example of the latest generation of fast and accurate one-box testers using multi-DSP technology.

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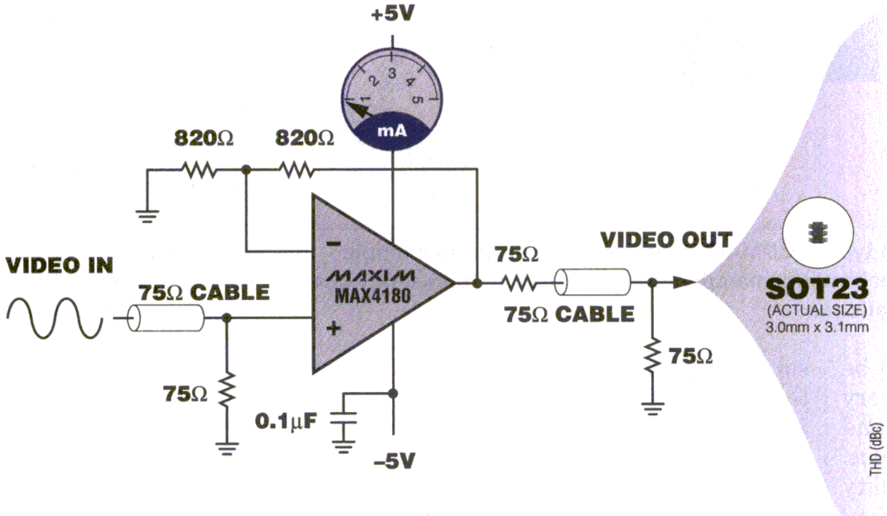
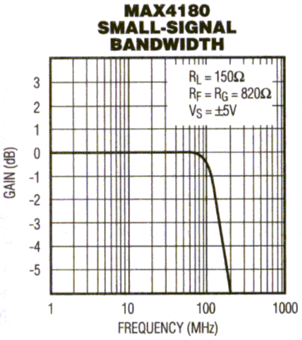
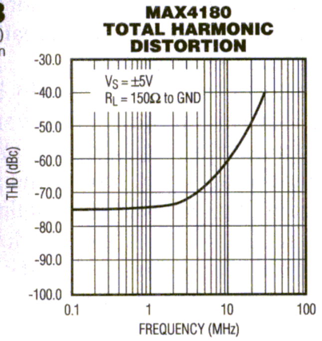


VIDEO LINE DRIVER





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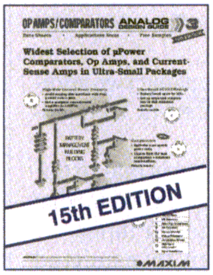
MAX4180/4181	**1**	**2/1**	**245/270**	**90/60**	**0.08/0.03**	**20**	**450/340**	**Yes**	**6-pin SOT23, 8-pin SO**
MAX4182/4184	2	2/1	245/270	90/60	0.08/0.03	20	450/340	No	8-pin SO
MAX4183/4185	2	2/1	245/270	90/60	0.08/0.03	20	450/340	Yes	10-pin µMAX, 14-pin SO
MAX4186/4187	4	2/1	245/270	90/60	0.08/0.03	20	450/340	No	14-pin SO, 16-pin QSOP



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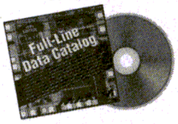

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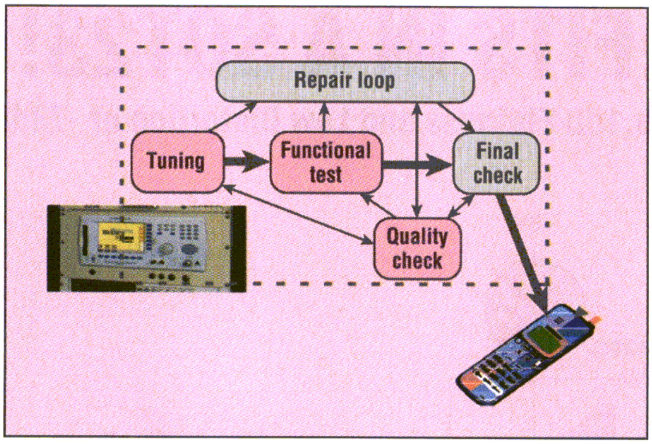

2. A typical CDMAOne test concept performs multiple checks of the manufacturing process at optimal physical locations.

case, the effect on the bottom line would be the same as too much testing, since profits would decline due to a decrease in sales.

The "test concept" can be defined as a placement of a select group of tests at various points in the manufacturing process so that failures in components and assembly processes are detected. Obviously, the test concept is not the same for every mobile phone—it should be optimized to each one. If the components and processes were exactly the same for each mobile phone manufactured, no testing would be needed. But this would require very costly production equipment, and component scrap would be enormous. Conversely, inexpensive, low-quality components could be used with sloppy assembly processes if testing were extensive. But the test station required would be enormously expensive, the manpower required would be huge, and mobile-phone scrap would fill warehouses.

Tests selected for use in the test concept should be fast and accurate. Obviously, the one-box tester selected for manufacturing should have the highest measurement speed, which requires the latest multi-DSP-measurement technology. (An example of this one-box tester is shown in Fig. 1.) High accuracy is also a requirement since this supports tighter pass/fail limits and results in improved manufacturing yield and more-highly tuned mobile phones (with longer battery life). High accuracy is necessary not only at the test-equipment level, but at the test-station level as well.

The manufacturer must strike a balance between quality and expense of the test concept, assembly process, and components to achieve the goals of production volume, quality, and profit. Optimization of the test concept is key to achieving this balance, since balancing the one can balance all three simultaneously.

The ANSI-98 minimum performance standard provides a wealth of tests and pass/fail limits that could conceptually be used in the test concept for a CDMAOne mobile phone. But manufacturers must recognize the tests in this standard for what they are—a voluntary suite of tests that can be used for advertising and negotiation purposes if the mobile phone conforms. The tests (and particularly pass/fail limits) are not intended to be used for checking the components or the assembly process of a CDMAOne mobile phone, although they are often used for this purpose due to the lack of other defined tests.

Manufacturers should restrict the number of tests selected for a test concept to a minimal set that tests those components and assembly processes that have the highest risk of failure. Excess parametric tests should be eliminated to reduce test time to the absolute minimum. In the manufacturing flow, the location of test should be physically close to the first point where the bad components or faulty assembly processes can be

GLOSSARY

Authentication—The process carried out by the network to validate a mobile phone's identity.

AWGN—Additive White Gaussian Noise.

CDMAOne—code-division multiple access. A global term referring to IS-95 CDMA along with all of its derivatives.

Codec—coder/decoder. One of a variety of techniques that is used to convert analog voice to and from digital information.

DSP—digital signal processor.

Fading—Natural variation in the amplitude and the phase of the link between the mobile phone and base station.

FER—frame error rate.

Forward link—RF-level information transmitted from the base station to the mobile phone.

Functional test—Manufacturing tests performed on an assembled phone to determine operability.

GPIB—general-purpose interface bus; IEEE-488.

GSM—Global System for Mobile Communications/Groupe Speciale Mobile.

Interference test—A receiver test using one additional signal generator at a frequency offset from the desired carrier.

Intermodulation test—A receiver test using two additional signal generators to generate different frequencies at the carrier frequency.

Match—A measure of the reflected signals due to differences in impedance between two transmission media; for example an RF cable and a one-box-tester input.

Reverse link—RF-level information transmitted from the mobile phone to the base station.

SMS—short-messaging service.

Tuning test—Manufacturing tests performed on an assembled board to determine operability and correct for offsets in frequency and amplitude.

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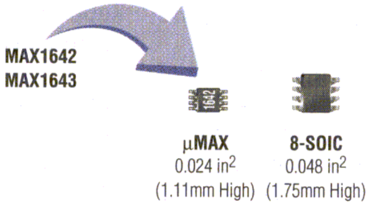

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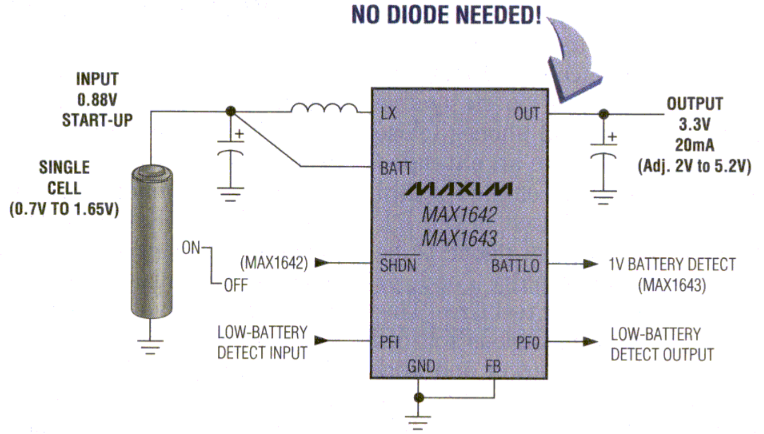

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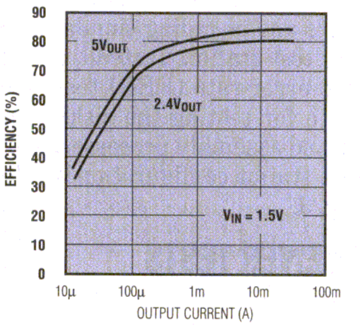

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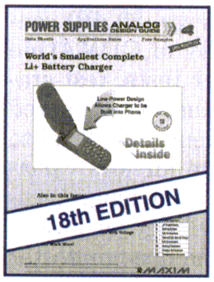
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identified. For example, tests that identify problems in component assembly should be tested at the tuning stage, not later in the functional test stage. Figure 2 shows an example of a typical test concept in a manufacturing flow.

Tests that test only software functions should be eliminated from consideration for the test concept. Since software is the same from mobile phone to mobile phone, there is no risk of bad-quality phones being shipped if the software test is eliminated. Tests in this category include authentication, data (excluding multi-traffic, channel-data tests), and SMS.

Since there are a huge number of tests available for a CDMAOne phone, manufacturers should avoid test concepts that add extra pieces of test equipment to a test station. For example, complex receiver tests involving intermodulation, interference, and fading should be avoided since they primarily test the mobile phone's design (not the manufacturing process) and would add extra signal generators and/or fading simulators to every test station. Instead, a simple frame-error-rate (FER) test is appropriate for testing the risky components and assembly processes. A typical test-station configuration is shown in Fig. 3.

RECEIVER TESTS

The core CDMAOne receiver tests in the mobile-phone test concept should consist of FER tests with or without AWGN. Manufacturers should select channels and forward/reverse power levels that best indicate the presence of an issue with the components or assembly process. Optimization of the receiver tests involves use of statistical methods to measure FER. This, in turn, involves accurate calibration, minimizing noise on the forward link, and simultaneous measurement with transmitter tests.

3. CDMAOne test stations should incorporate minimum hardware to support focused testing of only the manufacturing process.

4. The WWG MMS-4300 will incorporate a CDMAOne codec in the future to facilitate audio testing.

FER tests can be the most time-consuming part of the test concept due to the large number of frames required to achieve the necessary accuracy. The test process should incorporate statistical methods to accelerate the measurement of FER through early algorithm termination. Algorithms used include "pass with confidence" and "fail with confidence" as defined in ANSI-98. Typically, these algorithms are built into the one-box tester used in the test station.

Use of confidence-based methods passes good mobile phones more quickly, but marginal phones (close to the limit) still take an extended amount of time. Noise on the forward link can cause variation in the RF level and cause a good phone to be measured as marginally good, or even fail—with longer test time. This noise can come from various sources including 60-Hz AC power and local transmitters operating on the same frequency. Coupling of the noise into the forward link can be avoided with shielded cables, isolation boxes, and high-quality RF connectors.

Highly accurate level calibration of the test station is necessary to extrapolate RF levels from the one-box tester to the phone and avoid failing marginal phones due to inordinately wide pass/fail limits. Since the match of the components in the forward and reverse RF path (including connectors, combiners, the one-box tester, and the mobile phone) vary with frequency, loss must be measured at several points over frequency. In addition, match of the one-box tester may vary with level as attenuators are switched in for low levels. This necessitates additional loss measurements at high and low levels.

To the extent possible, receiver and transmitter measurements should be made simultaneously, with the goal of reducing total test time. This may prove to be difficult due to conflicting modes of operation (e.g., open-loop versus closed-loop power control) within the mobile phone. But selection of tests, sequence, and active power control makes simultaneous testing possible.

TRANSMITTER TESTS

Compared to CDMAOne receiver tests, there are a wide variety of transmitter tests available to detect issues in components and assembly processes. As with CDMAOne receiver measurements, channel and power levels that best reveal the presence of a problem should be selected. Optimization of the transmitter tests involves accurate system calibration in conjunction with the usage of multi-DSP technology to make several measurements at once.

Highly accurate level calibration of the test station is as important for transmitter tests as it is for receiver tests. Since measurements of mobile-transmitter power over an extremely wide dynamic range (80 dB) constitute the majority of CDMAOne transmitter tests, test-station loss must be measured over frequency and level to compensate for loss variation due to matching. Accurate knowledge of power levels at the one-box tester also allows the user to select the tightest pass/fail limits based on one-box-tester accuracy specifications.

True audio tests are typically not used in the

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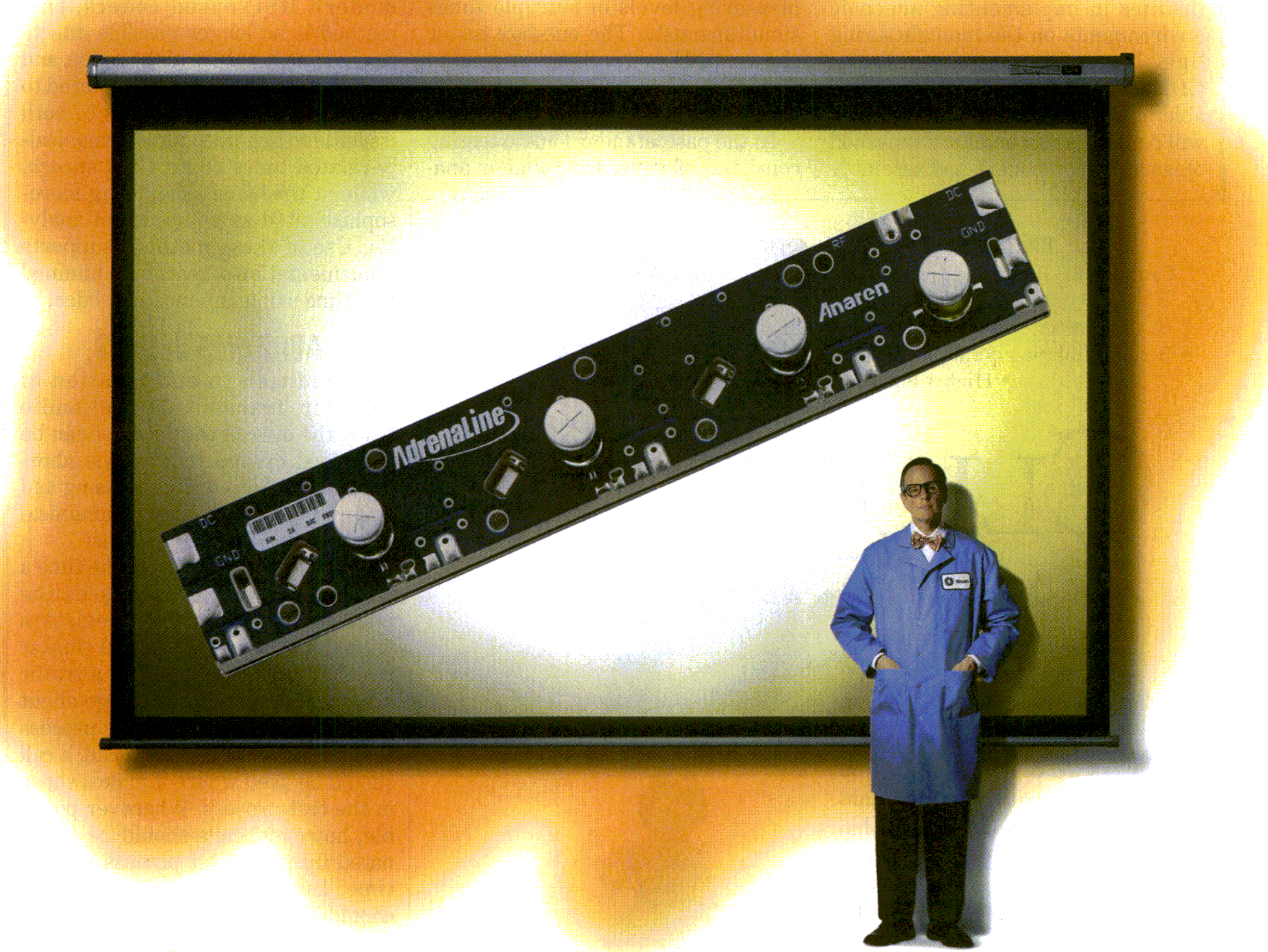

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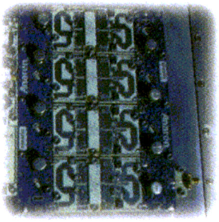

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CDMAOne test process due to the lack of availability of a codec integrated with a one-box tester and difficulties in implementing anechoic environments on the manufacturing line. Regardless of these facts, CDMAOne codecs will become available in the future, and audio testing will be used as an invaluable method of isolating component and assembly process issues. When it becomes available, optimization will involve various methods for generating and measuring levels of multiple tones simultaneously. The one-box tester shown in Fig. 4 will be upgraded in the future to incorporate a CDMAOne codec.

In the past, standard audio testing consisted of generating and/or analyzing one audio tone at a time. Using this method, frequency-response testing was a lengthy process. With modern DSP-based codecs, this method is no longer possible due to the nonlinear nature of the codec, and audio level in is not linearly related to audio level out. The solution to both issues is to generate non-harmonically-related tones or artificial speech, while at the same time, using more-sophisticated audio-spectrum analysis. Use of these methods supports implementation of tests with minimal test time using any modern codec.

AVOIDING DELAYS

In addition to optimization of receiver, transmitter, and audio tests, the overall test concept can be optimized by avoiding delays inherent in CDMAOne call processing and by limiting time spent in communication between test subsystems.

Up to 20 s can pass from the time a CDMAOne mobile phone sees the pilot channel to when it registers with the system. Additional time is required to set up a call on a traffic channel. If there is knowledge about the components or assembly process that is gained by making a call, a call should be used where it makes sense in the test process. Wherever possible, however, calls should be eliminated from the test process to save time. Instead, custom test modes should be implemented in the mobile phone to quickly get to the specific mode to be tested.

In the typical test station, a one-box tester makes individual measurements or groups of measurements under GPIB control of a PC-based computer. The PC acts as the test controller, containing the test sequences and pass/fail limits. Using a modern multi-DSP-based, one-box tester, the measurements being performed are often faster than the communications required to request the measurement and transfer the results to the controller. In this case, transfer of the controller function to the one-box tester serves to optimize the test process, with the one-box tester controlling the phone directly for custom test modes.●●

References

1. Dataquest (June 1999 Estimates).

Continuous Time Active Filter Design

T. Deliyannis, Yichuang Sun, and J.K. Fidler

This book presents the design of active filters operating in continuous time. Topics include active filter fundamentals, realization of active filters using operational amplifiers (opamps) and operational transconductance amplifiers (OTAs), cascade realization of active filters, and active filter realization with inductive-capacitive (LC) ladder networks.

The book takes the reader through the basics of continuous-time active filter design while reviewing the opamp approaches to active filter solutions that were established in the past, and then introduces the reader to state-of-the-art approaches to active filter design using OTA devices with many design examples and circuit implementation.

The book's opening chapter reviews filter topology, steps in filter design, nodal analysis, and continuous-time filter functions. The second chapter reviews the first order of the lowpass prototype function and includes tables for the realization of the Butterworth, Chebyshev, Papoulis, or Cauer configurations.

Chapter 3 introduces the reader to ideal elements and devices that have one to three ports with properties that make them useful in network synthesis. Chapter 4 reviews the realization of first and second order using opamps. Chapter 5 reviews the realization of high-order functions. Cascaded second-order stages without feedback, high-order ladder networks, and embedded operational amplifiers in resistor and capacitor (RC) networks are offered. Cascaded connections of second-order sections, pole-zero paring, gain distribution, and multiple-loop feedback filters are also presented.

Chapter 6 reviews the simulation of LC ladder filters using OA including lowpass, highpass, as well as bandpass transforms. Chapter 7 discusses wave-active-filter (WAF) design as an alternative approach to the simulation of LC ladder filters in an effort to obtain active RC filters of low sensitivity. Chapters 8 presents single OTA filters including lowpass, highpass, and bandpass admittance models with transfer functions, design formulas, and sensitivity results.

Chapter 9 reviews OTA filters beginning with OTA building blocks and OTA filters with design examples of lowpass, highpass, and bandpass topologies. Chapters 10 and 11 introduce OTA filters based on ladder simulations and multiple integrator loop-feedback filters. Chapter 12 presents current-mode filters with first-order and second-order architectures as well as the design methodology for the structures. (1999, 443 pp., hardcover, $94.95 ISBN: 0-8493-2573-0, $94.95) **CRC Press, LLC, 2000 Corporate Blvd. N.W., Boca Raton, FL 33431; (800) 272-7737, FAX: (800) 374-3401, Internet: http://www.crcpress.com/www/order.htm.**

Design Waveguide Bandpass Filters

Despite more recent technologies, waveguide bandpass filters that operate above 8 GHz are still used for precision designs and high power levels.

Richard M. Kurzrok
Professional Engineer
RMK Consultants, 82-34 210th St., Queens Village, NY 11427-1310; (718)-776-6343, FAX: (718) 776-6087, e-mail: rmkconsulting@aol.com.

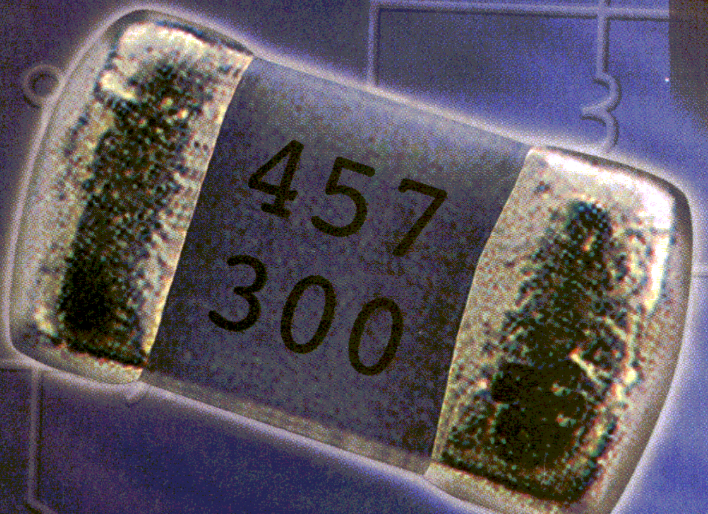
WAVEGUIDE bandpass filters are frequency-selective circuits or devices that perform valuable functions in microwave equipment used in communications, electronic warfare (EW), radar, and automatic test equipment (ATE). They are most compatible with waveguide antenna feeds. They are required for high-power applications, and are preferred for precision performance. At low signal levels, they are primarily used at frequencies from 8 to more than 100 GHz. The main function of a waveguide filter is to provide adequate stopband selectivity without introducing unacceptable passband insertion losses and distortions. For example, in microwave receivers, waveguide bandpass filters reject unwanted out-of-band interference and establish sensitivity by defining the front-end noise bandwidth. In microwave transmitters, they reduce unwanted frequencies (spurii) and suppress transmitter noise at receive frequencies. Waveguide bandpass filters are also used in various microwave multiplexers. This article presents a discussion of key features in waveguide bandpass filter design, development, and construction.

A waveguide is a microwave transmission line that uses only a single conductor. It has low attenuation and excellent power-handling capability. It is usable to frequencies in excess of 100 GHz and can provide precision that is not ordinarily available in coaxial lines or strip transmission lines. A waveguide also has inherent highpass filter characteristics such as cutoff frequency and dispersive transmission characteristics.

This article is primarily concerned with waveguides that are in the shape of non-square rectangular tubes. These tubes are wider than

Table 1: Waveguide bandpass-filter typical design and development cycle

1. Analysis of filter specifications (electrical, mechanical, environmental, and cost)
2. Determination of a compliant filter-response shape
3. Selection of an appropriate filter structure
4. Computation of filter-coupling parameters and resonator lengths
5. Computation and/or development of filter couplings
6. Determination of applicable filter fabrication methods
7. Preparation of filter-shop drawings through manual or AutoCAD
8. Fabrication of prototype filter in model shop or by external vendor
9. Assembly, alignment, and test of prototype filter
10. Record data and modify/recycle (if necessary)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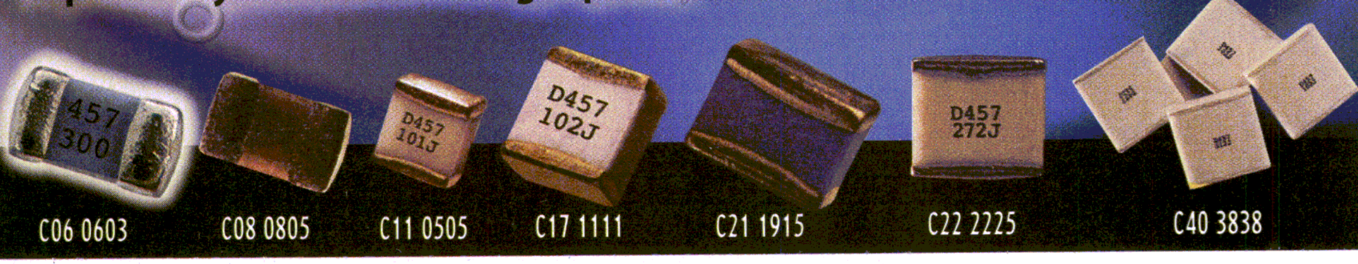
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C22 2225
C40 3838

they are high, which means that they have an aspect ratio of greater than 1:1. These waveguides propagate in the dominant TE_{10} mode, and their useful frequency range is limited to approximately 40 percent of center frequency. For waveguides with a 2:1 aspect ratio (two units wide for every one unit high), the dominant-mode propagation is unique up to two times the dominant-mode cutoff frequency.

FILTER-DESIGN TECHNIQUES

Waveguide bandpass filters originated in Bell Telephone Laboratories and the MIT Radiation Laboratory of World War II. Early waveguide bandpass filters used quarter-wave coupled resonators.[1] In 1957, a milestone paper[2] introduced direct-coupled waveguide bandpass filters that quickly evolved into a preferred configuration. Much of the prior art and new original work on waveguide bandpass filters can be found in a 1964 classic reference[3] among those listed at the end of this article.

The design equations for direct-coupled waveguide bandpass filters[2] start with the normalized circuit g's of a lowpass prototype. For Tchebychev (equal-passband-ripple) responses normalized to the ripple bandwidth, normalized susceptances for the shunt-inductive couplings and filter-corrected resonant lengths can be readily computed. Normalization to the 3-dB bandwidth or different filter response shapes can also be used.[4,5] Some of the design equations can be rewritten in terms of alternate parameters such as normalized singly loaded q's and coefficients of coupling.[6]

The total Q of a bandpass filter is defined by equation 1:

$$Q_T=F/BW \qquad (1)$$

where:

Q_T = the total Q,

F = the center frequency, and

BW= the normalizing bandwidth.

For nominal half-wavelength waveguide resonators, the effective total Q, taking into account dispersion, is:

$$Q=2Q_T[\pi\ (\lambda G_0/\lambda_0)^2] \qquad (2)$$

where:

λG_0 = the guide wavelength at filter's center frequency,

λ_0 = Free-space wavelength at filter's center frequency, and

π = the transcendental number pi (approximately 3.14).

Normalized values of singly loaded q's (for input and output couplings) and coefficients of coupling (for interstage couplings) are attainable from published equations and handbook tables.[5]

Letting:

q_1 = the normalized input singly loaded q,

q_n = the normalized output singly loaded q, and

k_{ij} = the normalized coefficient of coupling between the ith and jth resonators.

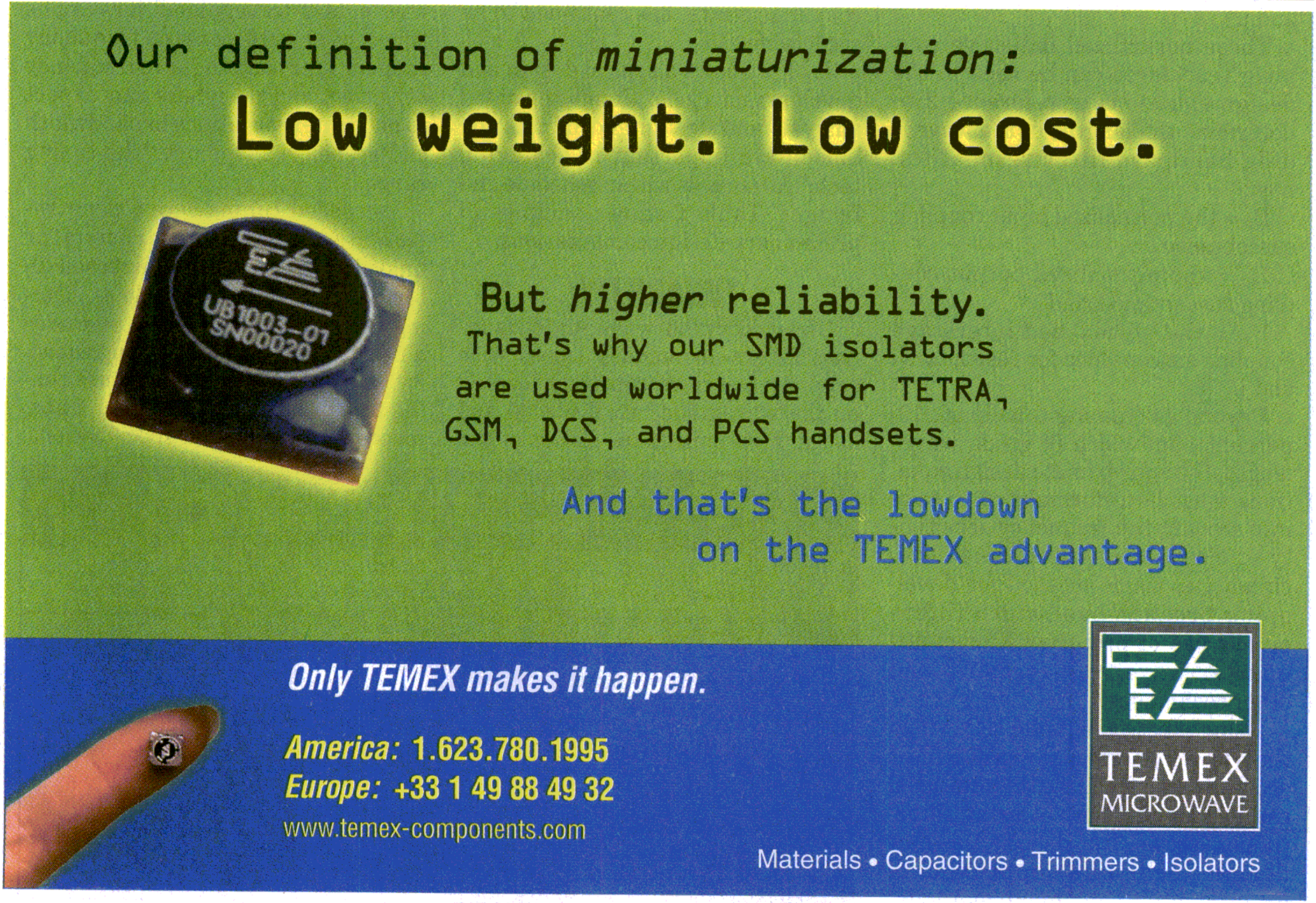


Table 2: Sample preliminary design computations

Design parameter	Value
Waveguide size	WR-75
Center frequency	13.25 GHz
3-dB bandwidth	40 MHz
Q_T	331.25
Number of poles	4
Passband ripple	0.001 dB
Normalization	3-dB bandwidth
Filter symmetry	Symmetrical
Normalized q_1	0.9114
Normalized k_{12}	0.7765
Normalized k_{23}	0.5412
$(\lambda G_0/\lambda_0)^2$	1.546
Q	136.41
Input normalized susceptance B_0	11.06
Interstage normalized susceptance B_{12}	175.7
Interstage normalized susceptance B_{23}	252.0
First resonator length	0.537 in. (1.36 cm)
Second resonator length	0.552 in. (1.40 cm)

then:

$$Q_1=Qq_1=\text{absolute input singly loaded } Q \qquad (3)$$

$$Q_n=Qq_n=\text{absolute output singly loaded } Q \qquad (4)$$

$$K_{ij}=k_{ij}/Q=\text{absolute coefficient of coupling between } i\text{th and } j\text{th resonators} \qquad (5)$$

now:

$$X_0=SQR[(1/Q_1)/(1-1/Q_1)]=1/B_0 \qquad (6)$$

$$X_n=SQR[(1/Q_n)/(1-1/Qn)]=1/B_n \qquad (7)$$

$$X_{ij}=K_{ij}/(1-K_{ij}^2)=1/B_{ij} \qquad (8)$$

where:

X_0 = the normalized input coupling reactance,

X_n = the normalized output coupling reactance, and

X_{ij} = the normalized interstage coupling reactance for resonators i and j.

These normalized inductive coupling reactances can be used in the design equations of reference 2 to determine the lengths of the waveguide bandpass filter resonators. now:

B_0 = the normalized input coupling susceptance,

B_n = the normalized output coupling susceptance, and

B_{ij} = the normalized interstage coupling susceptance for resonators i and j.

Beyond calculating a ballpark 10-percent bandwidth in guide wavelength, the approximate design equations must be reformulated to take into account the frequency sensitivity of distributed (transmission-line) circuits. A viable method for developing broader-bandwidth filters entails use of prototypes for multi-quarter-wave transformers[7] and other techniques.[8]

Using electromagnetic (EM)-field theory, designers can improve filter accuracy and eliminate the additional complexity and cost of using filter-tuning screws. But despite this new design technique, approximate design and development methods[2] have proven adequate for most waveguide bandpass-filter design. Use of tuning screws, with or without coupling screws, has continued to be acceptable.

Table 1 shows a typical design and development cycle. Computer-aided analysis and design and fabrication liaison are important in achieving technical success within schedule and budget. Table 2 shows samples of preliminary design computations.

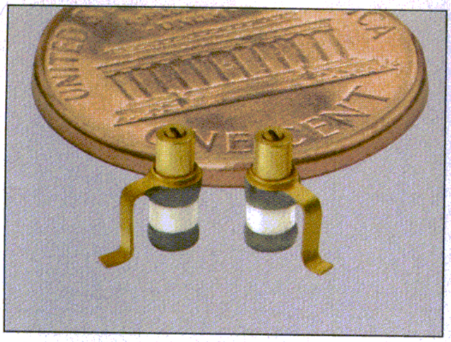
TUNABILITY

Direct-coupled waveguide bandpass filters are usually tuned with capacitive screws centrally located on the waveguide broad wall(s) and at the high-impedance planes of the waveguide resonators. These screws compensate for design inaccuracies and fabrication tolerances. Many rectangular-waveguide filters can be tuned over a 10-percent frequency range. Filter couplings are frequency sensitive, and designers can expect to encounter variations in bandwidth and response shape over the tuning range.

Increased tuning-screw penetration depth degrades resonator unloaded Q's and causes increased filter passband insertion losses. Tuning-screw penetration also degrades a filter's peak power-handling capacity. A design decision not to use tuning screws must consider filter transmission and reflection specifications,

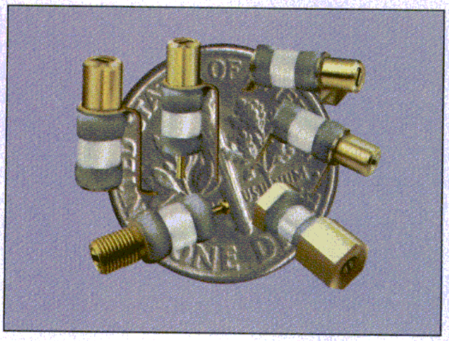
Table 3: Typical tuning screw sizes for various waveguide bands

Waveguide size	English tuning screws	Metric tuning screws
WR-229	12-28	6.0 × 1
WR-137	10-32	5.0 × 0.8
WR-112	8-32	4.0 × 0.7
WR-90	6-32	3.5 × 0.6
WR-75	4-40	3.0 × 0.5
WR-62	2-56	2.0 × 0.4
WR-51	2-56	2.0 × 0.4
WR-42	1-72	1.6 × 3.5
WR-28	0-80	1.6 × 1.5



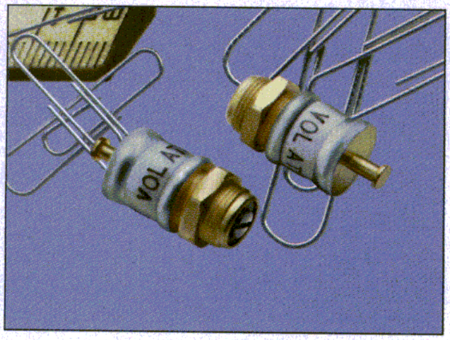
A_2 Series

- Capacitance range: 0.3 to 1.2 pF
- Self-resonance over 5 GHz
- Q: 1000 min. at 1 GHz and 1.2 pF
- Size 0.24 in. long x 0.094 in. diameter
- Working voltage up to 1500 VDC
- 7 turns of linear tuning
- High reliability solid dielectric
- Replaces expensive sapphire trimmers



A_1 Series

- 3 capacitance ranges from 0.45 to 12 pF
- Working voltage from 125 to 1000 VDC
- Q: 2000 min. at 100 MHz
- Self-resonant frequency to 2.3 GHz
- High reliability solid dielectric
- Up to 10 turns of linear tuning resolution
- Replaces expensive air and sapphire dielectric piston trimmers



A_30 Series

- Smallest 30 pF piston trimmer available
- Size: 0.50 in. long x 0.30 in. diameter
- High reliability solid dielectric
- Q: 2000 min. at 100 MHz and 30 pF
- 40 psi seal
- 10 turns of linear tuning

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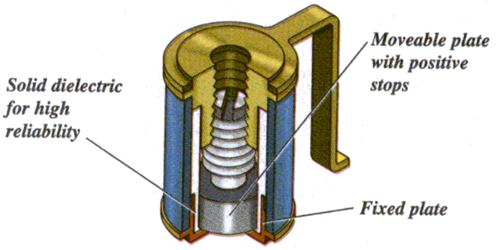

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fabrication tolerances, filter input and output interfaces, as well as production volume. As with other types of filters, tunability becomes less of a necessity as the percent bandwidth is increased. Table 3 shows typical tuning-screw sizes for some popular rectangular-waveguide sizes. Brass screws are preferable to stainless-steel screws.

Environmental changes can have discernible effects on the tuning of waveguide bandpass filters.[9] Thermal expansion in a waveguide's metal walls and the presence of humidity can detune a waveguide bandpass filter. This can become an acute problem when the filter bandwidth is very narrow. Altitude and corrosion also can affect performance.

COUPLING

The design must also account for normalized susceptances of the filter's couplings. There are several different types of inductive-coupling structures that can be used in waveguide bandpass filters.[10] The desired normalized susceptances can be obtained from handbook data[11] or by using developmental procedures.[11,13] Alternatively, singly loaded Q's and coefficients of coupling can be obtained developmentally.[12,13]

When the waveguide bandpass filter must compensate for mismatches at source and load interfaces, adjustable input and output couplings are desirable. When filter bandwidth must be adjustable over a specified tuning range, adjustable interstage couplings are also desirable. Adjustable couplings also permit precision design and alignment to meet stringent performance specifications. Table 4 shows typical coupling-post diameters. Coupling irises, apertures, and vanes use thin-precision shim stock. A 0.031-in. (0.07874-cm)-thick stock is used in WR-112 and WR-90, while 0.020-in. (0.0508-cm)-thick stock is used in WR-75, WR-51, WR-42, and WR-28. Some waveguide bandpass filters use both posts and irises.

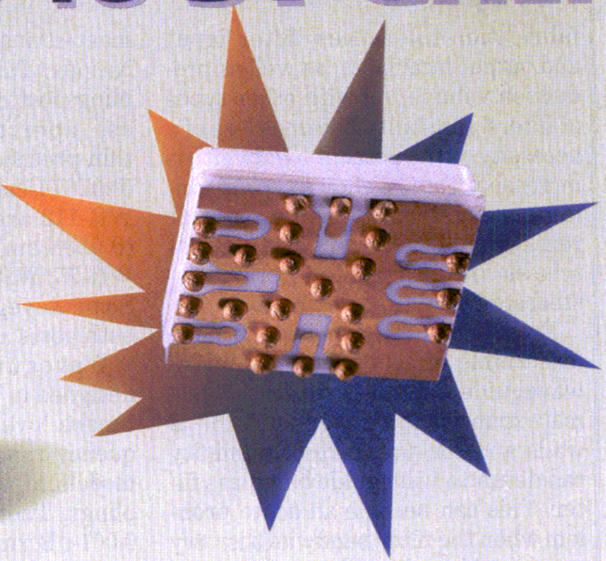
Waveguide bandpass filters designed in WR-430 waveguide were tunable over the 1.7-to-2.3-GHz frequency range, using three different models, all with adjustable filter couplings. These filters were five-pole, 0.001-dB ripple units designed for a nominal 60-MHz, 3-dB bandwidth. Over the central 20 MHz of the passband, the filters had return losses in excess of 30 dB. This was necessary to meet echo-distortion specifications in a high-capacity, multihop, terrestrial-communications system. Mechanical parts for these filters are summarized in Table 5.

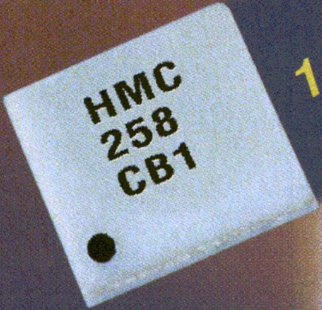
INSERTION LOSS

Waveguide bandpass-filter insertion losses are quite important in microwave front-end applications. Lossy filters can dissipate precious power in transmitters, and degrade noise figures in receivers. For a waveguide bandpass filter with a specified center frequency, bandwidth, and responses shape, the passband insertion loss is primarily determined by the unloaded Q of the filter resonators.[14] Practical unloaded Q data are available for real-world waveguide bandpass filters.[15] The following five factors affect the res-

Table 4: Typical coupling post diameters for various waveguide bands

Waveguide size	Post diameter-in.	Post diameter-mm
WR-229	0.312	8.0
WR-137	0.187	5.0
WR-112	0.156	4.0
WR-90	0.125	3.0
WR-75	0.093	2.0
WR-62	0.062	1.5
WR-51	0.046	1.0
WR-42	0.031	0.75
WR-28	0.031	0.75

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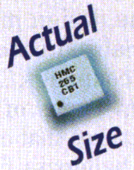
CB1


Actual
HMC
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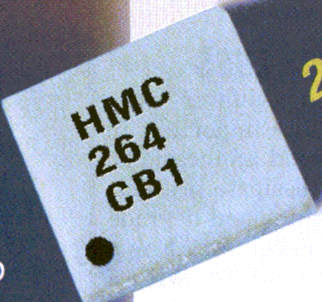
Size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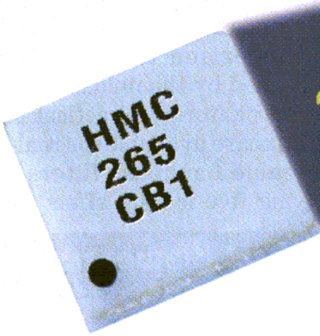
HMC
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CB1

Table 5: 2-GHz waveguide (WR-430) bandpass-filter mechanical parts

Waveguide bandpass filter's part	Physical realization
Resonator tuning screws	5/8-24
Coupling screws	3/8-24
Input/output coupling double posts	0.375 diameter
Interstage coupling double posts	0.625 diameter

onator unloaded Q's:[16]

1. Size and cross-sectional geometry
2. Mode of wave propagation
3. Interior materials of construction
4. Interior surface finish
5. Interior surface contamination

Spurious couplings into unwanted modes can result in dissipation that further degrades resonator unloaded q's. Some filter-response shapes can be helpful to reduce dissipative losses.[17] Elliptic-function filters often exhibit lower dissipation losses at the expense of complexity and unit cost.

FABRICATION TECHNIQUES

Waveguide bandpass filters usually use extruded copper (Cu) or Cu alloy tubing with typical surface finishes of approximately 16 µin. Tubing radii have a very small effect on actual waveguide cutoff frequency. Good metallic conductivity should be maintained to at least three skin depths. Waveguide flanges are often silver (Ag) soldered to the waveguide housing. Other parts such as tuning bushings, coupling screws, coupling irises, and posts can be soft soldered to the housing. Cu conductors must be protected against corrosion. Gold (Au) plating and varnish work best.[18] The best surface finish, 8 µin. or less, is attainable through the electroforming process using stainless-steel mandrels. Cu and nickel (Ni) can be electroformed.

Invar waveguide is needed for very-narrow bandwidth filters when environmental detuning cannot be tolerated. Pressurization is used to combat the effects of humidity. For tunable filters, sealing and evacuation of the filter would require filter tuning through bellows. This is avoided with a dynamic dehydrator system maintaining an ongoing pressure of approximately 2 psi. For pressurized filters, pressure fittings and waveguide windows are required.

A waveguide has two different power-handling capabilities—average power and peak power. Average power handling is defined as an acceptable temperature rise due to incidental dissipation, while peak power handling is defined as a power level where voltage breakdown occurs. Average power handling is enhanced by heat-flow techniques, such as air and liquid cooling, radiating fins, and heat pipes. Peak power handling is enhanced by evacuation, sealing, and use of gases such as sulphur hexafluoride. High-power waveguide bandpass filters are designed with rounded corners and no sharp discontinuities. Tuning and coupling mechanisms must be designed for high-power operation.

Waveguide bandpass filters can be designed for coaxial interfaces using adjustable input and output probe couplings.[19] Power handling is often limited by the choice of coaxial connectors.

ALTERNATE STRUCTURES

Waveguide cross-sections other than non-square rectangular should also be considered. Oversize waveguides can have higher unloaded Q's than standard rectangular waveguides. Cylindrical[3] and square[20] waveguides can support dual-mode operation, which is useful for cross-polarized antenna feeds. The TE01 circular electric mode in cylindrical waveguides[3] has the highest unloaded Q but is not the dominant mode. Ridged waveguides[21] have degraded unloaded-Q and power-handling capabilities but are capable of single-mode operation well beyond an octave in frequency. Filter miniaturization can be achieved using evanes-

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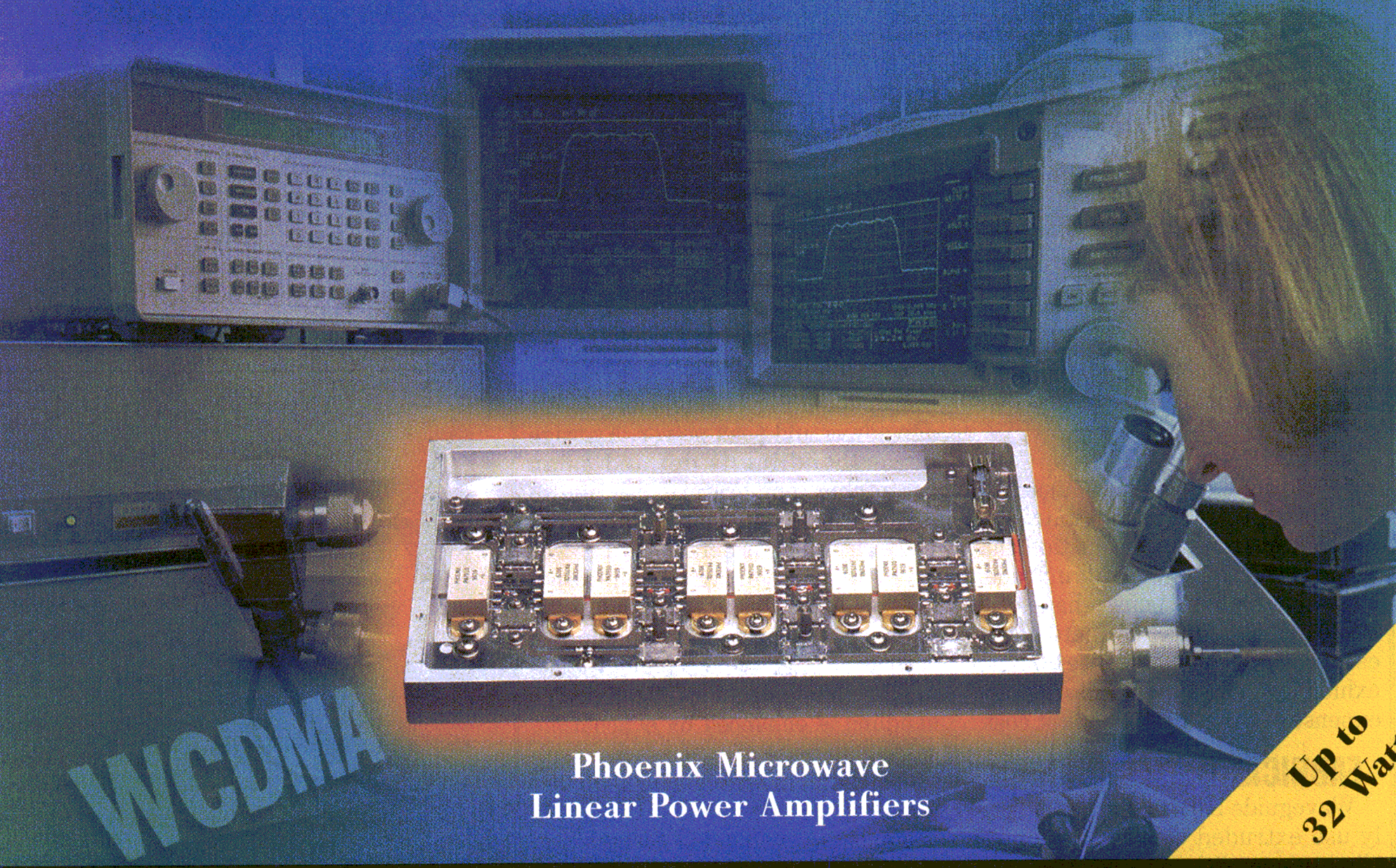

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Gain (dB.)	26	20	50	49	40
Phase Linearity (degrees)	±0.3	±3.0	±0.5	±3.0	±2.0
Pout @ 1 dB. comp. (dBm.)	+42	+41	+45	+45	+44
Noise Figure (dB.)	3.0	4.0	2.5	2.5	4.0
IP3 (two tone in dBm.)	+60	+56	+63	+62	+61
CDMA ACPR (Res BW 30KHz) IS-97 885 KHz 1.256 MHz 2.75 MHz	fc=880MHz (dBc.) (dBm.) -55/-54 @ +33 -58/-57 @ +33 -75/-76 @ +33	fc=1.96GHz (dBc.) (dBm.) -56/-56 @ +30 -59/-60 @ +30 -71/-72 @ +30	fc=880MHz (dBc.) (dBm.) -61/-61 @ +36 -63/-63 @ +36 -71/-71 @ +36	fc=1.96GHz (dBc.) (dBm.) -60/-60 @ +36 -63/-63 @ +36 -71/-71 @ +36	fc=2.6GHz (dBc.) (dBm.) -58/-58 @ +33 -61/-62 @ +33 -73/-74 @ +33
Isolation (dB.)	49.2	41.0	70	67	67
Return Loss In/Out (dB.)	-19/-20	-20/-21	-18/-20	-16/-20	-16/-20
DC Required (volts/amps)	+15/5.8	+15/5.5	+12/13.7	+12/13.8	+12/13.8

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cent-mode resonators[22] or dielectric resonators.[23] In waveguides, higher-order modes can propagate above readily determinable cutoff frequencies. For design purposes, mode charts[3,9] are useful to determine waveguide cross-section. EM-field configurations[9,11] are effective in determining methods of excitation and coupling.

Conventional waveguide bandpass filters have frequency-sensitive couplings, resulting in substantial variations in filter bandwidth over a tuning range. A different waveguide bandpass-filter structure has circumvented this difficulty. The filter uses fixed resonator lengths, and each resonator is tuned by varying the waveguide width.[24] Input, output, and interstage couplings use transverse coupling apertures located for minimum frequency sensitivity of filter bandwidth over a tuning range.

In conventional waveguide bandpass filters, non-adjacent resonators are not coupled. These filters are considered minimum phase-shift networks. Adding one or more bridge couplings between non-adjacent resonators converts a general filter[25-29] to a non-minimum phase-shift network. This class of waveguide bandpass filters can realize elliptic-function responses or provide enhanced differential group delay within the filter passband. Some of these filters employ dual-mode resonators,[26,27] which result in appreciable savings in filter size, weight, and cost.

Corrugated waveguide bandpass filters and waffle-iron filters use low-pass structures in waveguides to provide high-frequency selectivity. Low-frequency selectivity is provided by waveguide cutoff. Both of these filters were created by Dr. S.B. Cohn and are described in reference 2.

Waveguide bandpass filters are also used in microwave multiplexers that include directional filters. [3] The filters use inductive-coupling irises with adjustable input- and output-coupling screws. Further discussion of microwave multiplexers is beyond the scope of this article. Three survey articles on microwave filters are listed in references 30, 31, and 32.

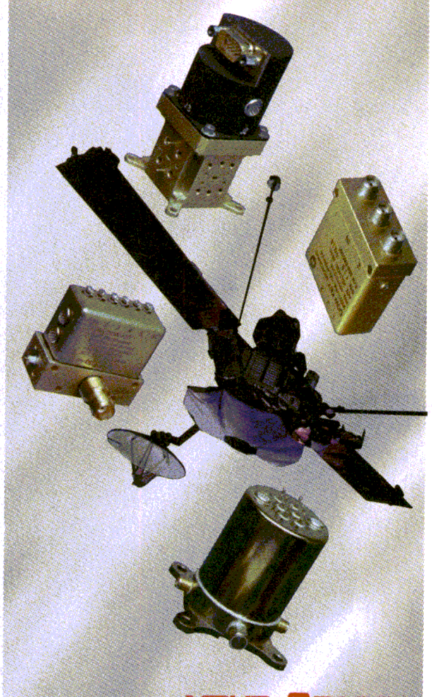
Waveguides continue to thrive as new applications open up in the millimeter range of frequencies. Researchers continue to investigate waveguide theory and develop new and improved structures and materials to reduce bandpass-filter costs and ease alignment.

Acknowledgment

This paper has been provided with only a limited bibliography. Many other engineers and scientists have made significant contributions to the design and development of waveguide bandpass filters. Use of adjustable coupling screws in waveguide bandpass filters was suggested by E.M. Bradburd.

References

1. W.W. Mumford, "Maximally Flat Filters in Waveguide," *Bell Sys. Tech. Journal*, Vol. 27, pp. 684-713, October 1948.
2. S.B. Cohn, "Direct-Coupled Resonator Band-Pass Filters," *Proc. IRE*, Vol. 45, pp. 187-195, February 1957.
3. Matthaei, Young, and Jones, *Microwave Filters, Impedance Matching Networks, and Coupling Structures*, McGraw-Hill, 1964.
4. M. Dishal, "Design of Dissipative Bandpass Filters Producing Exact Amplitude-Frequency Characteristics," *Proc. IRE*, September 1949.
5. A.I. Zverev, *Handbook of Filter Synthesis*, John Wiley & Sons, New York, 1967.
6. R.M. Kurzrok, "Interchangeability Of Coupling Parameters In Waveguide Bandpass Filters," *Frequency Technology*, Vol. 8, pp. 12-13, July 1970.
7. L. Young, "The Quarter-Wave Transformer Prototype Circuit," *IRE Trans MTT*, Vol. MTT-8, pp. 483-489, September 1960.
8. T.R. Cuthbert Jr., "Wideband Direct-Coupled Filter Having Exact Response Shapes," *IEEE MTT-S Newsletter*, pp. 27-38, Spring 1996.
9. "Reference Data for Engineers, Radio, Electronics, Computer, And Communications," *SAMS*, Eighth Edition, Prentice Hall Computer, Carmel, IN, Ch. 30, 1995.
10. R.M. Kurzrok, "Inductive Couplings—The Best Choice for Waveguide Filters," *EDN*, pp. 46-49,143-144, November 8, 1967.
11. *Microwave Engineers' Handbook*, Vol. 1, Artech House, Dedham, MA, pp. 19-92, 1971.
12. M. Dishal, "Alignment and Adjustment of Synchronously Tuned Multiple-Resonator Circuit Filters," *Proc. IRE*, Vol. 39, pp. 1448-1455, November 1951.
13. R.M. Kurzrok, "Nodal Voltages Offer Key to Filter Design," *Microwaves & RF*, Part 1, pp. 72, 75-76, 79-80,82,84, April 1999 and Part 2, pp. 67-69, May 1999.
14. S.B. Cohn, "Dissipation Loss in Multiple-Coupled Resonator Filters," *Proc. IRE*, Vol. 47, pp. 1342-1348, August 1959.
15. C.M. Kudsia and V. O'Donovan, *Microwave Filters for Communications Systems*, Artech House, Dedham, MA, pp. 129-130, 1974.
16. R.M. Cox and W.E. Rupp, "Fight Waveguide Losses 5 Ways," *Microwaves*, Vol. 5, pp. 32-40, August 1966.
17. J.J. Taub, "Minimum Loss Band Pass Filters," *Microwave Journal*, pp. 67-76, November 1963.
18. W.F. Smith, "How to Combat Waveguide Corrosion-Gold Plating and Varnish Work Best," *Microwaves*, pp. 34-38, August 1965.
19. R.M. Kurzrok, "Waveguide Bandpass Filters with Coaxial Interfaces Reduce Equipment Costs," *Applied Microwave & Wireless*, pp. 100 and 102, June 1999.
20. N.A. Spencer, "Crossed-Mode Tunable Selector for Microwaves," *IRE Convention Record*, Part 5, pp. 129-132, 1956.
21. S.B. Cohn, "Properties of Ridge Waveguide," *Proc. IRE*, Vol. 35, pp. 783-788, 1947.
22. G.F. Craven and C.K. Mok, "The Design of Evanescent Mode Waveguide Bandpass Filters for a Prescribed Insertion Loss Characteristic," *IEEE Trans MTT*, Vol. MTT-19, pp. 295-308, March 1971.
23. D. Kajfez and P. Guillon, *Dielectric Resonators*, Vector Field, Oxford, MS, 1990.
24. R.L. Sleven, "Design of a Tunable Multi-Cavity Waveguide Bandpass Filter," *IRE Convention Record*, Part 3, pp. 91-112, 1959.
25. R.M. Kurzrok, "General Three Resonator Filters in Waveguide," *IEEE Trans MTT*, Vol. MTT-14, p. 46, January 1966.
26. A.E. Williams, "A Four Cavity Elliptic Waveguide Filter," *IEEE Trans MTT*, Vol. MTT-18, pp. 1109-1114, December 1970.
27. A.E. Atia and A.E. Williams, "Non-Minimum Phase Optimum Amplitude Bandpass Waveguide Filters," *IEEE Trans MTT*, Vol. MTT-22, pp. 425-431, April 1974.
28. D.A. Taggert and R.D. Wanselow, "Mixed Mode Filters," *IEEE Trans MTT*, Vol. MTT-22, pp. 898-902, October 1974.
29. R. Levy, "Filters with Single Transmission Zeros at Real or Imaginary Frequencies," *IEEE Trans MTT*, Vol. MTT-24, pp. 172-182, April 1976.
30. E.N. Torgow, "Microwave Filters," *Electro-Technology*, Vol. 67, pp. 90-96, April 1961.
31. J.D. Rhodes, "Microwave Filters," *IEEE Circuits and Systems*, Vol. 7, pp. 2-8, August 1975.
32. R. Levy and S.B. Cohn, "A Brief History of Microwave Filter Research, Design, and Development," *IEEE Trans MTT*, Vol. MTT-32, pp. 1055-1067, September 1984.



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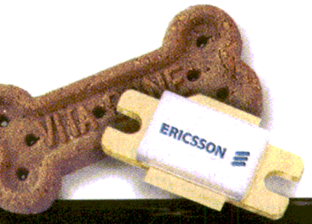

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PTF 10036	860–960MHz	85	11.0	28	−30	55	Input Matched
PTF 10020	860–960MHz	125	11.0	28	−30	55	Push Pull
PTF 10100	860–960MHz	165	12.0	28	−30	47	Input Matched
PTF 10149	925–960MHz	70	16.0	26	−30	50	Input Matched
PTF 10021	1.4–1.6 GHz	30	11.0	28	−30	48	I/O Matched
PTF 10125	1.4–1.6 GHz	135	11.5	28	−30	45	I/O Matched
PTF 10035	1.9–2.0 GHz	30	11.0	28	−30	35	I/O Matched
PTF 10112	1.8–2.0 GHz	60	11.0	28	−28	41	I/O Matched
PTF 10120	1.8–2.0 GHz	120	10.0	28	−30	40	I/O Matched
PTF 10048	2.1–2.2 GHz	30	10.0	28	−30	39	I/O Matched
PTF 10122	2.1–2.2 GHz	50	9.5	28	−30	39	I/O Matched
PTF 10134	2.1–2.2 GHz	100	10.0	28	−30	36	I/O Matched

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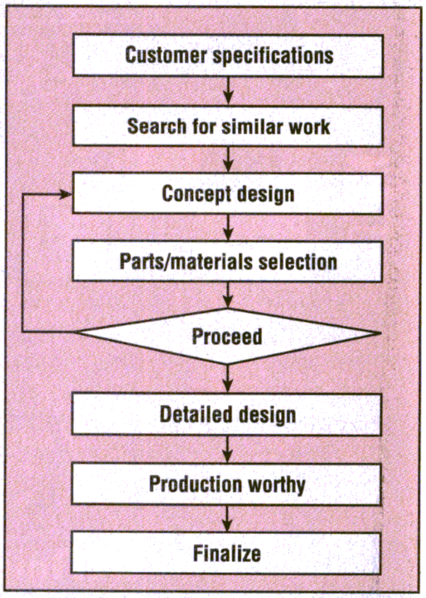
TURNING an ideal RF power-amplifier (PA) design into something that can be produced cost-effectively is a critical step in any development effort. It is one thing to conceive an ideal PA design, yet it is quite another to implement the desired results in a low-cost manufacturing process. Performance requirements, cost, and time constraints often conspire to make design realization a difficult challenge. Unfortunately, improving the design for manufacturability and process tolerances usually comes at a time when the overall development is being pushed to meet an "optimal" market window and critical amplifier specifications. Knowing what aspects of the design are critical in the practical implementation of the amplifier and how to properly simulate them can save considerable time and improve the probability of design success.

While the details of "closing the loop" on a particular design may ultimately determine overall success, this more practical phase of the development effort is frequently given hasty consideration. Areas in need of scrutiny are the following:

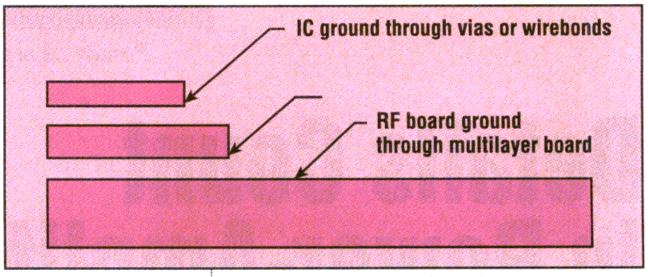
1. Overall design flow.
   - Packaging factors and output realization.
   - Key product development drivers.
2. Transistor-to-board variables.
   - Packages.
   - Output matching and grounds.
3. Package trade-offs.
   - Ground and signal paths.
   - Package models, first order.
   - Ground isolation
4. Output-match simulation.
   - Realization of output match.
   - Simulation models.
   - Electromagnetic (EM) analysis.
   - Test-fixture effects.

It is critical for designers to work with the final Printed-circuit-board (PCB) design to understand what effects it will have on output matching. A good start to turn a PA design into a workable product should begin by looking at the overall design flow,



1. The first step in RF PA design is to develop a process flow chart that describes the overall implementation plan.

which is typically based on a set of specifications that explicitly define one or more sets of operating conditions, as well as any limitations on package size (Fig. 1). Both cost and risk are very important factors, but are not always adequately considered. In addition, it is not uncommon for specifications to resemble more of a "wish list" than actual requirements. Scrutinizing actual needs versus specifications can yield important trade-offs that will save valuable time and effort. Other considerations include the system form factor, manufacturing capability, standards, performance versus cost, volume versus cost, performance versus manufacturing technology, transition from design to realization, risk versus time, and test fixturing.



2. Three types of parasitics are present in a PA mounted on a PCB—in the integrated circuit (IC) itself, the package, and the board elements.

The value of design reuse can be substantial. Why reinvent the wheel when you do not have to? Leveraging existing work, even if it requires some modification, can significantly reduce risk and time to market.

The first-concept design provides a good hint at the difficulties that can be encountered when bringing the design to fruition. At the concept stage, the designer may already be investigating materials, parts, packaging, and technologies for fabricating the active and passive components. Eventually, the decision to proceed must be made, necessitating inevitable trade-offs between performance, cost, and risk. For example, a "no-frills" manufacturing process reduces risk and minimizes cost, but can severely limit performance. At the same time, the innovative use or modification of a standard manufacturing process with options can result in improved performance, while still arriving at desired cost and risk thresholds.

CHECKING PARASITICS

A good design effort takes all significant parasitics into account based on the operating conditions of the final design. For PAs, the output match is normally achieved off-chip so that higher Q-match structures and lower losses may be achieved. This greatly increases the value of acquiring a solid understanding of the final PA matching configuration.

A wide range of specifications is affected by package and output-match configurations. All of the spec-

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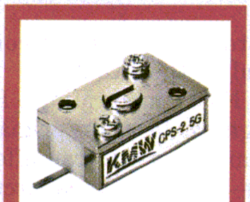
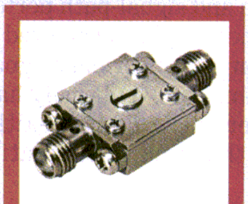
VSWR (Max.)	1.25:1	1.25:1	1.25:1
Incremental Phase Shift	90 degree min. @ 2GHz		
Electrical Delay	125 psec min.		
Nominal Impedance	50 ohm		
I/O Port Connector	SMA(F) / SMA(F)		
Average Power Handling	20W @ 2GHz		
Temperature Range	-30°C ~ +60°C		
Dimension (inch)	A type : 1.496*1.102*0.457 B type : 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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ifications of a mobile PA that might be employed in a code-division-multiple-access (CDMA) system can be altered by either the package or output match. Knowing what their effects are is critical. These include, but are not limited to, the operating frequency, small-signal gain, gain variation over frequency, temperature, and supply voltage, gain linearity, harmonics, adjacent-channel power ratio (ACPR), noise figure (NF) in band, supply voltage, and case operating temperature.

At this point, choosing the proper simulation tools is key. A good toolset is Agilent Technologies Advanced Design System (ADS), an integrated simulation environment that includes "back-end" tools required to complete and analyze the layout.

THE VALUE OF DESIGN REUSE CAN BE SUBSTANTIAL. WHY REINVENT THE WHEEL WHEN YOU DO NOT HAVE TO? LEVERAGING EXISTING WORK, EVEN IF IT REQUIRES SOME MODIFICATION, CAN SIGNIFICANTLY REDUCE RISK AND TIME TO MARKET.

As seen in Fig. 2, integrating a PA into the design creates three primary sources of parasitics that can affect performance—the integrated circuit (IC), the package, and the RF board. All three levels impact relative ground-plane and signal-path performance, and need to be considered to realize the target performance goals for the system. The ADS easily handles the inter-related complexities inherent in this kind of simulation challenge.

Of all the parasitic effects produced, ground inductance is of particular importance. The leadframe and package must be designed to provide for maximum ground isolation. Additionally, for optimum isolation, the

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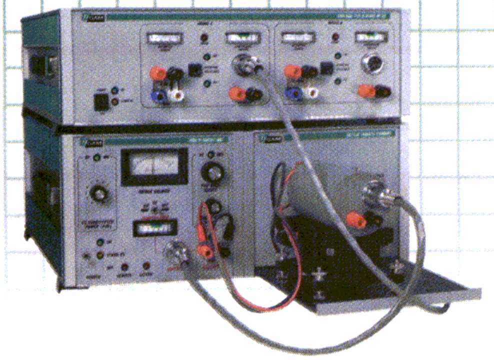

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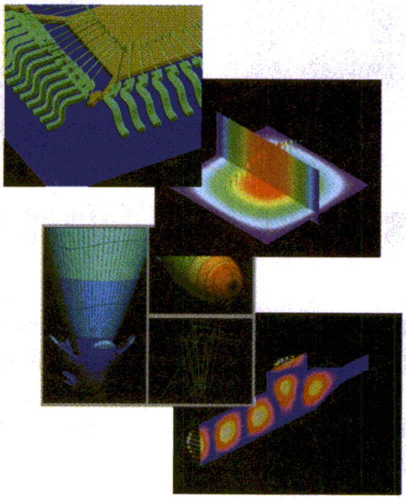
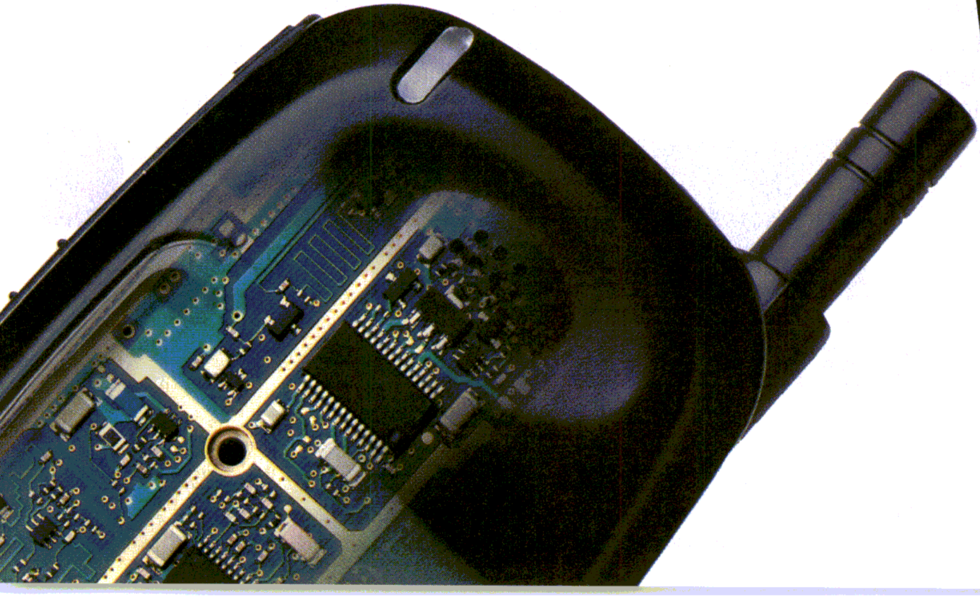





The Choice is Yours

RF board should employ a split ground structure.

At the IC level, the power transistor is typically connected to a substrate ground using via structures or wirebonds. In applications that use wirebonds, ground inductance can be reduced by employing multiple wirebonds.

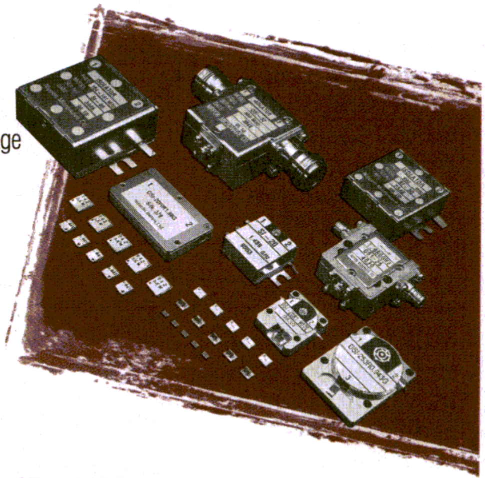
At the package level, ground is normally achieved through a ground paddle attached to the bottom of the package or a ground connection through the package leadframe. The leadframe can be modified in a number of ways to reduce inductance.

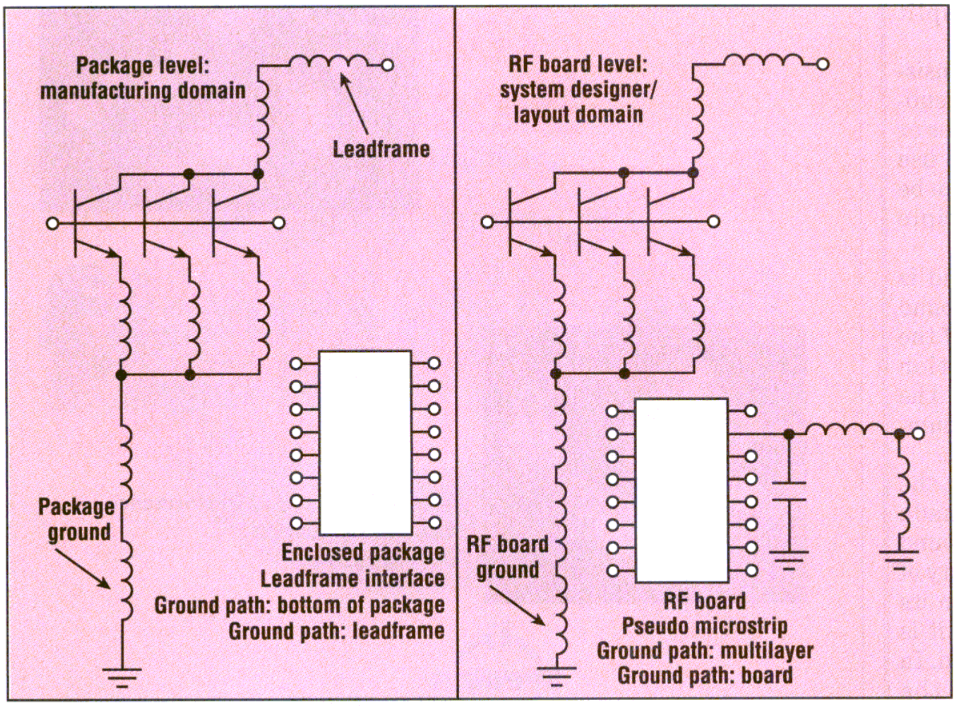
Finally, ground connections at the RF board level are usually made through vias to a dedicated ground plane within the board. The quality of this ground varies depending on its physical features and how well it is connected to the "system" ground. In a typical multilayer board, the ground plane may be buried several layers down in the board, requiring long via connections that increase inductance. Signal paths can be constructed using a number of different transmission-line arrangements, including microstrip, stripline, and coplanar waveguide (CPW). The final design typically uses a hybrid structure that requires accurate models for reliable simulation results.

PACKAGE TRADE-OFFS

At the package level, more parasitic inductance is added to signal and ground paths. For instance, wirebonds may be longer than desired to accommodate package construction limitations (covered in more detail later). At the RF board level—the domain of system and layout designers—ground is typically accessed through vias in the board, adding more inductance (Fig. 3).

Figure 4 shows a comparison of the effects of ground and signal inductance on a PA. In the sample circuit, a 1-nH inductor is inserted in the ground path (source) and the signal path (drain). The results of simulations with and without these inductances are summarized. Notice the large shift in optimum impedance match (Sopt) for output power with a relatively small change in inductance.





3. These first-order models at the package- and RF-board level show that inductance is added in the signal and ground paths by the packaging and board materials.

The myriad of package options now available is beyond the scope of this article, but a good example is to look at the SSOP-16, a package commonly used in mobile handsets. This approach provides a sound basis for exploring package construction tradeoffs as well as the effects of signal and ground paths on active devices—knowledge that can be applied to other packages.

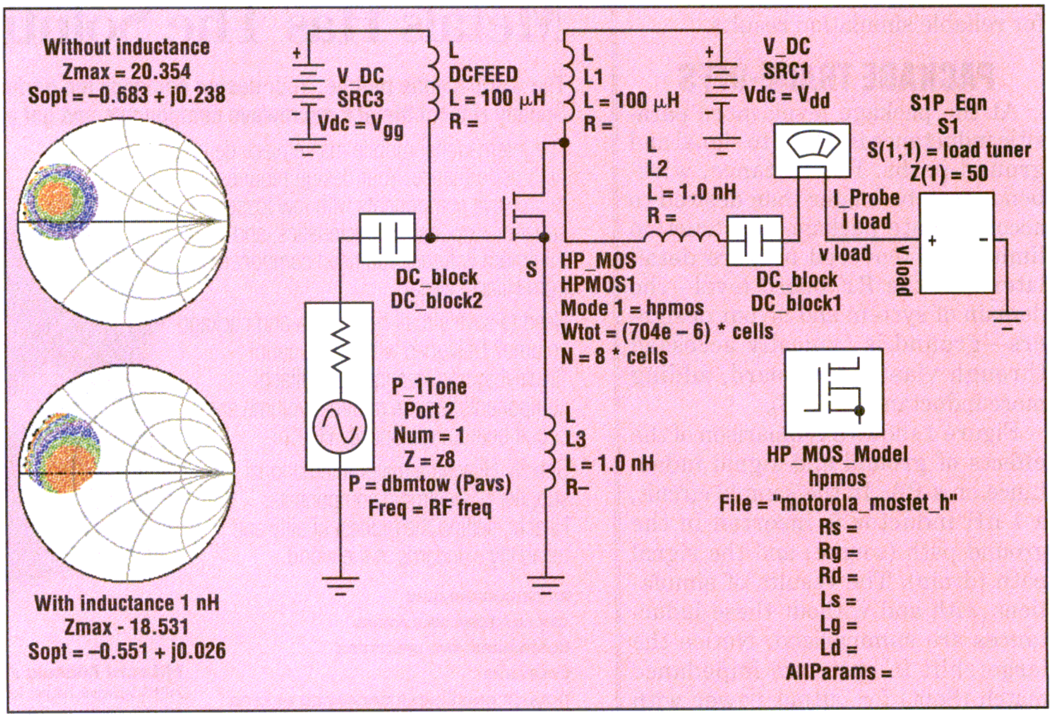
For this example, assume that cost is a key driver, manufacturing volumes will be large, and that time to market is critical. Clearly, using an existing package is a plus, and perhaps a necessity, since redesign will probably take too much time. With this limitation, making modifications to the leadframe may be a practical option. Similarly, a range of electrical options is typically available despite the package's mechanical limitations.

There are usually a number of ground options available within a particular package body, other than the leadframe. For example, the package might provide the option of using a paddle (ground button/slug) or a down-set leadframe for ground. Three general arrangements are available for package ground and signal paths.

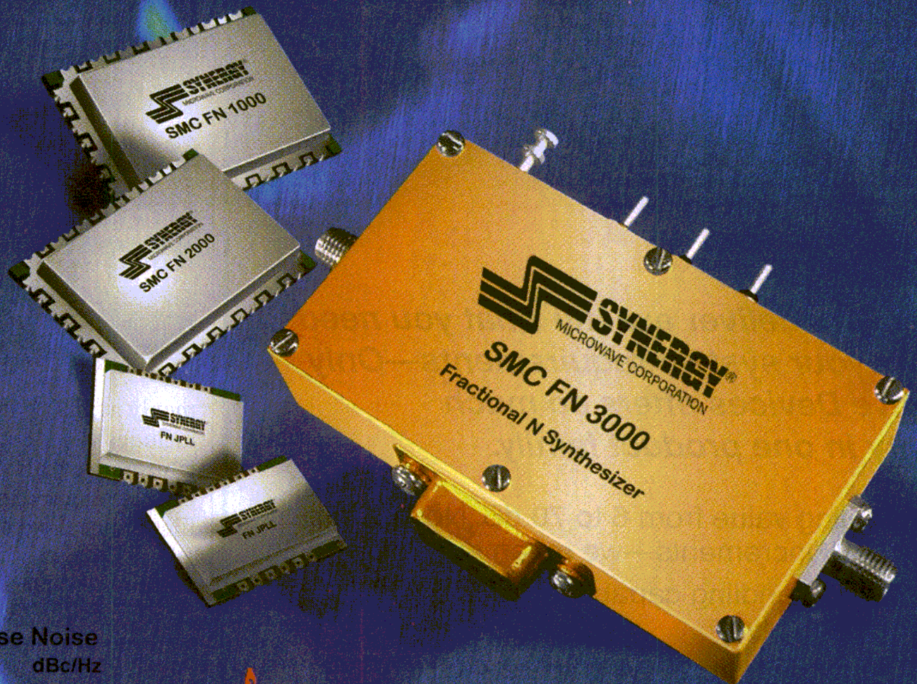
The first option does not use a backside ground contact and is the lowest-cost approach. More ground inductance is added since the ground path is through the leadframe, but leads may be combined to minimize ground- and signal-path inductance.

The most-expensive approach is to make use of a ground paddle, which is typically brazed onto the leadframe. Ground inductance is extremely low and thermal performance is also improved. The leadframe can be modified to reduce signal-path inductance.

The last option is to employ a down-set leadframe configuration. This is less costly than a paddle, but additional overhead is required because signal-path wirebonds must be longer. This is also the case for ground paths if the IC does not include substrate vias.



4. A small amount of inductance—only 1 nH—makes a significant difference in a PA's impedance-match characteristic as shown in these ADS simulations.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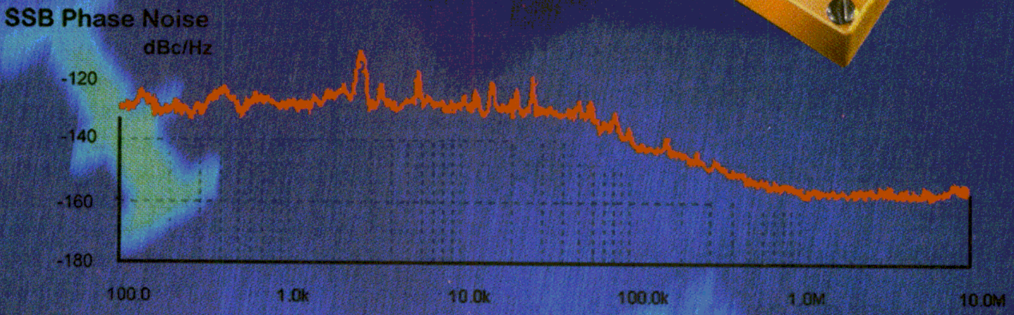

SSB Phase Noise
dBc/Hz
-120
-140
-160
-180
100.0
1.0k
10.0k
100.0k
1.0M
10.0M

The output-match realization process assumes that a particular "ideal" output-match circuit exists which accounts for microstrip and stripline transmission structures with appropriate models. This process is an iterative one that begins with a generation of an output-match circuit, then proceeds with fundamental- and second-order analysis, EM analysis, updating the circuit, and then performing analysis again. For this article, three options are considered—lumped, microstrip, and stripline—and an EM analysis is run on the stripline structure.

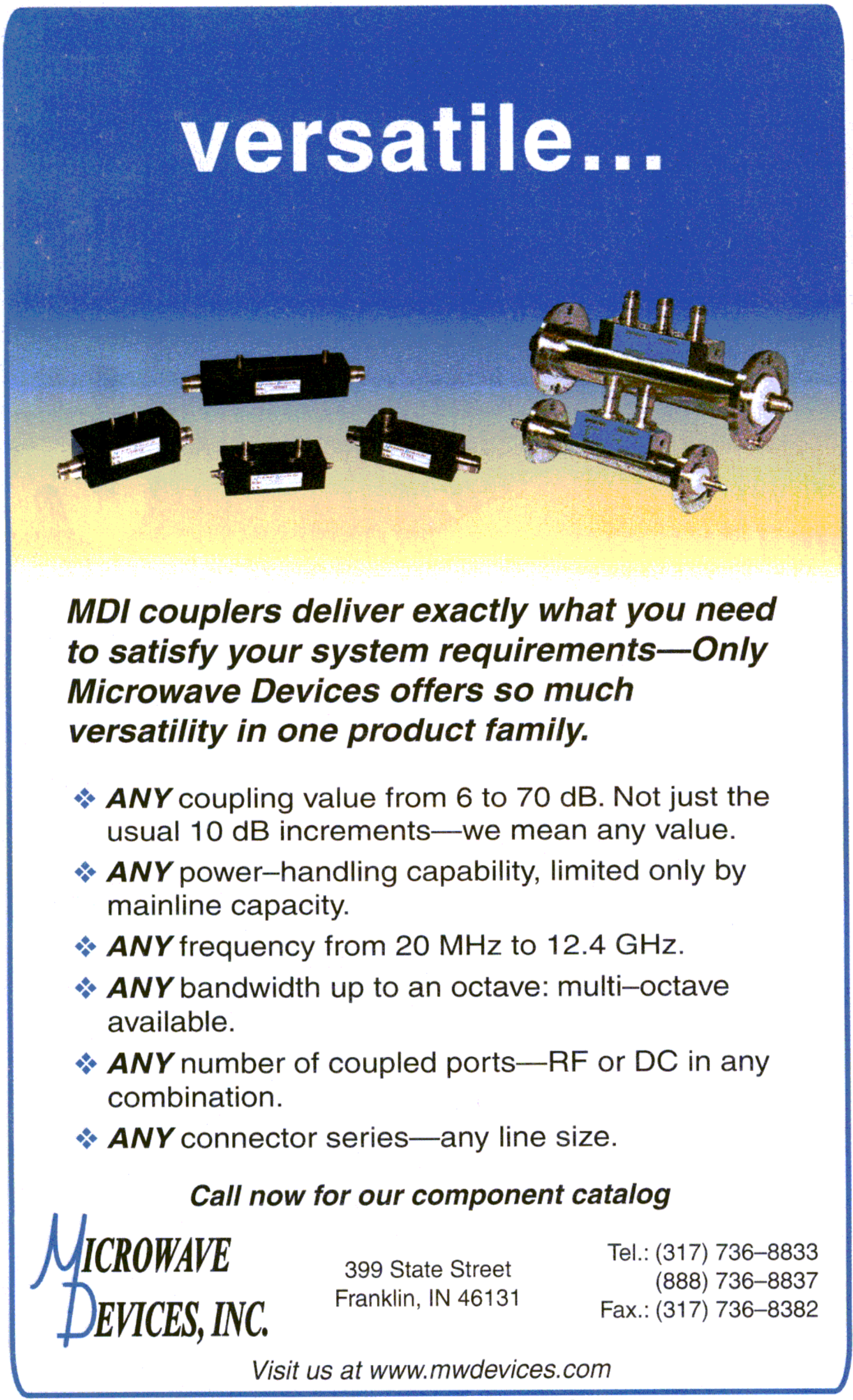
Figure 5 shows the output-match circuit and initial results for lumped, microstrip, and stripline structures. The derived output-match structure is designed to provide a match at 1.9 GHz, and then look similar to an open circuit at 3.8 GHz.

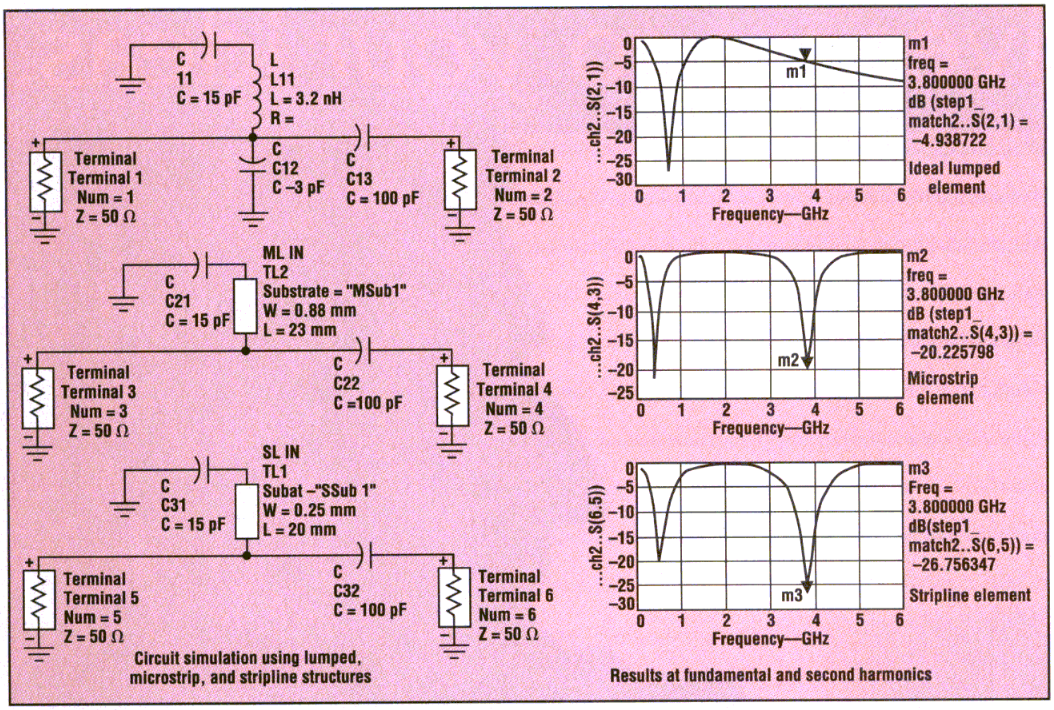
Considering the stripline structure, there is a potential problem with the circuit as depicted for two reasons. First, the stripline has a coplanar area surrounding it, which could create a hybrid transmission structure. Second, there are two unaccounted vias that connect to the stripline structure.

To investigate further, the board-layout data are read in. This is commonly available in GDS II format and includes the RF board-level information and total area. For a typical mobile-phone application, board profiles generally contain 12 or more layers. FR4-type dielectric material is commonly used to minimize cost. Next, focus in on the RF subsections that require simulation by deleting or removing areas of the board that are not part of the target area or layers.

A "NO- FRILLS" MANUFACTURING PROCESS REDUCES RISK AND MINIMIZES COST, BUT CAN SEVERELY LIMIT PERFORMANCE. AT THE SAME TIME, THE INNOVATIVE USE OF A STANDARD MANUFACTURING PROCESS CAN RESULT IN IMPROVED PERFORMANCE.

In Fig. 6, the stripline layer that requires analysis is identified, including the profile around the stripline and the via structures. In the subprofile, notice the close proximity of the ground-plane area to the stripline. Once the profile is defined and input and output ports are added, the structure can be simulated—in this case using the Momentum package in the Agilent ADS software (Fig. 7). As seen in the figure, a mesh is created to define the area over which to perform the simulation. Simulation





5. EM simulation analyses of three different transmission-line output-match structures are shown here—lumped, microstrip, and stripline. The stripline case must be analyzed by other ADS software to deal with coplanar areas and vias.

produces an S-parameter file that is read into the circuit schematic page for a repeat of the analysis illustrated in Fig. 5.

Focusing on the EM-analysis process, in the first step, the board layout is read. The key here is to choose a simulation tool that is compatible with common board-layout formats, such as GDS II, EGS, HPGL, HP IFF, and IGES. In the next step, the areas to be analyzed are isolated. Since EM simulation is computation intensive, a concerted effort should be made to minimize simulation time, such as deleting area and layers of no interest. Once

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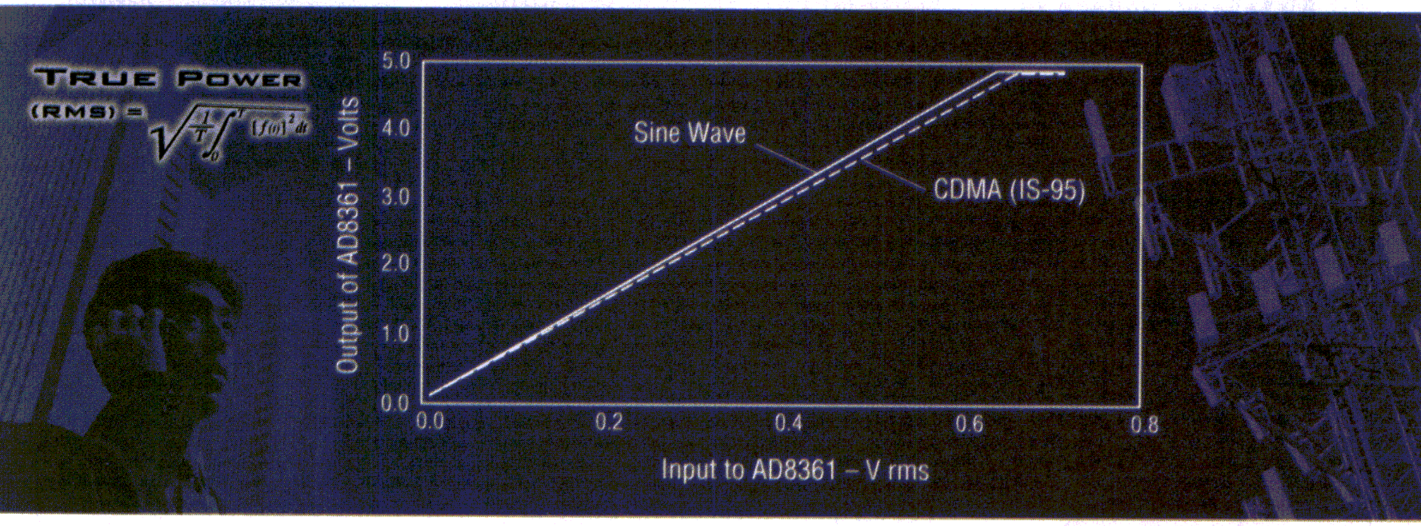

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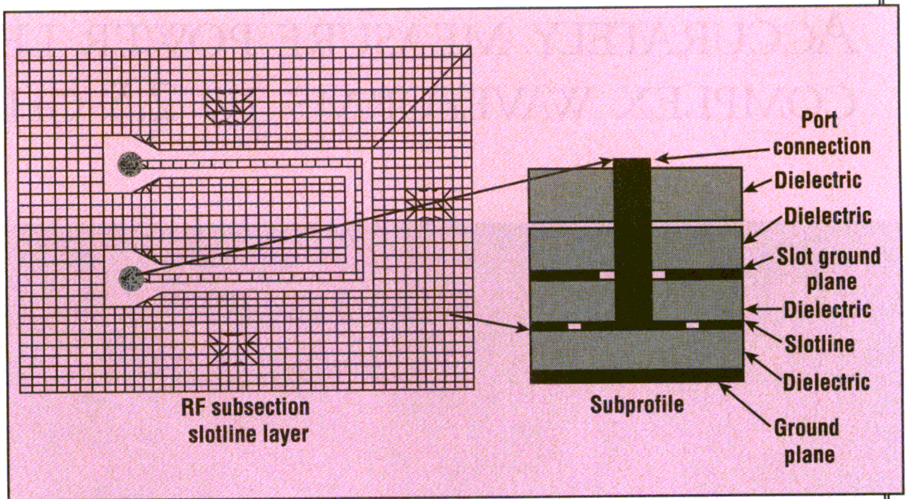


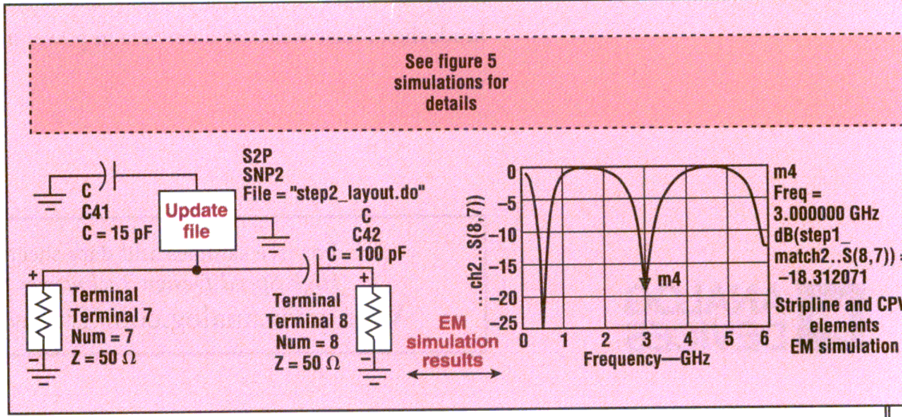
6. The stripline layer in Fig. 5 is shown here in flat and profile views. When defined with input and output ports, the structure can be simulated in ADS.

isolation is complete, the material and thickness of all metals and dielectrics used are specified.

In addition to the parasitic effects of stripline structures, there are many other factors that could be considered. Examples include the equivalent circuit for a surface-mounted capacitor or measuring actual values of dielectric materials. If either of these parameters is different than expected, it could cause a significant shift in the output-match response.

Another important factor to consider is final testing of the PA. Testing is typically carried out on high-throughput test fixtures designed to handle large volumes of parts. The mechanical structure of the test fixture may require moving and even modification of the output-match structure. Good information and an accurate representative circuit schematic of the test fixture can make this process much easier. It is critical that variable effects of the test fixture will not cause instability in the PA, and that resulting correlations are meaningful.

Many testing strategies can reduce or eliminate the need for test fixtures. One way to simplify the test fixture is by limiting the testing to DC tests only. Another approach is to test the IC devices while still in wafer form. Ultimately, the goal is to minimize the amount and complexity of testing wherever possible to reduce costs.●●



7. EM simulations of the output-match structures of Fig. 5 are shown here using the Momentum simulation software of ADS.

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IE3D Simulation Examples and Display

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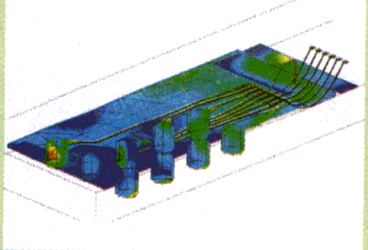
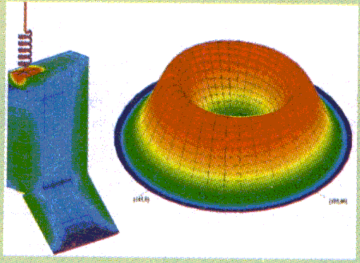


The current distribution and radiation pattern of a handset antenna modeled on IE3D



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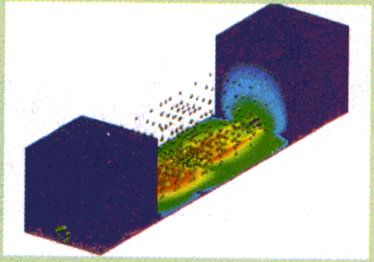
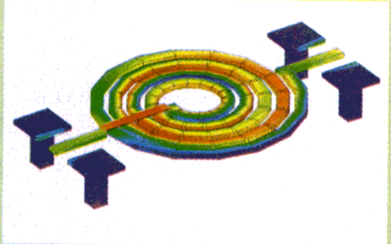
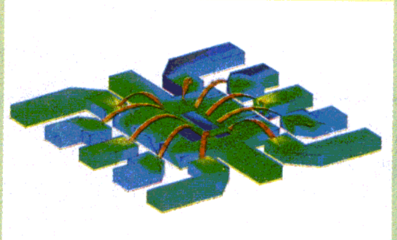
The near field and Poynting vector display on a packaged PCB structure with vias and connectors



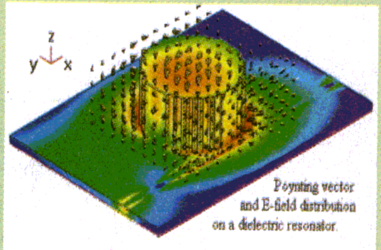
IE3D modeling of a circular spiral inductor with thick traces and vias



IE3D modeling of an IC Packaging with Leads and Wire Bonds



FIDELITY modeling of a cylindrical dielectric resonator and the Poynting vector display



Poynting vector
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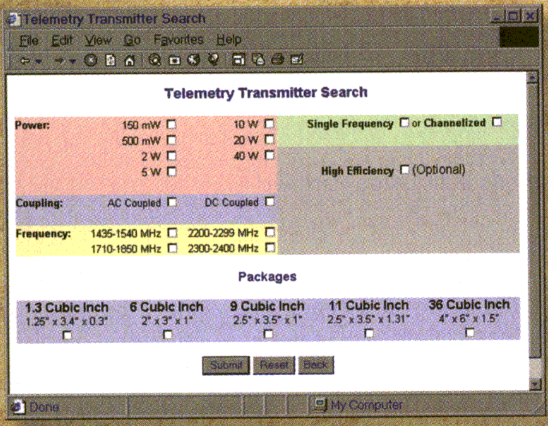

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Single Frequency ☐ or **Channelized** ☐

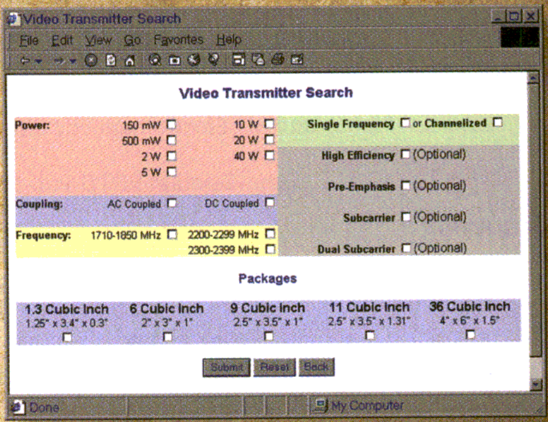
High Efficiency ☐ (Optional)

Coupling: AC Coupled ☐ DC Coupled ☐

Frequency: 1435-1540 MHz ☐ 1710-1850 MHz ☐ 2200-2299 MHz ☐ 2300-2400 MHz ☐

Packages

1.3 Cubic Inch	6 Cubic Inch	9 Cubic Inch	11 Cubic Inch	36 Cubic Inch
1.25" x 3.4" x 0.3"	2" x 3" x 1"	2.5" x 3.5" x 1"	2.5" x 3.5" x 1.31"	4" x 6" x 1.5"
☐	☐	☐	☐	☐



Video Transmitter Search

Power: 150 mW ☐ 500 mW ☐ 2 W ☐ 5 W ☐ 10 W ☐ 20 W ☐ 40 W ☐

Single Frequency ☐ or **Channelized** ☐

High Efficiency ☐ (Optional)

Pre-Emphasis ☐ (Optional)

Subcarrier ☐ (Optional)

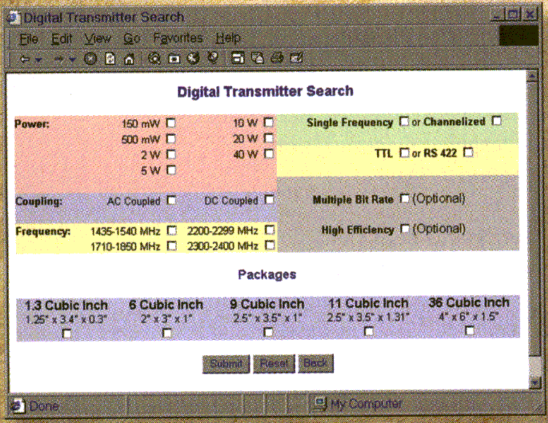
Dual Subcarrier ☐ (Optional)

Coupling: AC Coupled ☐ DC Coupled ☐

Frequency: 1710-1850 MHz ☐ 2200-2299 MHz ☐ 2300-2399 MHz ☐

Packages

1.3 Cubic Inch	6 Cubic Inch	9 Cubic Inch	11 Cubic Inch	36 Cubic Inch
1.25" x 3.4" x 0.3"	2" x 3" x 1"	2.5" x 3.5" x 1"	2.5" x 3.5" x 1.31"	4" x 6" x 1.5"
☐	☐	☐	☐	☐



Digital Transmitter Search

Power: 150 mW ☐ 500 mW ☐ 2 W ☐ 5 W ☐ 10 W ☐ 20 W ☐ 40 W ☐

Single Frequency ☐ or **Channelized** ☐

TTL ☐ or **RS 422** ☐

Multiple Bit Rate ☐ (Optional)

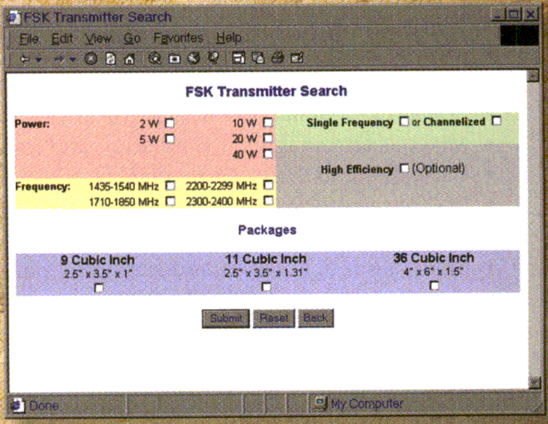
High Efficiency ☐ (Optional)

Coupling: AC Coupled ☐ DC Coupled ☐

Frequency: 1435-1540 MHz ☐ 1710-1850 MHz ☐ 2200-2299 MHz ☐ 2300-2400 MHz ☐

Packages

1.3 Cubic Inch	6 Cubic Inch	9 Cubic Inch	11 Cubic Inch	36 Cubic Inch
1.25" x 3.4" x 0.3"	2" x 3" x 1"	2.5" x 3.5" x 1"	2.5" x 3.5" x 1.31"	4" x 6" x 1.5"
☐	☐	☐	☐	☐



FSK Transmitter Search

Power: 2 W ☐ 5 W ☐ 10 W ☐ 20 W ☐ 40 W ☐

Single Frequency ☐ or **Channelized** ☐

High Efficiency ☐ (Optional)

Frequency: 1435-1540 MHz ☐ 1710-1850 MHz ☐ 2200-2299 MHz ☐ 2300-2400 MHz ☐

Packages

9 Cubic Inch	11 Cubic Inch	36 Cubic Inch
2.5" x 3.5" x 1"	2.5" x 3.5" x 1.31"	4" x 6" x 1.5"
☐	☐	☐

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CIRCLE NO. 233

Site Surveys Bluetooth Components And Applications

This site provides the browser with tutorials and applications on Bluetooth radios, global position receivers, keyless entry devices, and fractional-N synthesizers.

ALAN ("PETE") CONRAD
Special Projects Editor

Bluetooth is a wireless personal connectivity standard based on radio links at 2.4 GHz. With more than 1300 electronics manufacturers currently registered in support of the Bluetooth standard, it is a wireless application poised for explosive growth in the next several years. For those who wish to know more about Bluetooth, one of the leading integrated-circuit (IC) and component developers for the standard, Philsar Semiconductor (Nepean, Ontario, Canada) offers extensive product and application information on their website, at http://www.philsar.com.

Philsar is a fabless developer of semiconductor solutions for personal wireless connectivity. Designs based on the company's technological innovations in single-chip radio technology enable wireless original-equipment manufacturers (OEMs) to get to market faster with low-power, communications products that incorporate creative design approaches to reduce the number of components and lower the total system cost. The company's line of components for personal wireless connectivity includes cellular handsets, accessories such as headsets, as well as notebook computers and personal digital assistants (PDAs) geared toward Bluetooth control and applications. Other products include devices for remote-keyless-entry (RKE) designs, receiver chips for Global Positioning System (GPS) applications, and a family of low-power fractional-N frequency synthesizers.

Visitors to the site will find application notes describing the use of silicon germanium (SiGe) for Bluetooth products, a background review of Bluetooth applications, and a PowerPoint presentation on robustness and autonomy in Bluetooth RF IC designs. The site also features a detailed article about GPS with functional circuit descriptions and a review of two-way crypto systems.

The application note on SiGe reviews this novel semiconductor process and how it can be applied to combine the functions of high-speed bipolar and complementary-metal-oxide-semiconductor (CMOS) devices as well as bipolar-CMOS (BiCMOS) devices in a single chip with a host of analog, linear, and digital devices.

The Bluetooth application note explains the Bluetooth specification for small-form-factor, low-cost, short-range radio links between mobile personal computers (PCs), mobile telephones, and other portable devices. The website also offers a Microsoft PowerPoint file that reviews Bluetooth application requirements, different Bluetooth transmit-power classes and their performance limits, an analysis of the Bluetooth environment, and a review of the receiver and transmitter architecture.

An RKE technical note reviews the difference between one-way and two-way RKE security systems with appropriate product descriptions. The technical note points out that current one-way wireless RKE devices, even with coded signals, offer little security. But with the use of two-way RKE technology and a simple ping-pong-ping coding process, the security of these devices can be greatly improved.

The GPS tutorial reviews the functions and detailed operation of a fully integrated GPS receiver chip. The browser is guided from the antenna input to the receiver output with descriptions of each circuit's performance.

Browsers can also review a family of fractional-N frequency synthesizer components. They bring high performance to personal wireless connectivity applications through an innovative architecture that delivers fine step size (below 100 Hz) to support applications in need of low phase noise, fast switching speeds, and low power consumption. All of the data sheets are thorough. ●

For more information, contact:

Philsar Semiconductor, Inc., 146 Colonnade Rd. S., Nepean, Ontario K2E 7Y1, Canada; (613) 274-0922, FAX: (613) 274-0915.

Internet: http://www.philsar.com.

DSP Tutorials Dominate Informative Site

Engineers in need of information on digital-signal-processing (DSP) techniques and technologies will find all that they can handle at this comprehensive site.

ALAN ("PETE") CONRAD
Special Projects Editor

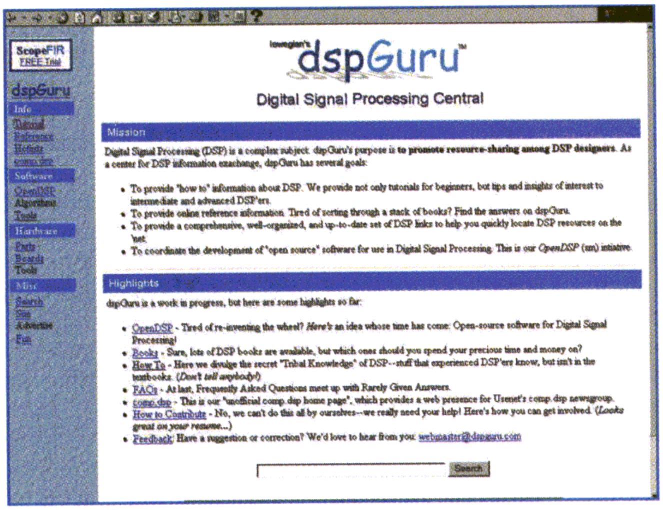
Digital signal processing (DSP) is instrumental to the effective operation of many modern communications formats. DSP is used, for example, to provide the complex matched filters required for spread-spectrum systems. For engineers needing to know more about DSP design approaches and applications, a visit to the DSP Guru site at http://www.dspguru.com can tell them what they need to know. The site, which is liberally sprinkled with links to other companies, provides tutorials for beginners with tips and insights of interest to intermediate and advanced DSP designers.

The site's many tutorial articles *(see figure)* focus on practical DSP implementation issues. Topics include finite-impulse-response (FIR) filters, infinite-impulse-response (IIR) filters, Fast Fourier transforms (FFTs), multirate-sampling-rate techniques, and coordinate-rotation-digital-computer (CORDIC) techniques for calculating trigonometric functions, such as sine, cosine, cosecant, and tangent functions. Articles on FIR basics cover the types of digital filters used in DSP applications, the differences between FIR and IIR filters, and a comparison of the advantages and disadvantages of both filter types. FFT basics cover an explanation of an FFT, a description of how it works, and an explanation of Discrete Fourier transform (DFT) DSP techniques. Articles on mulitrate techniques include the definition of multiple rate-sampling systems, and advantages and disadvantages of implementation. The articles also describe decimation, interpolation, and downsampling.

The CORDIC tutorial explains the technique of rotating the phase of a complex number, by multiplying it by a succession of constant values. However, the "multipliers" can all be powers of 2 so that, in binary arithmetic, they can be performed using only shifts and adds and no actual "multiplier" is needed. The article includes an iterative algorithm for calculating trigonometric functions including sine, cosine, as well as tangent functions.

The DSP Guru site includes links to tutorials on prime numbers, prime-number theory, Artin's constant, Backhouse's constant, Brun's constant, Hadamard-de la Vallée Poussin constants, Hardy-Littlewood constants, Linnik's constant, and Mills' constant. The site also includes Smarandache Notions Journal. This online journal contains a variety of results that are related to primes, such as criteria of: primality, simultaneously primality, and coprimality, and a formula for pi (x).

The site links to several low-cost filter-design programs and a free Matlab-style analysis package. Links to software sites include ScopeFIR and ScopeDSP from http://www.iowegian.com, JCP Software at http://www.jcpsoftware.com, Momentum Data Systems at http://www.mds.com, and Scilab at http://www-rocq.inria.fr/scilab/scilab.html. ●



Iowegian's dspGuru™

Digital Signal Processing Central

Mission

Digital Signal Processing (DSP) is a complex subject. dspGuru's purpose is **to promote resource-sharing among DSP designers**. As a center for DSP information exachange, dspGuru has several goals:

- To provide "how to" information about DSP. We provide not only tutorials for beginners, but tips and insights of interest to intermediate and advanced DSP'ers.
- To provide online reference information. Tired of sorting through a stack of books? Find the answers on dspGuru.
- To provide a comprehensive, well-organized, and up-to-date set of DSP links to help you quickly locate DSP resources on the 'net.
- To coordinate the development of "open source" software for use in Digital Signal Processing. This is our *OpenDSP* (sm) intiative.

Highlights

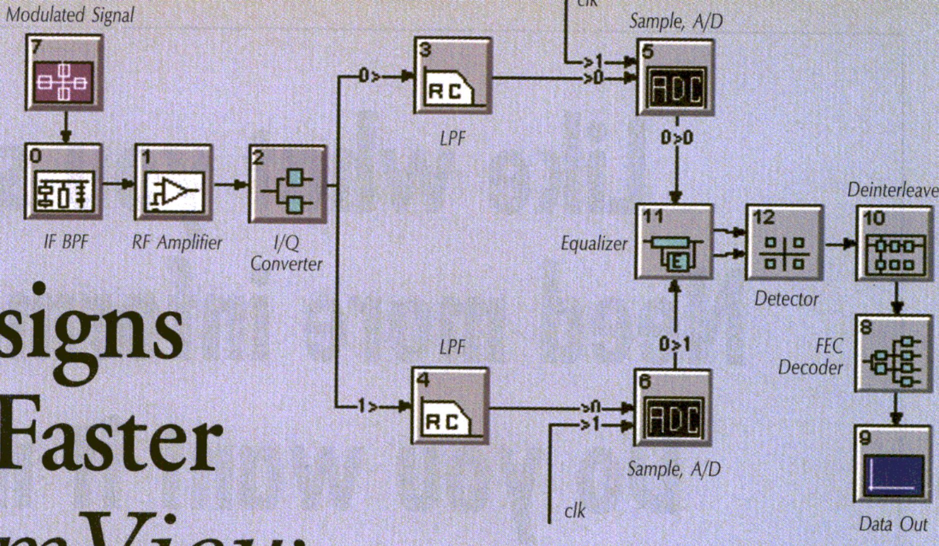
dspGuru is a work in progress, but here are some highlights so far:

- OpenDSP - Tired of re-inventing the wheel? *Here's* an idea whose time has come: Open-source software for Digital Signal Processing!
- Books - Sure, lots of DSP books are available, but which ones should you spend your precious time and money on?
- How To - Here we divulge the secret "Tribal Knowledge" of DSP--stuff that experienced DSP'ers know, but isn't in the textbooks. *(Don't tell anybody!)*
- FAQs - At last, Frequently Asked Questions meet up with Rarely Given Answers.
- comp.dsp - This is our "unofficial comp.dsp home page", which provides a web presence for Usenet's comp.dsp newsgroup.
- How to Contribute - No, we can't do this all by ourselves--we really need your help! Here's how you can get involved. *(Looks great on your resume...)*
- Feedback: Have a suggestion or correction? We'd love to hear from you: webmaster@dspguru.com

Visitors to the DSP Guru website at http://www.dspguru.com can take advantage of many design tips and applications based on DSP technology.

Get Your Comm Designs to Market Faster Using *SystemView*®

BY ELANIX



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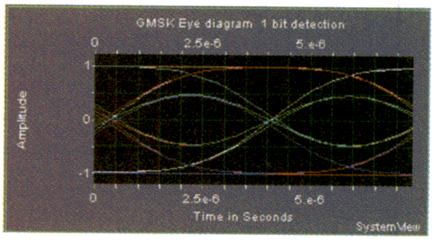
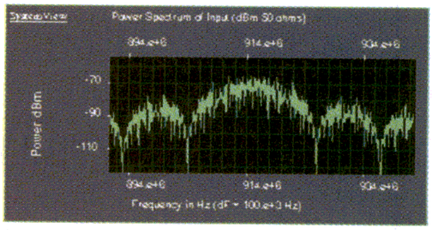
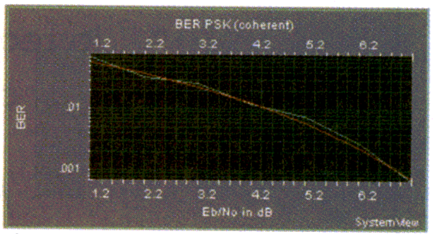


GMSK Eye Diagram (1-bit Detection)



Input Power Spectrum



Theoretical vs. Actual BER (Coherent PSK)

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- Steven Hall, CommQuest Technologies -

"For digital filter design, SystemView was indispensable due to its accurate simulation of the fixed point arithmetic mode employed on the actual DSP processor used in my design."
- Bisla Balvinder, Itron -

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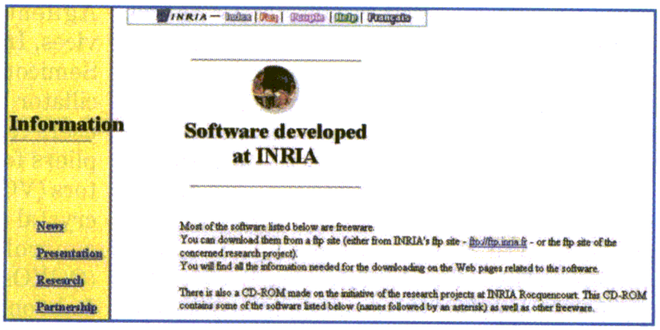
CIRCLE NO. 368

Site Offers Free Software Packages

Visitors to this website will find more than 30 free utility programs, including a package for modeling and simulation of dynamic systems.

ALAN ("PETE") CONRAD
Special Projects Editor

Free software usually provides value proportional to its price. Visitors to Inria's website at http://www.inria.fr/Information/logiciels-eng.html, however, will find more than 30 free utility programs with various degrees of quality and value, including Scilab, which is a powerful tool for modeling and simulation of dynamic systems. The site is supported by The French National Institute for Research in Computer Science and Control.



Software developed at INRIA

Most of the software listed below are freeware.
You can download them from a ftp site (either from INRIA's ftp site - ftp://ftp.inria.fr - or the ftp site of the concerned research project).
You will find all the information needed for the downloading on the Web pages related to the software.

There is also a CD-ROM made on the initiative of the research projects at INRIA Rocquencourt. This CD-ROM contains some of the software listed below (names followed by an asterisk) as well as other freeware.

The Inria website at http://www.inria.fr offers a host of free software tools, including the powerful Scilab signal-processing and analysis program.

The Inria site *(see figure)*, which can be selected in either French or English languages, offers a number of free programs with features and functions that emulate high-priced programs. Free software includes Ialloc, a dynamic allocation library written in C language; AlaDyn, a dynamic simulator for virtual reality and robotics applications; and ALIAS, a library for solving and analyzing systems of equations with a finite number of solutions using interval analysis.

Scilab, which features a graphical user interface (GUI) much like that of the popular Matlab mathematical modeling software from Math Works, Inc. (Natick, MA), was developed for system control and signal-processing applications. It handles both continuous and discrete subsystems and has an intuitive GUI and includes an interactive environment for modeling and simulation of hybrid systems. Systems are modeled by interconnecting blocks and subsystems. Blocks can be defined by the user or found in palettes.

Scilab features hundreds of built-in math functions with two- and three-dimensional (2D and 3D) graphics animation. Among the built in libraries are linear algebra, sparse matrices, and signal processing.

The software tool is composed of three distinct parts: an interpreter, libraries of functions and Scilab procedures, and libraries of Fortran and C routines. Key features of the Scilab syntax are its abilities to handle matrices and basic operations such as addition or multiplication. The software can perform basic matrix manipulations such as concatenation, extractions, and transpositions. It can also manipulate rational or polynomial transfer matrices.

Scilab provides a variety of powerful primitives for the analysis of non-linear systems. Integration of explicit and implicit dynamic systems can be accomplished numerically. The program's toolbox supports the graphic definition and simulation of complex interconnected hybrid systems.

Scilab has an open programming environment where the creation of functions and libraries of functions is completely in the hands of the user. Functions are recognized as data objects in Scilab and can be manipulated or created as other data objects. For example, functions can be defined within the program and passed on as input or output arguments of other functions. In addition Scilab supports character-string data types, which support on-line creation of functions.

The program supports easy interfaces with Fortran or C subprograms. This enables use of standardized packages and libraries in the interpreted environment of Scilab. Scilab is available for most Unix workstations, personal computer (PC), and Linux machines. The program is freely distributed in source-code format and is available at http://www-rocq.inria.fr/scilab/scilab.html. ●

Site Links Designers To Suppliers

Designers in need of components can select the parts they need from this site's generic wireless/RF block diagram.

ALAN ("PETE") CONRAD
Special Projects Editor

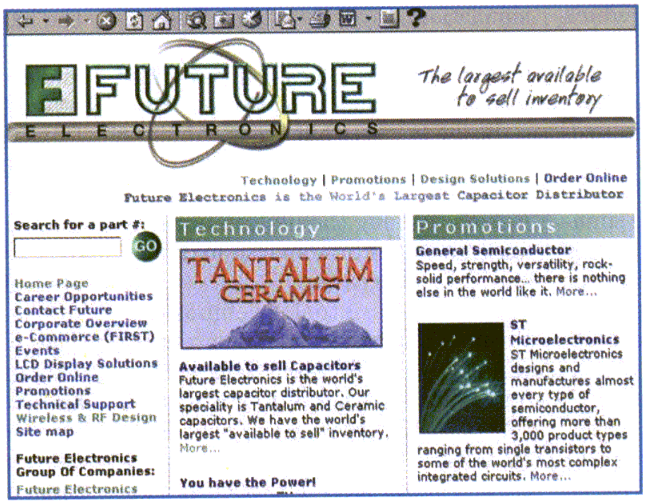
Visitors to Future Electronics' website at http://www.future.ca will find novel solutions to their transmitter and receiver chip-set applications. The site includes a fully integrated, state-of-the-art worldwide online communications system, 24-hour-a-day product-marketing support and expertise to effectively meet the needs of design engineers for prototype component selection. In addition, the site offers market intelligence regarding industry trends, pricing, product availability, and technology roadmaps to help browsers navigate through the wireless as well as RF marketplace.

After a short registration process, visitors can choose from a series of viewing options. These include RF design solutions, new products, application reference designs, an online newsletter, and online technical assistance. A unique block-diagram worksheet *(see figure)* allows visitors to select components from the antenna input to the digital-signal-processing (DSP) output port. Each component supplier includes a link to their individual website, with additional data sheets, selector guides, and application notes.

Component families listed on the Future Electronics website include RF filters, transmit and receive (Tx/Rx) switches, low-noise amplifiers (LNA), mixers, intermediate-frequency (IF) bandpass filters, IF amplifiers, demodulators and modulators, analog-to-digital converters, (ADCs) digital-to-analog converters (DACs), and DSPs. Nearly all of the suppliers' sites contain numerous application notes on the use of their product line.

For example, clicking on the RF amplifier block opens a window with a choice of LNA suppliers, including Agilent Technologies, Analog Devices, Intersil, Motorola, and Philips Semiconductors. Clicking on the oscillator block opens a window where users can select from a choice of suppliers for voltage-controlled oscillators (VCOs), temperature-controlled crystal oscillator (TCXOs), or oven-controlled crystal oscillators (OCXOs), such as Motorola, Murata, Raltron, Fox, IQD, Exar, and AVX.

The site's new-product section features the latest product innovations from partner suppliers. By selecting a reference design, a visitor gains access to a library of application-specific reference diagrams. By clicking on the *Wireless & RF Newsletter*, visitors open an 18-page online newsletter with links to suppliers' products and design updates. Design kits are available from a wide range of suppliers with a simple click of the computer mouse. Components selected during the design process are immediately available for online purchasing and viewing of other catalog items. ●



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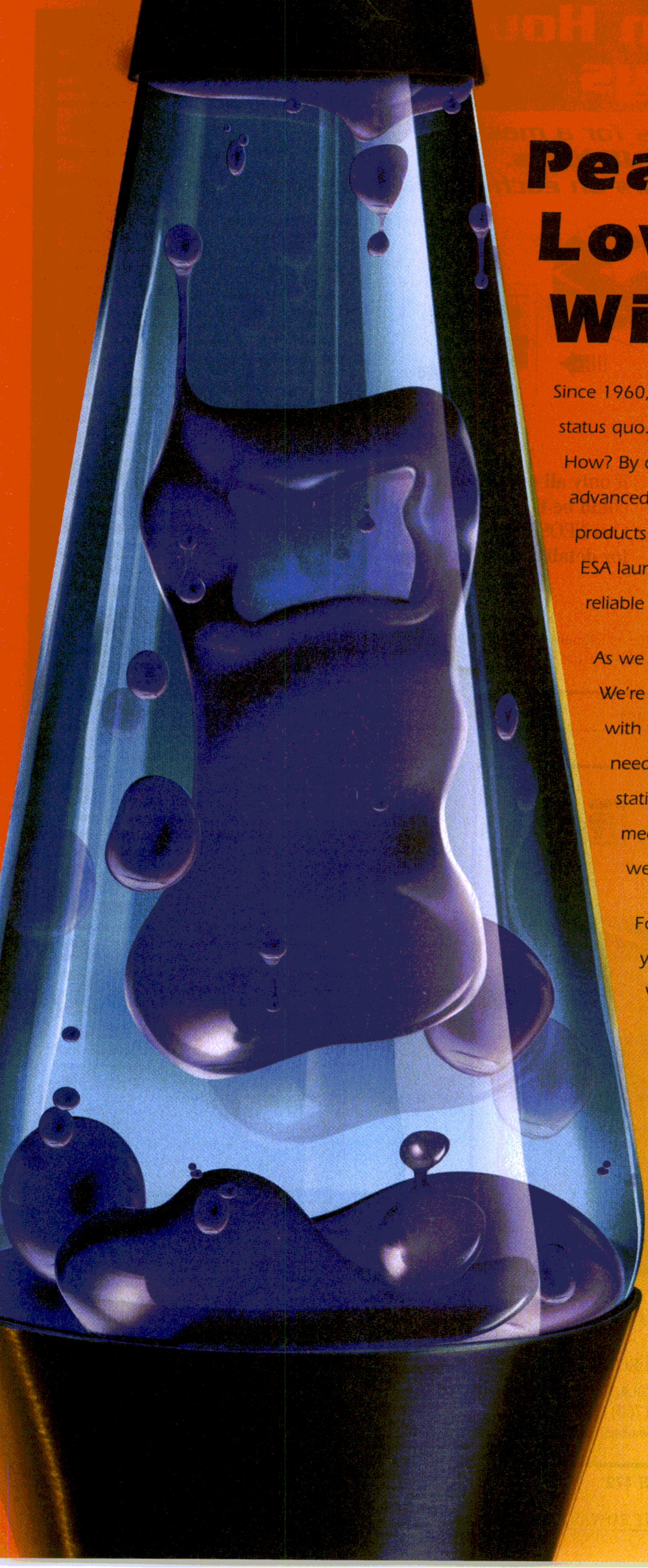
The Future Electronics website at http://www.future.ca features information on a wide range of components, including a generic block diagram to help engineers with their specifying decisions.

Future Electronics, 41 Main St., Bolton, MA 01740; (978) 779-3000, FAX: (978) 779-3050.
Internet: http://www.future.ca.



Site Features Analog And Digital Components

This comprehensive site contains a host of military, commercial, and COTS components for terrestrial and space applications.

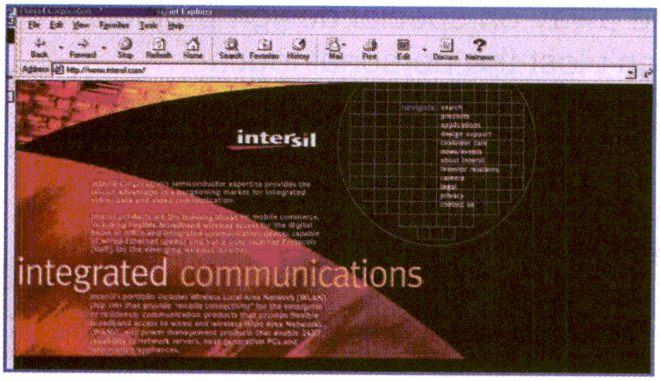
ALAN ("PETE") CONRAD
Special Projects Editor

Component specifiers will find a wide selection of products at the Intersil Corp. site at http://www.intersil.com. With 15 categories of components, designers can choose from among commercial, military, and commercial-off-the-shelf (COTS) grade components. Among the products are analog and linear integrated-circuit (IC) components, data converters, digital-signal-processing (DSP) chips, a family of radiation hardened components for military and space applications, and a family of wireless-local-area-network (WLAN) ICs.

The website *(see figure)* features a generous blend of product data sheets and application notes. Data sheets on analog and linear ICs, which can be downloaded from the site, cover comparators, differential amplifiers, operational amplifiers, sample-and-hold (S/H) devices, and transistor arrays. Data sheets for all components can be downloaded from the site. Among the many application notes are opamp noise prediction, applications for operational transconductance amplifiers, and evaluation programs for PSpice opamp models. The site also contains data sheets for a family of data conversion components, including high-speed analog-to-digital converters (ADCs), integrating ADCs, sigma-delta ADCs, general-purpose digital-to-analog converters (DACs), and high-speed DACs.

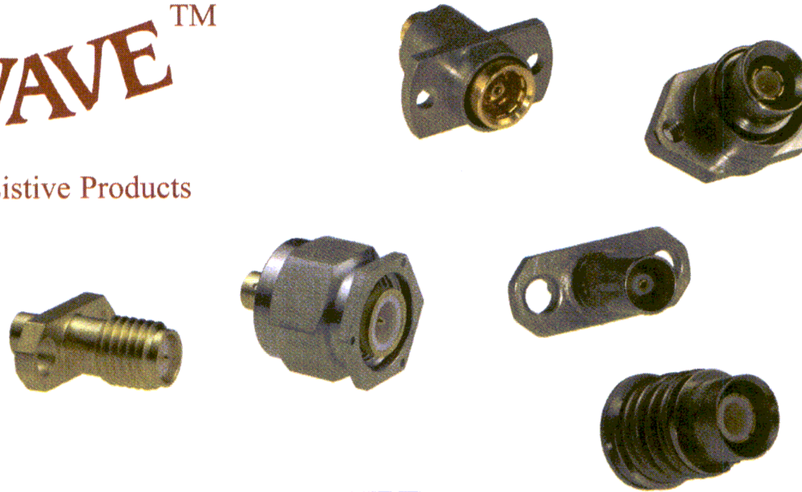
Designers of military and space systems will appreciate the wide variety of radiation-hardened components. They consist of analog and linear ICs, data-acquisition (DAQ) components, and logic devices. Linear ICs include operational amplifiers, buffers, comparators, and transistor arrays. Radiation-hardened DAQ components include ADCs, DACs, multiplexers, and switches.

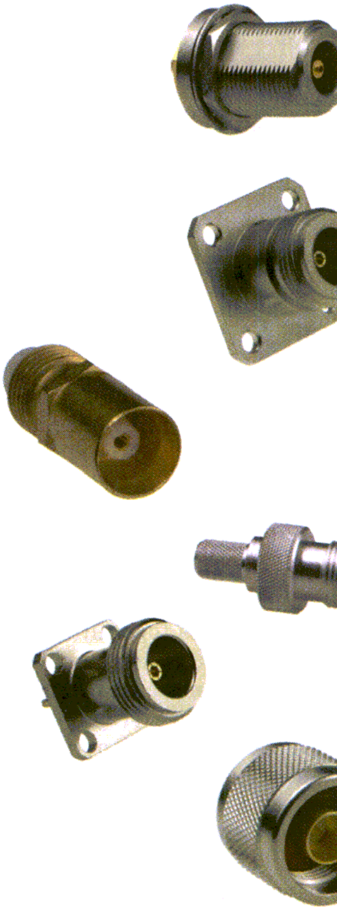
Despite this wealth of component data, Intersil may still be best known for its line of WLAN ICs, notably the PRISM chip set. Now in its second generation, the PRISM chips provided improved operating times on battery power with higher efficiency, the direct result of a silicon-germanium (SiGe) semiconductor process. The original PRISM chip set supported data rates at 1 and 2 Mb/s for IEEE 802.11 standard operation, and to 4 Mb/s for nonstandard operation. The PRISM II chip set has a top data rate of 11 Mb/s, and is compliant to the high-data-rate draft extension to the IEEE 802.11 WLAN standard. The WLAN ICs support complementary-code-keying (CCK) modulation for the high-rate (HR) extension, as well as two other modulation schemes. Other PRISM II features provide advanced performance features that include an increase in effective range at the same data rates. Another benefit is that it can downshift to slower data rates (5.5, 2.0, or 1.0 Mb/s) to maintain the integrity of the wireless link should conditions deteriorate or as necessary to operate with legacy 802.11 equipment working at only the 1- or 2-Mb/s speed. ●

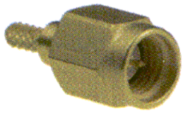


Intersil's website at http://www.intersil.com features a broad range of data sheets and application notes on analog, linear, and digital components for commercial and military applications.

Intersil Corp., 2401 Palm Bay Rd. NE, Palm Bay, FL 32905-3398; (888) 468-3774.
Internet: http://www.intersil.com.







Direct-conversion IC eliminates IF stages

Direct conversion of radio signals can eliminate costly intermediate-frequency (IF) stages in mobile radio designs. The "Othello" direct-conversion radio chip set from Analog Devices (Norwood, MA) provides all of the main functions necessary for implementing dual- or triple-band radios for Global System for Mobile Communications (GSM) cellular telephones. Comprehensive details on the chip set and its theory of operation can be found in the latest edition of *Analog Dialogue* (Volume 33), a free technical magazine published by Analog Devices.

Direct-conversion techniques are of interest in commercial and consumer electronics equipment since conversion stages add cost, size, and weight. Each conversion stage requires a local oscillator (LO), a mixer, a filter, and often an amplifier.

In the Othello direct-conversion radio chip set, the component count is reduced by integrating a front-end GSM low-noise amplifier (LNA) with the radio. This eliminates an RF filter used for image rejection from the mixer.

The Othello dual-band radio employs a superhomodyne architecture. In receive mode, a signal enters through the antenna connector to a transmit/receive (Tx/Rx) switch and travels along one of two paths for either GSM (925 to 960 MHz) or DCS (1805 to 1880 MHz). The signal then passes through an RF filter that attenuates out-of-band signals while passing the desired signals. This filter is followed by the LNA, and then the direct-conversion mixer that translates the incoming RF to an output baseband signal. The output of the mixer stage is then sent in quadrature to a variable-gain baseband amplifier stage, after which they are digitized by the receive-stage analog-to-digital converters (ADCs).

The article on Othello highlights frequency-planning strategies with the chip set, techniques for reducing spurious emissions from the radio, and advice on the selection of a voltage-controlled oscillator (VCO) for use as the LO. Copies of Volume 33 of *Analog Dialogue* are available upon request from: **Analog Devices, One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; (800) 262-5643, (781) 329-4700, FAX: (781) 326-8703, Internet: http://www.analog.com.**

CIRCLE NO. 194 or visit www.mwrf.com

Specifying AC power sources

Alternating-current (AC) power supplies are used in a wide range of applications within power systems, including in digital-to-analog (DC-to-AC) inverters, in frequency changers, and in voltage converters. They are also frequently used to power and back up critical onboard equipment in larger systems. In order to properly specify these sources, it is essential to understand the guidelines and specifications for AC sources, and these are outlined in a useful application note from Transistor Devices, Inc. (Cedar Knolls, NJ) entitled "A Guide to Specifying AC Power Sources."

The AC power-source guide points out the optimum configurations for best cost and flexibility, reviews AC power-supply applications, and explains DC-to-AC inverters in great detail (as well as derivatives of DC-to-AC inverters, such as AC-to-AC converters, AC-to-AC frequency converters, AC voltage regulators, and AC line conditioners). The guide also details AC uninteruptible power supplies (UPS) for power-supply protection against sudden surges and line transients.

The power-source guide reviews basic operating specifications for military and commercial systems, such as the output phase, the output voltage rating, the output frequency, the phase unbalance, and the total harmonic distortion (THD). The note also describes how to specify output power, DC offset, output ripple and noise, power factor (which is the ratio of the real load power to the apparent load power), and crest factor, which is the ratio of the peak output voltage to the total root-mean-square (RMS) value. Additional specifications are described for UPS systems, including hold-up time, recharge time, and transfer time.

The note includes a useful table of specifications and power-source parameters, as well as a blank template that can be used as a specification sheet when ordering a power source. Copies of the 19-page "A Guide to Specifying AC Power Sources" are free upon request from: **Transistor Devices, Inc., 85 Horsehill Rd., Cedar Knolls, NJ 07929; (973) 267-1900, FAX: (973) 267-2047, Internet: http://www.tdipower.com.**

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When everyone's counting on you for a dependable 10Gb/s product— count on us for your RF cables and connectors.

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CIRCLE NO. 327

Fiber-Optic Link Connects 10-GHz Signals

This self-contained, wide-bandwidth fiber-optic link actually delivers signal gain while maintaining low system noise figure.

David Krautheimer
Director of Marketing and Sales
Mustafa Syed and Daniel Sundberg
Engineering
MITEQ, Inc., 100 Davids Dr., Hauppauge, NY 11788-2086; (631) 436-7400,
FAX: (631) 436-7430, Internet: http://www.miteq.com.

FIBER-OPTIC technology has improved steadily in recent years to where optical links are now viable replacements for coaxial lines even at bandwidths as wide as 10 GHz. The MDD series from MITEQ, Inc. (Hauppauge, NY) is such a family of high-speed, high-bandwidth links, offering a 3-dB bandwidth of 1 to 11 GHz with low noise figure and generous link gain over single-mode fiber-optic cables. The links feature 50-Ω input (I) and output (O) interfaces for ease of connection to RF and microwave systems.

System designers who need to transmit RF and microwave signals over a distance of more than a few hundred meters will appreciate the advantages that a fiber-optic link has to offer versus a conventional cable transmission. Typically, a single-mode optical fiber has less than 0.5-dB attenuation per kilometer and is capable of carrying light signals that are direct amplitude modulated (AM) to tens of gigahertz. Translating this into a specific application means that a system designer can capitalize on these attractive features and transmit a very large volume of data, voice, and video signals over a long distance without regeneration.

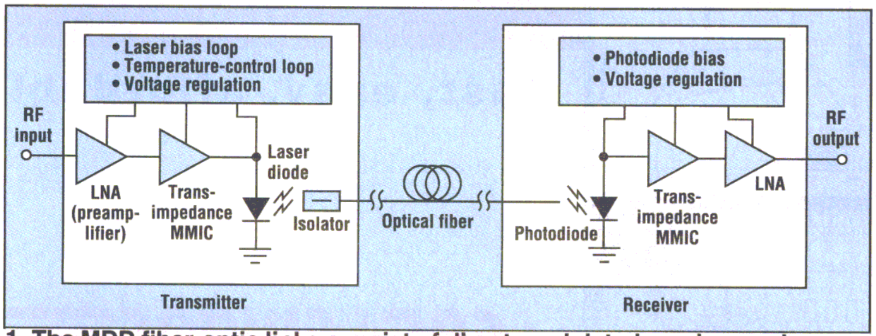
With the increased use of complex electronic systems on aircraft and ships where weight and space are at a premium, an optical-fiber system with its lightweight and small volume becomes even more attractive. An optical link offers several other advantages:

1. It is virtually immune to electromagnetic interference (EMI) and humidity, which are of paramount importance especially in the confines of a ship or an aircraft.

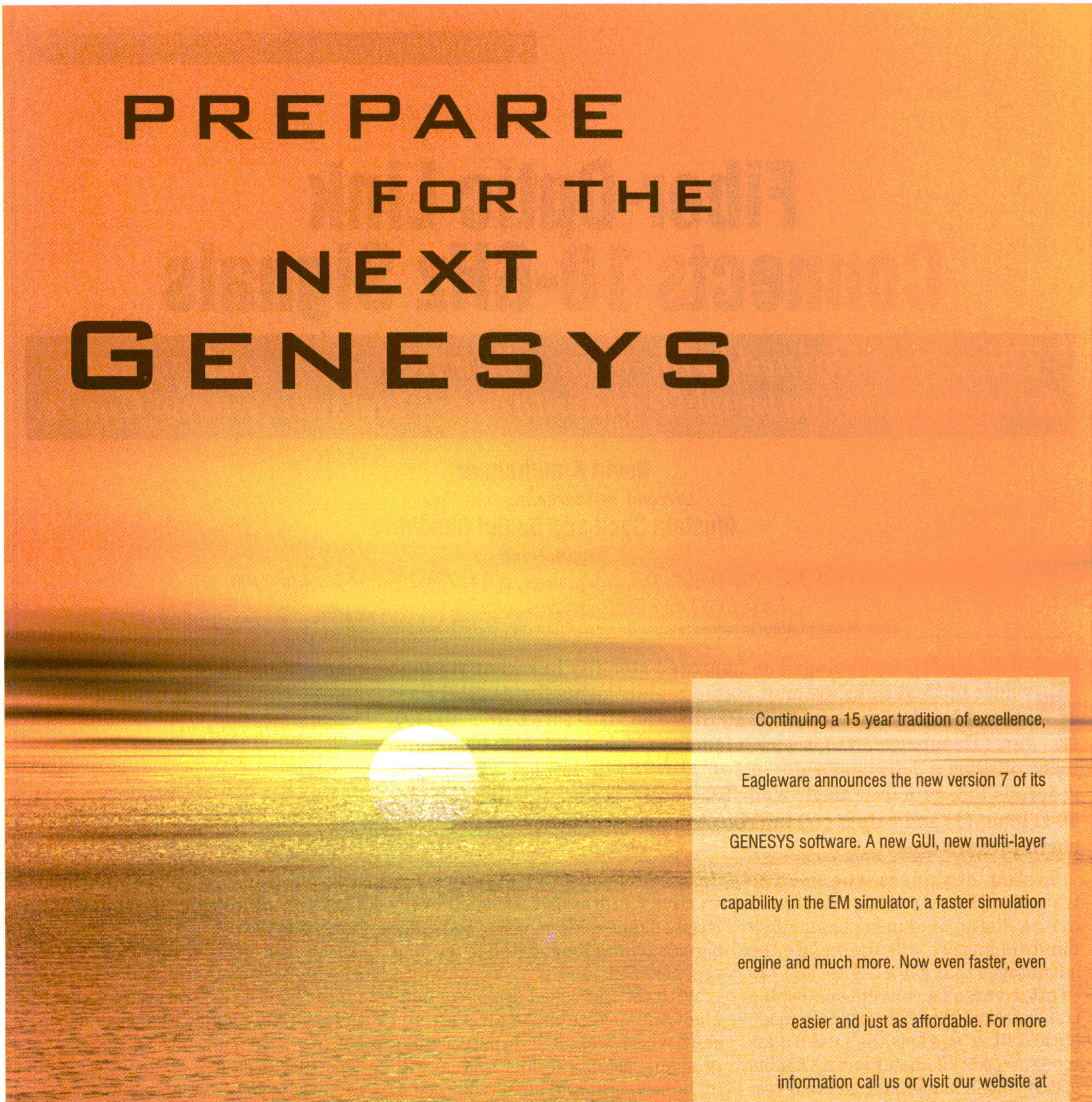
2. It is not very susceptible to interference from lightning.

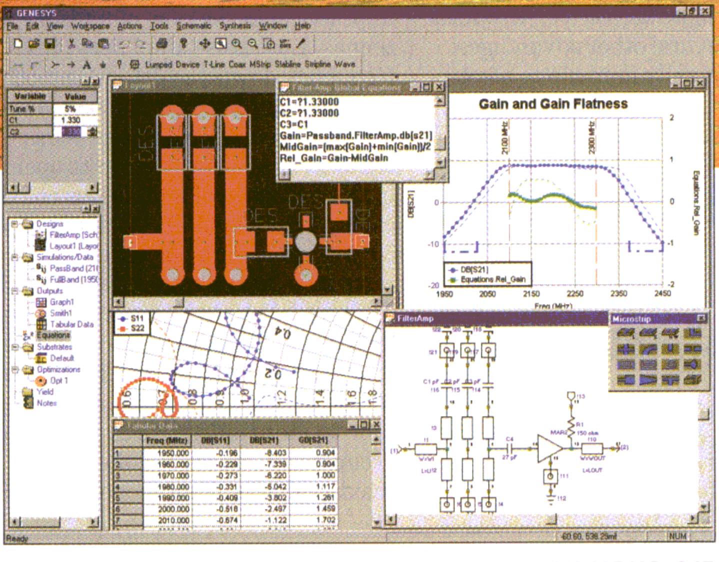
3. It is a relatively secure transmission media.

A typical application for a fiber-optic link, which emphasizes the various advantages of fiber-optic communications, is in the use of a remote antenna. An antenna site may consist of several receiver antennas spaced some distance from the central station. Due to the relatively high loss of coaxial copper (Cu) cable, it is often necessary to construct an equipment bay station directly adjacent to an antenna, which is impractical in the case of multiple antennas. Low-noise amplifiers (LNAs), frequency downconverters, and other types of equipment in the bay station are required in order to process the signal so as to allow the user to operate in the presence of a high-loss coaxial cable. Assuming 3-dB attenuation per 30 m of cable for a polystyrene coaxial cable at C-band frequencies, even a 50-dB-gain LNA at the front end would lose its effectiveness after a few hundred meters. With optical fiber, the attenuation and the attenuation slope (not to mention shifts in phase and group delay), which is quite evident in coaxial cable, is almost nonexistent. By



1. The MDD fiber-optic links consist of direct-modulated receiver and transmitter modules with simple 50-Ω input and output connections.





Variable	Value
Tune %	5%
C1	1.330
C2	1.330

```
C1=?1.33000
C2=?1.33000
C3=C1
Gain=Passband.FilterAmp.db(s21)
MidGain=(max(Gain)+min(Gain))/2
Rel_Gain=Gain-MidGain
```

	Freq (MHz)	DB[S11]	DB[S21]	GD[S21]
1	1950.000	-0.196	-8.403	0.904
2	1960.000	-0.229	-7.339	0.904
3	1970.000	-0.273	-6.220	1.000
4	1980.000	-0.331	-5.042	1.117
5	1990.000	-0.409	-3.802	1.261
6	2000.000	-0.518	-2.497	1.459
7	2010.000	-0.674	-1.122	1.702

performing an electrical-to-optical conversion close to the feed of the antenna, the signal can be transmitted a few kilometers over fiber without significant attenuation. This technique allows all signal-processing equipment to be located in a single facility that is virtually independent of its geographic location. Fiber-optic links also simplify the logistics of building a large earth station, which have multiple antennas that have to be well-separated in order to avoid side-lobe interference. Fiber-optic links are easy to install and are less expensive to maintain than their coaxial counterparts. Other typical applications may include phased-array antennas, delay lines, conformal antennas, and point-to-point links between facilities.

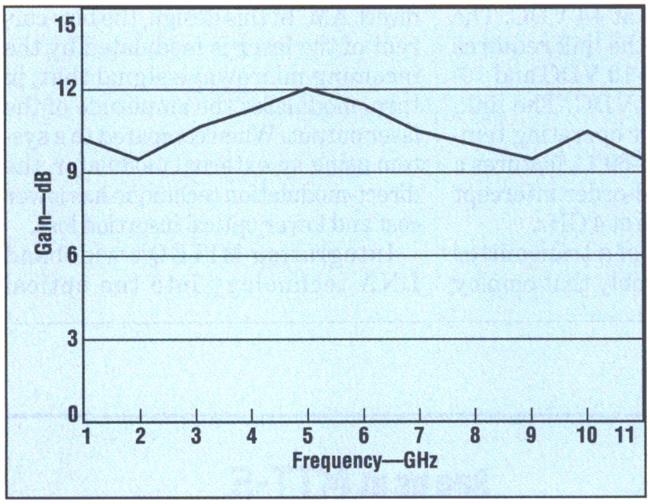
The MDD series of self-contained fiber-optic links from MITEQ is ideal for many of these broadband applications. They provide for RF-to-RF connections (Fig. 1) with a 3-dB bandwidth from 1 to 11 GHz (Fig. 2), noise figures as low as 15 dB (Fig. 3), and overall link gain of typically 10 dB. These features along with its small size and ability to be easily inserted into a system make this product an ideal replacement for its coax counterpart. The low-noise and low-transmission-loss characteristics of the MDD series make it well-suited for wideband point-to-point communication (Fig. 4).

THE LOW-NOISE AND LOW-TRANSMISSION-LOSS CHARACTERISTICS OF THE MDD SERIES OF FIBER-OPTIC LINKS MAKES IT WELL-SUITED FOR WIDE-BAND POINT-TO-POINT COMMUNICATIONS SYSTEMS.

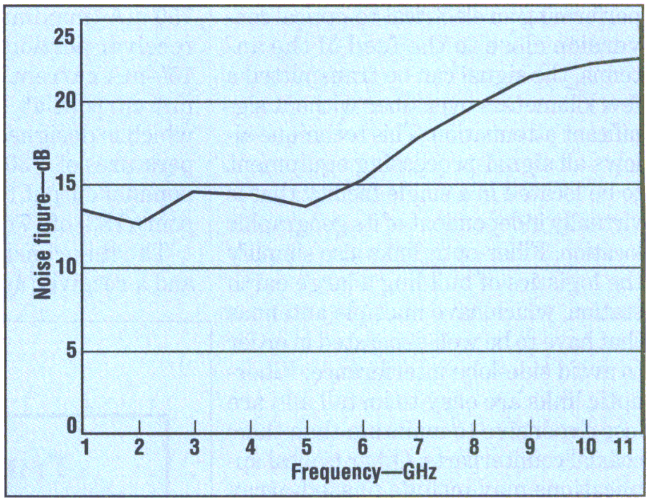
The MDD link operates at a wavelength of 1550 nm with peak-to-peak group delay of only 0.1 ns for a 1-km link distance. The transmitter achieves optical output power of 4 to 9 mW with power-supply requirements of 270 mA at +10 VDC, 12 mA at −10 VDC, and 750 mA (maximum) at +4 VDC. The receiver portion of the link requires 150-mA current at +10 VDC and 10-mA current at −10 VDC. The link, which is designed for operating temperatures of −30 to +60°C, features a nominal output third-order intercept point (IP3) of +7 dBm at 4 GHz.

The link consists of a transmitter and a receiver assembly that employ direct AM. In this design, the bias current of the laser is modulated by the incoming microwave signal that, in turn, modulates the amplitude of the laser output. When compared to a system using an external modulator, the direct-modulation technique has lower cost and lower optical insertion loss.

Integrating MITEQ's wideband LNA technology into the optical



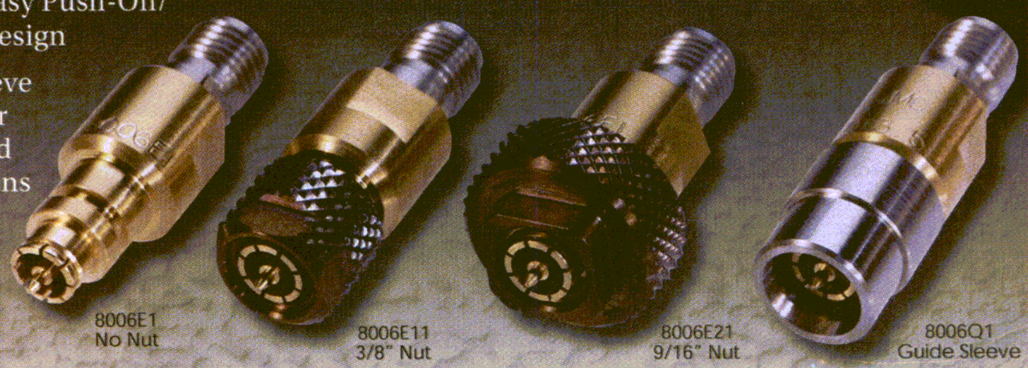
2. The 3-dB bandwidth of the MDD fiber-optic links is 1 to 11 GHz.

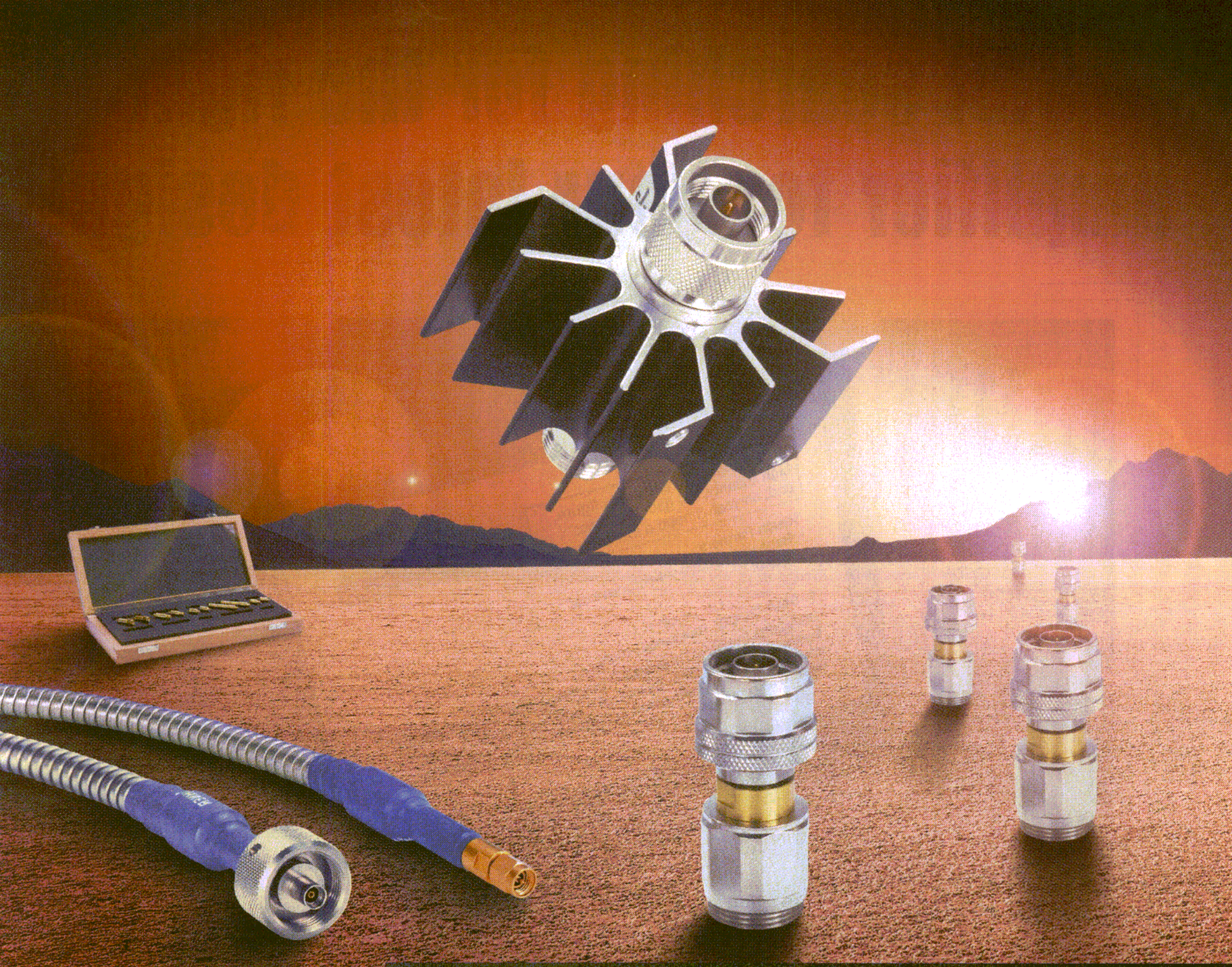


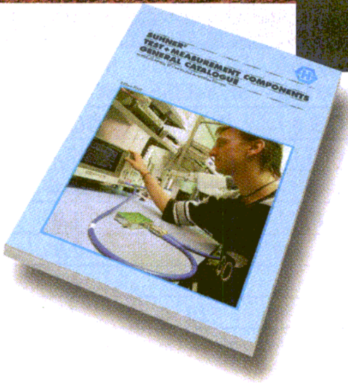
3. The noise figure of the MDD fiber-optic links is 14 dB at 4 GHz.

transmitter, the firm's engineers have been able to achieve a significant improvement in the noise figure (see table) compared to similar types of products. In addition, the MDD series of transmitter/receiver modules can be specially configured to match specific applications (i.e., with lower noise figures, higher intercept points, etc.).

It should be noted that many direct-modulation fiber-optic links suffer from high insertion loss and limited dynamic range. This is in part due to the large impedance mismatch between the approximate 10-Ω impedance of a laser diode and the typical 50-Ω impedance of a microwave system. To improve the dynamic range of the link, a gallium-arsenide (GaAs) monolithic-microwave- integrated-circuit (MMIC) transimpedance am-



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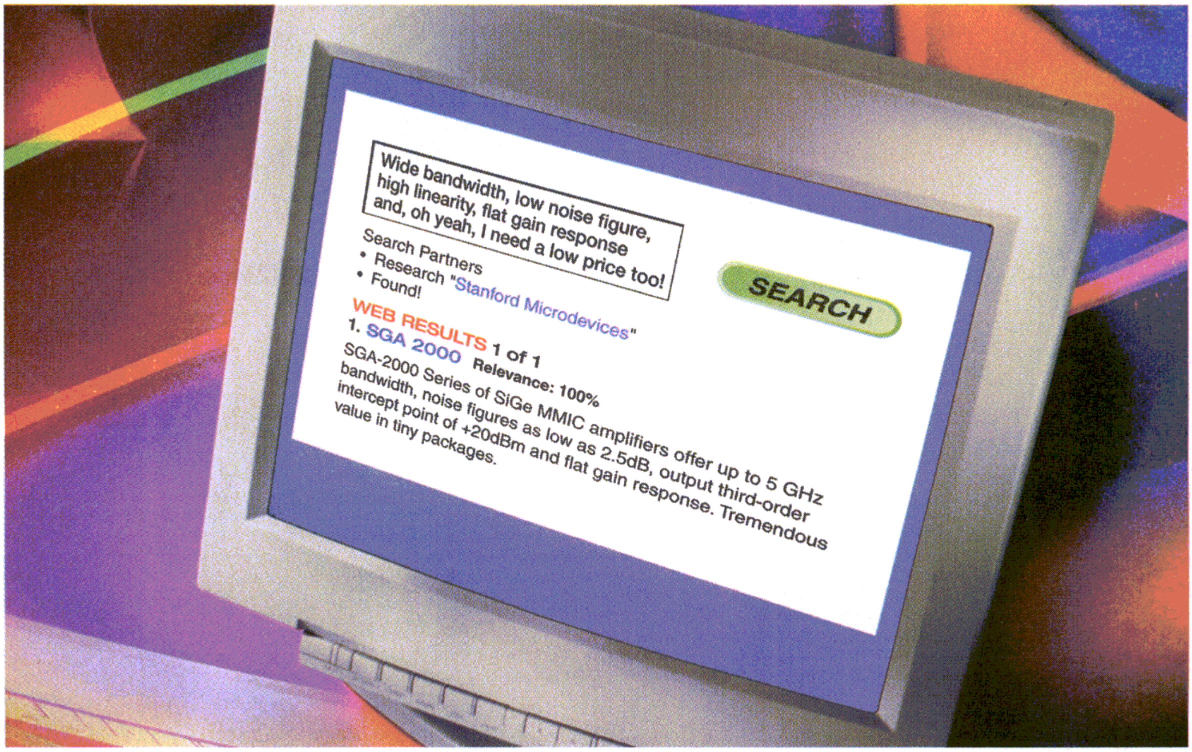

Wide bandwidth, low noise figure, high linearity, flat gain response and, oh yeah, I need a low price too!

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SGA-2000 Series of SiGe MMIC amplifiers offer up to 5 GHz bandwidth, noise figures as low as 2.5dB, output third-order intercept point of +20dBm and flat gain response. Tremendous value in tiny packages.

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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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CIRCLE NO. 267

plifier was developed by Thomson-CSF Detexis (Paris, France) in order to optimally match the RF system with the laser diode.

The normally diverging optical output of the laser diode is first collimated to pass through an optical isolator and then focused into the fiber core. The optical alignment and connectorization of the modules is performed by Diamond S.A. using their E-2000 plug-in optical connector.

To make the MDD link easy to use, the modules have been designed to be self-contained. The transmitter module has built-in thermal stabilization using a thermoelectric cooler (TEC). This cooler maintains the laser diode at a constant temperature by using feedback from a thermistor that is on the laser carrier. Laser-diode thermal stabilization helps minimize laser wavelength drifting. A good heat sink is necessary for the transmitter module to allow the TEC to shunt the heat effectively.

In addition, a second feedback loop in the control circuit senses the output of a photodiode that is located at the back facet of the laser to maintain the laser optical power at a constant level through the laser aging process. Both of the modules are provided with built-in regulators, reverse voltage polarity protection, and they are available in a hermetically sealed package.

The MDD fiber-optic link at a glance

Operating wavelength	1550 nm
3-dB bandwidth	10 GHz (1 to 11 GHz)
Input/output transfer characteristics	10 dB (nominal)
Noise figure	14 dB (nominal) at 4 GHz*
Output third-order intercept	7 dB (nominal) at 4 GHz**
Group delay (peak-to-peak)	0.1 ns (nominal)
Input VSWR	1.25:1 (nominal)
Output VSWR	1.25:1 (nominal)
Input/output impedance	50 Ω
Transmitter optical power	4 to 9 mW
Nominal DC power	Transmitter *** +10 VDC, 270 mA −10 VDC, 12 mA +4 VDC, 750 mA (maximum)
	Receiver +10 VDC, 150 mA −10 VDC, 10 mA
Optical input/output connectors	DIAMOND E-2000
RF input/output connectors	SMA female
Physical dimensions	1.43 × 2.47 × 0.48 in. (3.63 × 6.27 × 1.22 cm)
Operating temperature	−30 to +60°C
Storage temperature	−54 to +125°C

* Lower noise figure is available. ** Higher IP3 units are achievable.
*** Transmitter requires heat sinking.

Fiber-optic links are often associated with digital communications and fast data rates, although they are also powerful transmission media for analog communications systems. Analog fiber-optic links have traditionally been used in cable-television (CATV) systems to handle the transport of complex multichannel signals. More recently, these links are widely used within buildings and office campus environments to distribute cellular signals without the deleterious effects of phase distortion, signal loss, and EMI. Due to the minimal group delay of fiber-optic links (nominally 0.1 ns peak-to-peak for the MDD series) and low loss, in-building cellular signals carried by optical cables do not require the additional equalization and gain commonly used in coaxial lines.

The link is designed for analog applications to 11 GHz. It offers all of the advantages of fiber-optic technology, with simple 50-Ω interfaces for ease of interconnection with existing microwave systems. **MITEQ, Inc., 100 Davids Dr., Hauppauge, NY 11788-2086; (631) 486-7400, FAX: (631) 436-7430, Internet: http://www.miteq.com.**

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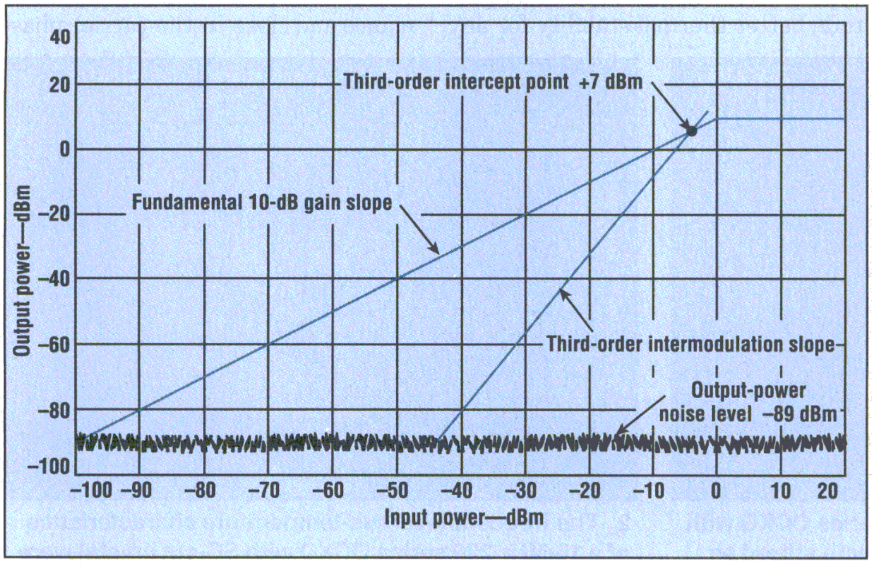


4. The wide dynamic range of the MDD fiber-optic link derives from MITEQ's strong background in LNA design.

OCXOs Shrink In Size And Power Consumption

The trend to miniaturize telecommunications and data-communications equipment is well-supported by these lines of small, but stable oven-controlled crystal oscillators.

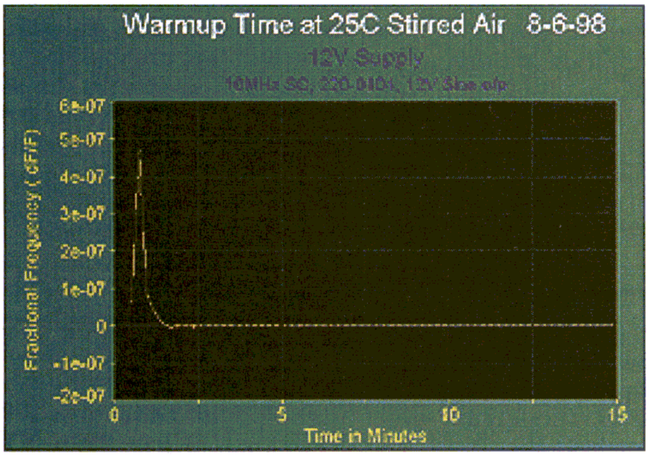
JACK BROWNE
Publisher/Editor

MINIATURIZATION and conservation of energy are key design drivers in modern telecommunications and data-communications systems. Since such systems rely on crystal oscillators for setting precise timing and frequency, system-level designers should be interested in the 220/221 series of oven-controlled crystal oscillators (OCXOs) from MTI-Milliren Technologies, Inc. (Newburyport, MA). These tiny crystal oscillators measure only 0.975 × 0.800 × 0.500 in. (24.8 × 20.3 × 12.7 mm), yet provide full-sized performance at fixed frequencies from 5 to 100 MHz.

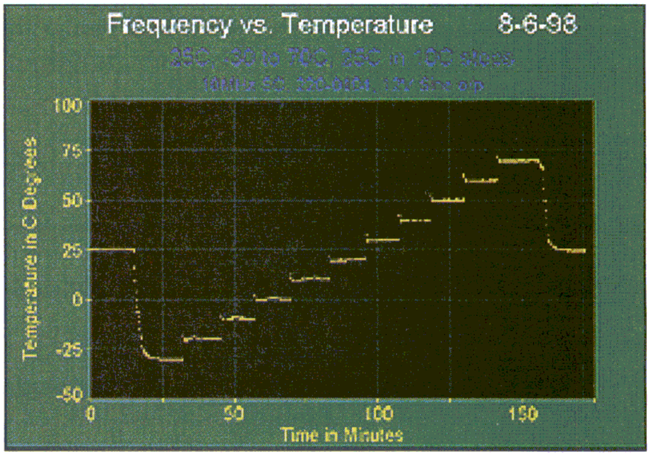
The 220 series OCXOs are supplied in 16-pin dual-in-line-package (DIP) hermetic housings for through-hole printed-circuit-board (PCB) mounting. The 221 series oscillators, which are available in the same set of frequencies from 5 to 100 MHz, are housed in true surface-mount hermetic packages. These tiny crystal oscillators require a warm-up time of less than 5 minutes (Fig. 1), and consume less than 1-W power.

The miniature oscillators are available with AT or stress-compensated (SC)-type crystals, with the latter type providing an order of magnitude better thermal stability for any particular frequency.

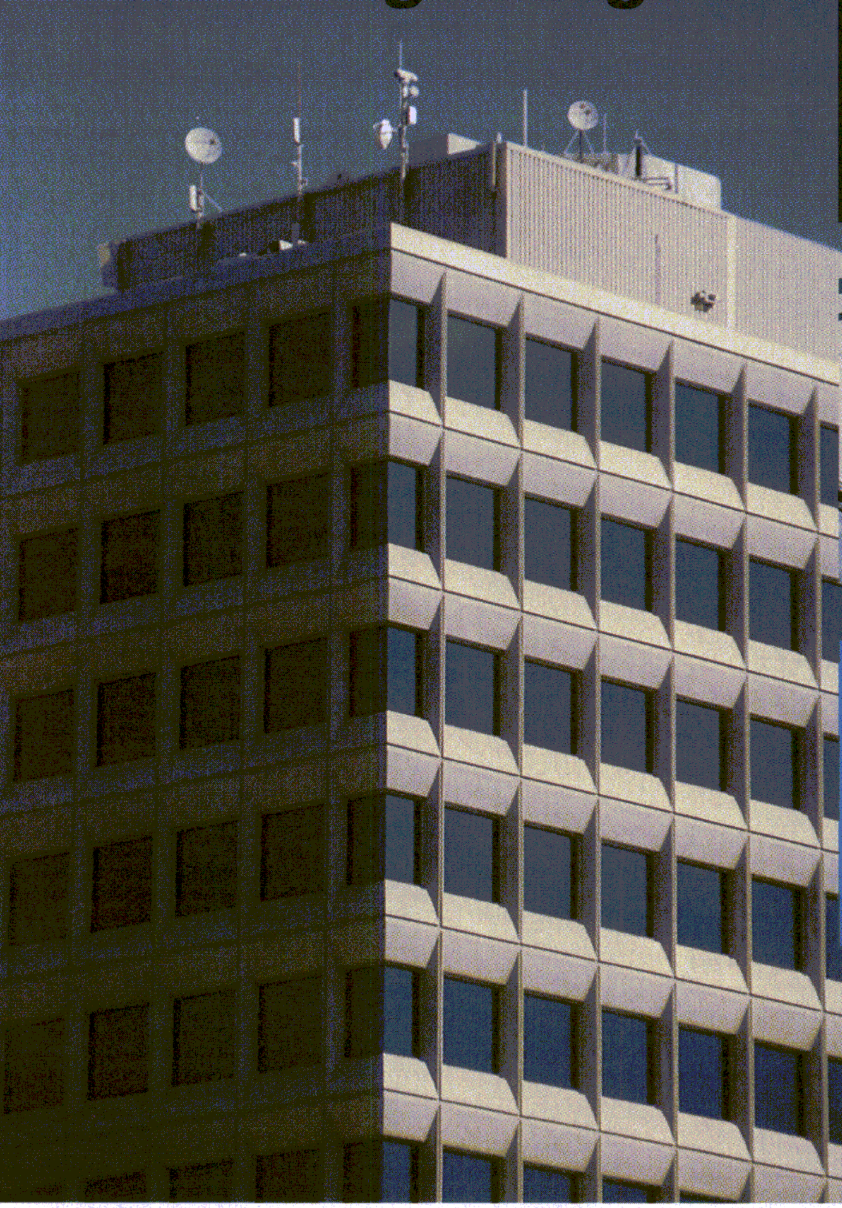
For example, an AT-cut, 10-MHz 220 series of OCXOs features a thermal stability of 2×10^{-7} for a temperature range of −30 to +70°C. For the same temperature range, an SC-cut 10-MHz 220 series OCXO exhibits thermal stability of 2×10^{-8} (Fig. 2). Both of the 10-MHz clocks deliver a short-term aging rate of 1×10^{-9}/day. The SC-cut model shows some improvement in long-term aging, with 1×10^{-7}/year compared to the 2×10^{-7}/year long-term aging rate for the AT 220 series 10-MHz oscillator. For oscillators with higher frequencies, however, the short- and long-term aging rates are close if not similar in performance, with the key difference in AT and SC oscillators being in thermal stability performance and close-to-the-carrier phase

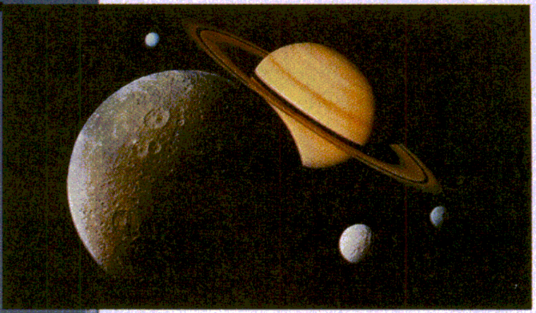


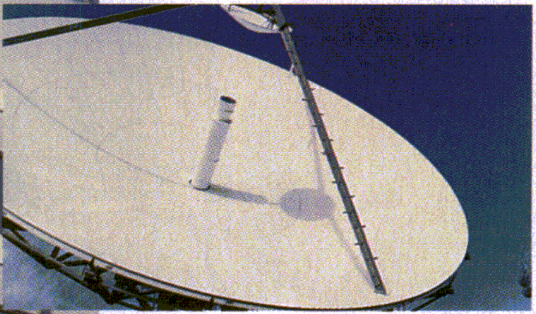
1. The warmup time for a 10-MHz 220 series OCXO with SC-cut crystal was measured at +25°C with stirred air and a +12-VDC supply. These OCXOs consume less than 1-W power.

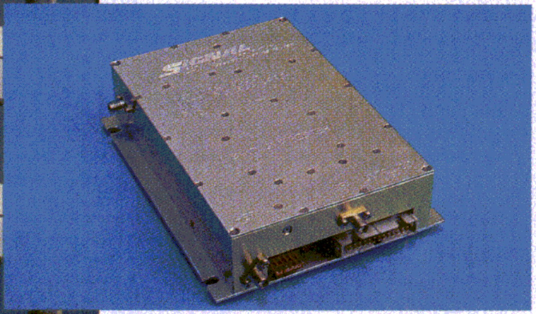


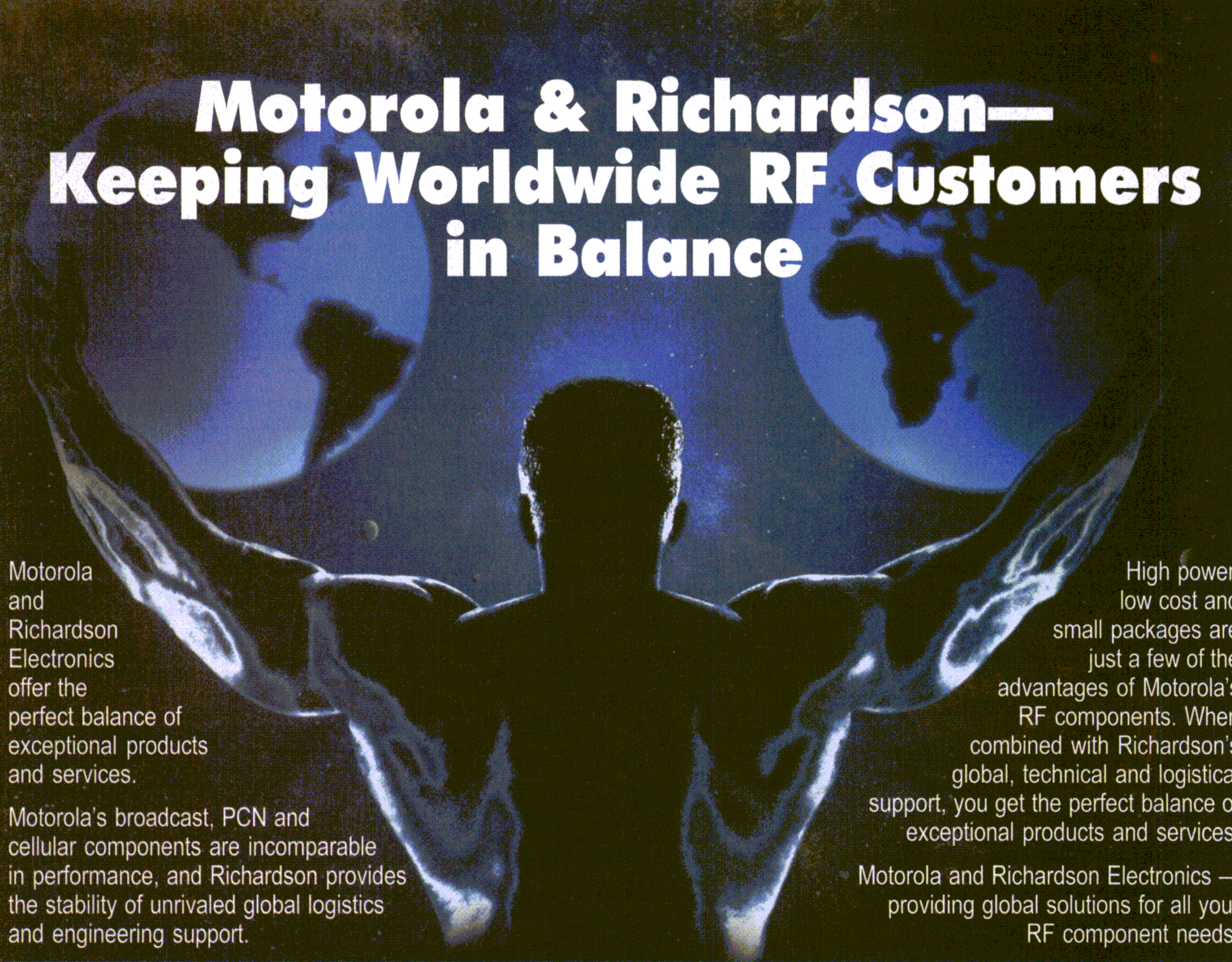
2. The frequency-versus-temperature characteristics of a 10-MHz 220 series OCXO with SC-cut crystal were evaluated from −30 to +70°C in 10° steps. This OCXO exhibits a thermal stability of 2×10^{-8}.











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Motorola and Richardson Electronics offer the perfect balance of exceptional products and services.

Motorola's broadcast, PCN and cellular components are incomparable in performance, and Richardson provides the stability of unrivaled global logistics and engineering support.

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small packages ar
just a few of th
advantages of Motorola'
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support, you get the perfect balance o
exceptional products and service

Motorola and Richardson Electronics –
providing global solutions for all you
RF component need

PCN PRODUCT

Device	Frequency	Voltage	Oper. Gain (Typ.)	Output Power
MRF18060A/AS	1805-1880 MHz	26 Volts	13.0 dB	60 Watts CW
MRF18060B/BS	1805-1880 MHz	26 Volts	13.0 dB	60 Watts CW
MRF18090A/AS	1930-1990 MHz	26 Volts	13.5 dB	90 Watts CW
MRF18090B/BS	1930-1990 MHz	26 Volts	13.5 dB	90 Watts CW
MRF19030/S	1930-1990 MHz	26 Volts	13.0 dB	30 Watts PEP
MRF19045/S	1930-1990 MHz	26 Volts	14.0 dB	45 Watts PEP
MRF19060/S	1930-1990 MHz	26 Volts	12.5 dB	60 Watts PEP
MRF19085/S	1930-1990 MHz	26 Volts	12.5 dB	90 Watts PEP
MRF19125/S	1930-1990 MHz	26 Volts	12.5 dB	125 Watts PEP
MRF21125/S	1930-1990 MHz	28 Volts	12.0 dB	125 Watts PEP
MRF21180/S	1930-1990 MHz	28 Volts	11.3 dB	160 Watts PEP

CELLULAR

Device	Frequency	Voltage	Oper. Gain (Typ.)	Output Power
MRF9180	880 MHz	26 Volts	17.0 dB	180 Watts PEP
MRF9085/S	880 MHz	26 Volts	17.0 dB	85 Watts PEP
MRF9045/S	945 MHz	28 Volts	18.0 dB	45 Watts PEP
MRF9045M	945 MHz	28 Volts	16.0 dB	45 Watts PEP

BROADCAST

Device	Frequency	Voltage	Oper. Gain (Typ.)	Output Power
MRF372	470-860 MHz	28 Volts	14.0 dB	180 Watts PE
MRF373A/AS*	470-860 MHz	28 Volts	11.2 dB	100 Watts PE
MRF374A*	470-860 MHz	28 Volts	12.0 dB	100 Watts PE

** Under development.*

MOTOROLA

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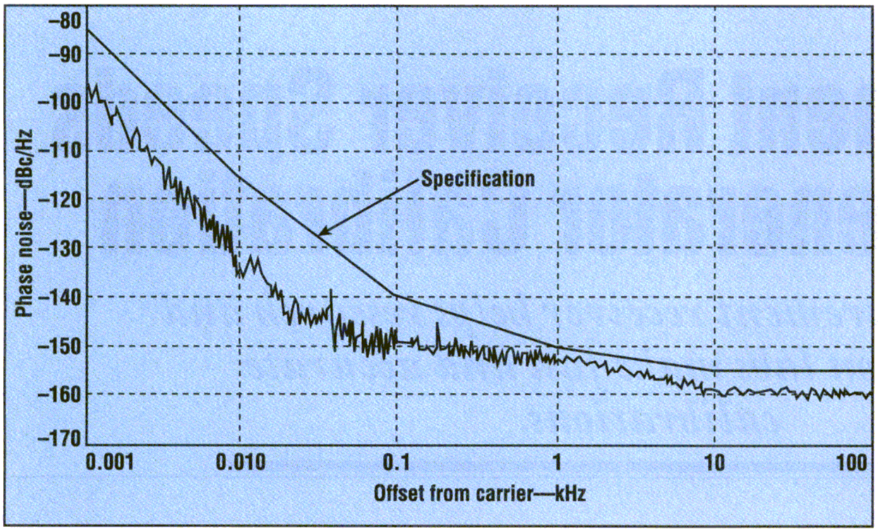
CIRCLE NO. 333



3. The phase noise of a 10-MHz SC-cut 220 series oscillator was evaluated with a 3048A phase-noise test set from Agilent Technologies (Santa Rosa, CA).

noise.

The phase-noise floor for the majority of 220 and 221 series of OCXOs lies at a quite respectable −155 dBc/Hz. For the 10-MHz 220 series OCXO with AT crystal, the single-sideband (SSB) phase noise is −80 dBc/Hz at 1-Hz offset from the carrier, −110 dBc/Hz at 10-Hz offset from the carrier, −130 dBc/Hz at 100-Hz offset from the carrier, −140 dBc/Hz at 1-kHz offset from the carrier, and −150 dBc/Hz at 10 kHz from the carrier. For the 10-MHz 220 Series OCXO with SC crystal, the phase noise is −85 dBc/Hz at 1-Hz offset from the carrier, −115 dBc/Hz at 10-Hz offset from the carrier, −140 dBc/Hz at 100-Hz offset from the carrier, −150 dBc/Hz at 1-kHz offset from the carrier, and −155 dBc/Hz at 10 kHz from the carrier (Fig. 3).

Both 220 and 221 series models can be supplied with a choice of output signals: high-performance complementary metal-oxide semiconductor (HCMOS)-level, adiabatic CMOS (ACMOS)-level, or sine-wave outputs with levels of 0 to +9 dBm. The OCXOs operate on supply voltages of +5 to +15 VDC and tuning voltages of 0 to +10 VDC. **MTI-Milliren Technologies, Inc., Two New Pastures Road, Newburyport, MA 01950; (978) 465-6064, FAX: (978) 465-6637, Internet: http://www.mti-milliren.com.**

CIRCLE NO. 52 or visit www.mwrf.com

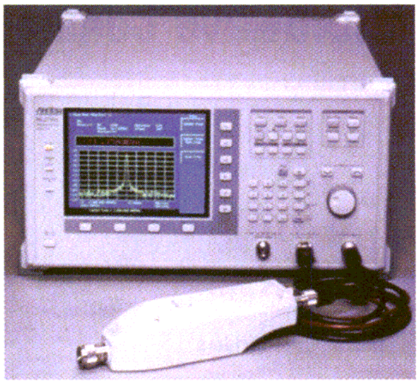
Measurement Receiver Speeds Signal-Generator Calibration

A new measurement receiver helps research and production labs make fast and accurate calibrations.

DON KELLER
Senior Editor

MEASUREMENT receivers are indispensable instruments for calibrating signal sources and attenuators. The increasingly low power levels used in wireless systems demand increasingly sensitive and accurate measurements. To meet this demand, Anritsu Co. (Richardson, TX), has introduced a new measurement receiver—the model ML2530A (see figure). The receiver measures signals at frequencies from 0.1 to 3000 MHz at power levels ranging from +20 to −140 dBm. It is designed for use in calibration laboratories as well as research and production environments to calibrate attenuator levels and signal-generator output levels. Measurements are displayed as units or subunits of decibels, watts, or volts.

The ML2530A has two modes of operation—manual-tuning mode and monitor mode. In the manual-tuning mode, the operator specifies the frequency to be measured by manually entering it through the numerical keys on the receiver's front panel. In this mode, high-speed measurements are available, and the receiver alphanumerically displays the signal's frequency and measured level. In the monitor mode, the operator marks a signal displayed on the receiver's spectrum monitor, and the receiver measures the signal. In this mode, the receiver alphanumerically displays the signal's level and graphically displays its spectrum.



The ML2530A measurement receiver's monitor mode displays the level and the spectrum of the measured signal.

Unlike some measurement receivers, the ML2530A does not analyze the modulation characteristics of a signal. Rather, its main purpose is to measure relative and absolute power levels of a signal accurately over a wide power range. To achieve this wide dynamic range, the receiver employs Anritsu's MA2540A thermal power sensor. The power-level range is divided into three subranges. Range 1 covers −35 to +20 dBm and has a resolution of 0.1 dB. Range 2 spans −80 to −25 dBm and provides a resolution of 0.01 dB. Range 3 covers −140 to −70 dBm and offers a resolution of 0.001 dB. The receiver also uses digital-signal-processing (DSP) technology in its level detector.

The ML2530A also differentiates itself from other measurement receivers by including a spectrum-monitor function, which allows the user to verify that he or she is measuring the desired signal, and to observe the spectral characteristics of the signal being measured. Similar to a standard spectrum analyzer, the spectrum monitor sweeps through a span of frequencies and displays the root-mean-square (RMS) amplitude of any signals it encounters. The span is operator adjustable from 10 kHz to 1 MHz, and the rate where it sweeps through a span is adjustable from 100 ms to 1000 s. Resolution bandwidth—the "chunk" of frequencies over which each RMS measurement is taken—is adjustable from 300 Hz to 100 kHz. Frequency resolution—the ability to discern two adjacent signals on the display screen—is 1 Hz. The spectrum monitor has marker functions that the operator uses to mark and measure a desired signal, and track it should it drift.

The receiver features a general-purpose interface bus (GPIB) for connection to an automated test setup. It can save and recall 100 measurement setups and 300 measurement results. The receiver also has a panel lock that disables all key and encoder functions except the power switch and the panel-lock key. **Anritsu Co., 1155 East Collins Blvd., Richardson, TX 75081; (972) 644-1777, FAX: (972) 644-3416, Internet: http://www.anritsu.com.**

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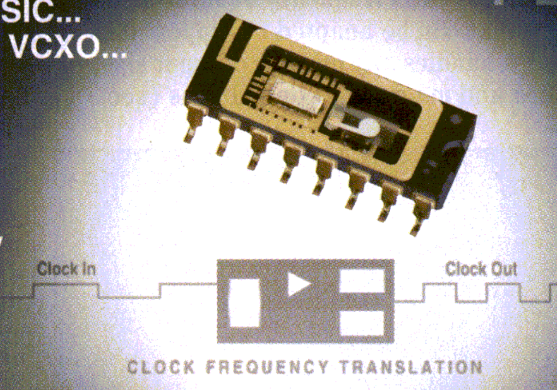

Clock In
Clock Out
CLOCK FREQUENCY TRANSLATION

Multicarrier Power Amplifier Boosts Cellular Signals

A new DSP-based power amplifier helps cellular networks boost digital and analog wireless signals.

DON KELLER
Senior Editor

RF power amplifiers (PAs) are integral components in the infrastructure 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. Wiseband Communications Ltd. (Herzelia, Israel) has introduced a new RF amplifier that meets both of these criteria. The Wise-800 is a multicarrier, 80-W PA that supports today's code-division-multiple-access (CDMA), time-division-multiple-access (TDMA), and Advanced Mobile Phone Service (AMPS) standards spanning the 869-to-894-MHz frequency band. It also has an open and flexible architecture that can be adapted to support future 3G standards. The multicarrier PA handles any number of input signals and it is ideally suited for micro and macrocell applications (see figure).

There are two chassis available for the Wise-800 modules—one can hold three amplifier modules, the other can hold four. Thus, the amplifiers can be deployed singly or combined with as many as three others per chassis to create scalable, redundant configurations that generate as much as 300-W total RF output power.

The amplifier is based on a proprietary digital-signal-processing (DSP) technology known as adaptive digital linearized core (ADLC). The company claims that ADLC allows the Wise-800 to continually correct RF hardware parameters, thus minimizing labor-intensive, costly tuning, and ensuring optimal operation of the amplifier throughout its life in the field. The ADLC control algorithm operates on the actual amplified signals, rather than on injected pilot tones. The company claims that this allows the amplifier to deliver superior linearity in dynamic signal environments such as frequency hopping and downlink power control.

The Wise-800 power-amplifier chassis can hold up to four amplifier modules.

The Wise-800 amplifier delivers a nominal gain of 60 dB, with a gain variation of ±0.5 dB. Typical intermodulation distortion (IMD) is −70 dBc. The amplifier offers −45-dBc maximum harmonics, −60-dBc maximum out-of-band spurious, as well as 1:1.5 maximum input/output (I/O) VSWR. The amplifier can operate at +21 to +31 VDC. At +26 VDC, it draws 25 A. The RF input connector is a female SMA and the RF output connector is a female N type. Control and monitoring connectors are DB-9 dry contacts. Protections and alarms include output mismatch, overtemperature, input overdrive, loop fail, DC failure, and fan failure. The amplifier also has forward- and reverse-power monitors.

Each Wise-800 amplifier module measures 14.21 × 5.83 × 18.30 in. (36.09 × 14.81 × 46.48 cm) and weighs 32 lb. (14.5 kg.). The three-module chassis measures 15.75 × 17.64 × 21.73 in. (40.01 × 44.81 × 55.19 cm) and weighs 129 lb. (58.5 kg.). The four-module chassis measures 15.75 × 21.64 × 21.73 in. (40.01 × 54.97 × 55.19 cm) and weighs 161 lb. (73 kg.). **Wiseband Communications Ltd., 103 Medinat Hayhudim St., P.O.B. 12189, Herzelia 46733, Israel; +972 9 951 5572, FAX: +972 9 951 5528, Internet: http://www.wiseband.com.**

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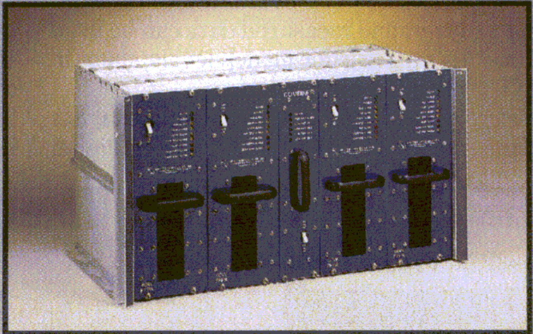

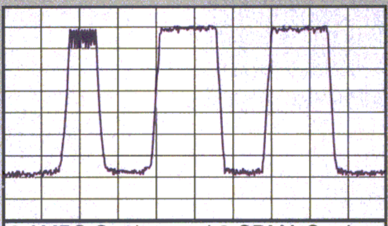

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CIRCLE NO. 364

Vector Signal Analyzers Augment Test Bandwidths

These powerful signal analyzers can capture complex modulation across a 36-MHz bandwidth for test signals up to 2.7 GHz.

JACK BROWNE
Publisher/Editor

VECTOR signal analyzers (VSAs) represent a new breed of test instrument for a new generation of digitally modulated communications signals. Since they can capture the phase and amplitude of modulated signals, VSAs are invaluable for troubleshooting and designing communications systems and their components. The new 89600 series of VXI-based VSAs from Agilent Technologies (Santa Clara, CA) brings increased measurement bandwidths to these systems, for carrier signals to 2.7 GHz.

The 89600 series of VSAs (see figure) is available with baseband in-phase (I) and quadrature (Q) signal bandwidths as wide as 39 MHz and intermediate-frequency (IF) analysis bandwidths as wide as 36 MHz, for RF carrier signals from DC to 2700 MHz. For higher-frequency signals, a VXI frequency downconverter card first translates signals to a 70-MHz IF prior to sampling and digitization through a high-speed analog-to-digital-converter (ADC) VXI card. The higher-frequency RF version of the measurement system, model 89640A, includes the downconverter for single-channel measurements, while a baseband version, model 89610A, is for analysis of baseband signals from DC to 40 MHz and can be supplied in single- or dual-channel versions.

The 89600 series of VSAs combines VXI test hardware with measurement software residing on a Windows NT personal computer (PC). By hosting the software on a PC, the 89600 series of instruments can be readily linked to the firm's Advanced Design System (ADS) electronic-design-automation (EDA) software. As a result, simulated results can be evaluated in the analyzer, and measured data can be used as the basis for model development in the EDA software.

The VSAs feature several analysis modes, including scalar, vector, digital demodulated measurements, and gated measurements. Triggering can be performed on baseband input signals or on IF signals, with adjustable trigger levels and trigger delays. Sweep modes include single sweeps or continuous sweeps, and averaging is included to support root-mean-square (RMS), peak-hold, and exponential displays of data.

Center-frequency resolution is 0.001 Hz for baseband and IF measurements. Initial frequency accuracy of the internal 10-MHz timebase is 0.1 PPM with an aging rate of 0.1 PPM/year. The phase noise for baseband measurements is −97 dBc/Hz offset 100 Hz from the carrier, 122-dBc/Hz offset 1 kHz from the carrier, and −137 dBc/Hz for offsets greater than 10 kHz. The amplitude measurement range in RF measurement mode (to 2.7 GHz) is −45 to +20 dBm in 5-dB steps. In baseband mode, the amplitude measurement range is −31 to +24 dBm in 5-dB steps. Full-scale amplitude measurement linearity is better than ±2 dB from +20 to +30°C. In RF and baseband measurement modes, the analyzers feature third-order intermodulation distortion (IMD) of −70 dBc. **Agilent Technologies, Test and Measurement Organization, 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052.**

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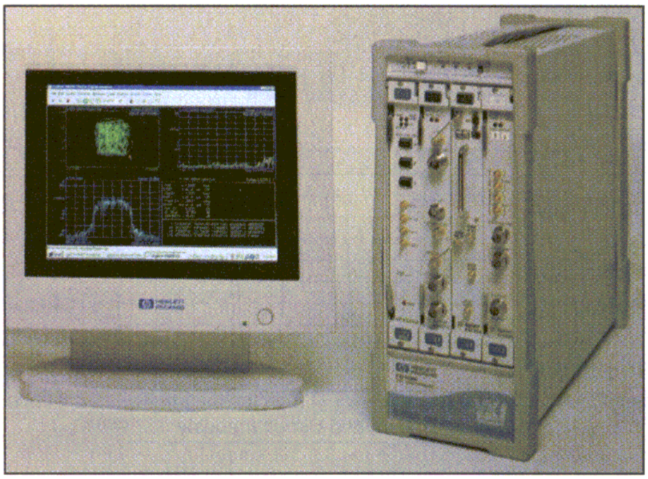

The 89600 series of VSAs is available in high-frequency single-channel RF versions for measurements to 2.7 GHz and lower-frequency baseband models with one or two channels for measurements from DC to 40 MHz.


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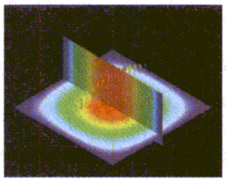

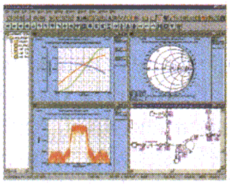

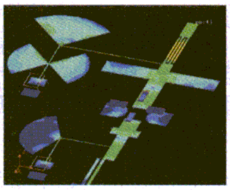

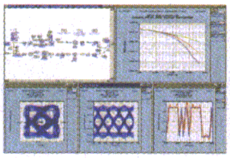

PRODUCT TECHNOLOGY

Test Set

Test System Evaluates Broadband Distortion

This modular PC-based test set offers digital communications signal generation and analysis across instantaneous channel bandwidths as wide as 45 MHz.

JACK BROWNE
Publisher/Editor

DISTORTION is an inevitable factor in nearly all communications systems. In modern, multichannel wired and wireless communications systems, distortion can degrade the ultimate bit-error rate (BER) of transmitted and received signals, resulting in lost data. And modern communications systems employing wide channel bandwidths pose particularly difficult challenges during test and evaluation stages. Unless a design or production engineer is equipped with a model CS29010 distortion test set from Celerity Systems (Cupertino, CA). This innovative, person-computer-based, modular test system performs such complex distortion measurements as magnitude and phase on adjacent-channel power ratio (ACPR), noise power ratio, and third-order intermodulation distortion (IMD3) over an instantaneous bandwidth of 45 MHz. When equipped with plug-in frequency downconverters, the modular system can scale a frequency range to 40 GHz.

The CS29010 distortion test set (see figure) is ideal for characterization of a wide range of broadband components and subsystems found in modern communications systems, including amplifiers, filters, traveling-wave tubes (TWTs), switch/modems, and switched filter assemblies. Based on a personal-computer (PC) architecture with a Pentium III microprocessor running at 600 MHz, the CS29010 test set digitizes input signals across a 45-MHz instantaneous bandwidth, converting these signals to 12-b data. The system can be configured with a variety of frequency conversion options, allowing the measurement bandwidth to be centered on carrier frequencies as high as 40 GHz with 1-MHz frequency resolution. The CS29010 handles input signals at levels from –60 to 0 dBm (and to +20 dBm with a high-power option).

In addition to its analysis power, the CS29010 distortion test set incorporates a high-performance arbitrary-waveform generator, which can create digitally modulated signals at bandwidths to 40 MHz. With its arbitrary-waveform generator and digital analyzer, the test set can perform IMD3 measurements to –55 dBc with two 0-dBm test tones. The system can also make noise-power-ratio (NPR) measurements of 50 dB using noise bandwidths from 0.1 to 28 MHz.

The model CS29010 distortion test set provides broadband generation and analysis of complex modulated signals over instantaneous bandwidths to 40 MHz.

In the CS29010 test set, data are captured in 4 Gb of random-access memory (RAM), enabling analysis of fine-grained details. The test system includes the company's customized LabVIEW-based (from National Instruments, Austin, TX) measurement and control software with intuitive user interface. Captured data can be plotted as the desired signal parameter, such a third-order IM, as a function of frequency and/or input/output (I/O) power. In addition, data files can be stored and transported as ASCII files for use in spreadsheet programs.

The CS29010 distortion test set is a flexible platform for evaluating a wide range of complex, digitally modulated communications signals, including quadrature-phase-shift-keying (QPSK), quadrature-amplitude-modulation (QAM), time-division-multiple-access (TDMA), and code-division-multiple-access (CDMA) signals. This single test platform can simplify and enhance measurements on components and subassemblies for modern wireless and wired communications systems. **Celerity Systems, an L3 Communications Co., 10411 Bubb Rd., Cupertino, CA 95014; (888) 274-5604, (408) 873-1001, FAX: (408) 873-1397, Internet: http://www.csidaq.com.**

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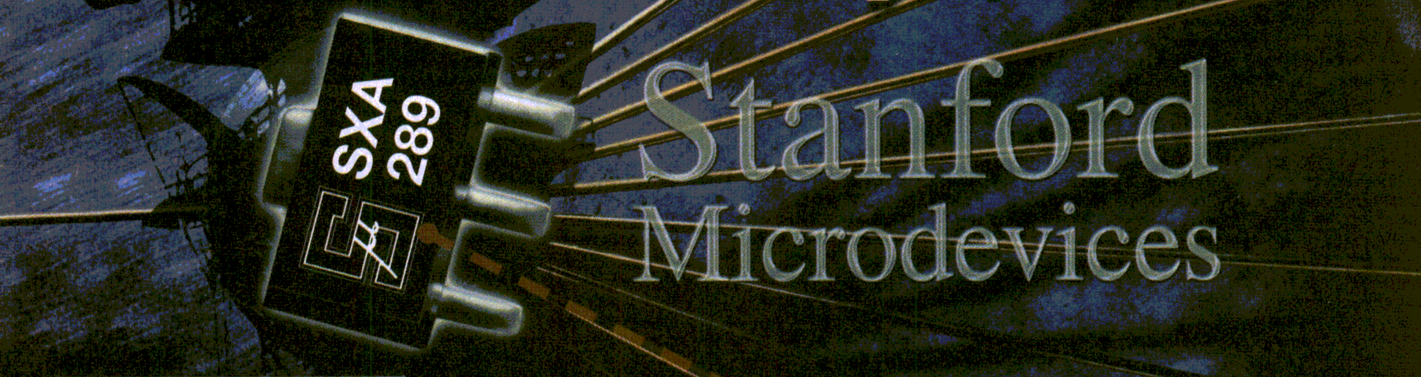
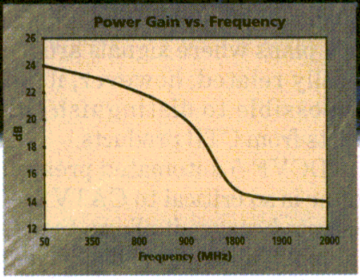
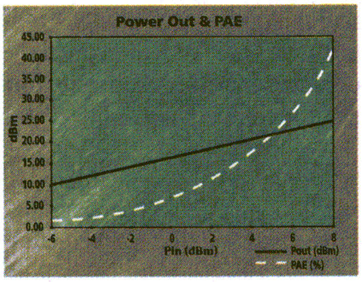
NEW! SXA-289 High Linearity Power Amplifier





Power Gain vs. Frequency



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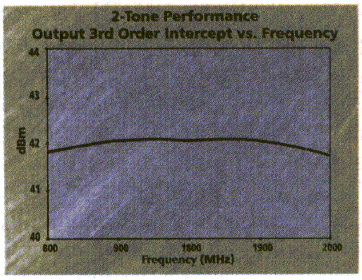

2-Tone Performance
Output 3rd Order Intercept vs. Frequency

Stanford Microdevices produces the highest performance products utilizing cutting edge technology at the lowest possible cost. All of Stanford MMICs are 100% tested and qualified annually to ensure reliable field performance even under the harshest environments, making Stanford Microdevices a favorite among major OEMs worldwide. Over the past five years Stanford Microdevices has become the preeminent leader in the design and manufacturing of GaAs, LDMOS and SiGe amplifier and switch products.

The **SXA-289** is a high efficiency GaAs Heterojunction Bipolar Transistor power amplifier, housed in a low cost surface-mountable plastic package and uses Darlington pair technology for broadband performance from 50-2000 MHz. It's fabricated using molecular beam epitaxial growth technology which produces reliable and consistent performance from wafer to wafer and lot to lot. The SXA-289 amplifiers were specifically designed for use as driver stages for infrastructure equipment in the 50-2000 MHz cellular, ISM and narrow band PCS bands. Its high linearity makes it an ideal choice for multi-carrier as well as digital applications.

Performance Matrix
SXA-289

Freq. (MHz)	Gain (dB) Typ.	S11 Typ.	S22 Typ.	P1dB (dBm)	TOIP (dBm)	Voltage	Current (mA) Typ.
800-900	20.0	1.5:1	2.0:1	24.0	40.5	5.0	115
1800-2000	14.5	1.5:1	2.0:1	24.0	42.0	5.0	115

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CIRCLE NO. 335

Automated Preselector Filter Streamlines CATV Testing

The use of an automated preselector filter can dramatically improve the accuracy of CATV performance testing with a spectrum analyzer or signal-level meter.

Ron Hollas

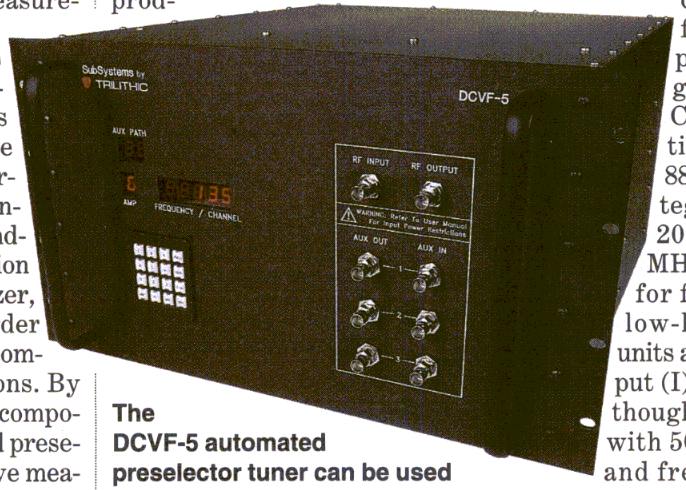
Director of Component Sales

TRILITHIC, 9202 East 33rd St., Indianapolis, IN 46236; (800) 344-2412, (317) 895-3600, FAX: (317) 895-3613, Internet: http://www.trilithic.com.

UNFILTERED measurements of cable-television (CATV) performance can be misleading. Whether a CATV system and its components are evaluated with a spectrum analyzer or a signal-level meter (SLM), unwanted and unfiltered spurious signals can easily overload the test equipment and provide false readings. One solution relies on the use of an automated preselector filter to prevent unwanted distortion signals from leaving the SLM or spectrum analyzer to measure only the desired signal.

Tunable automated preselector filters in the DCVF-5 series from TRILITHIC can assist the accurate measurement of composite triple beat (CTB), composite second order (CSO), and other spurious signals in CATV systems, fiber-optic communications networks, and other broadcast systems (see figure). Measurements made without a preselector filter are prone to error because spectrum analyzers and signal-level meters overload easily in the presence of multiple carriers. Under normal loading levels, the remaining carriers can produce second- and third-order intermodulation distortion (IMD) in the analyzer, causing second- and third-order IMD as well as inaccuracy in component and system evaluations. By eliminating unwanted signal components, the DCVF-5 automated preselector can improve the effective measurement range of a spectrum analyzer by 30 dB.

CTB is actually a composite of many third-order IMD products. It represents an extreme case of typical two-tone third-order IMD, since many IM products land on top of other video-carrier frequencies or other distortion products. CSO, on the other hand, is essentially the composite of second-order distortion products. Depending on the type of frequency plan used in a CATV system, it is often possible to differentiate CSO and CTB products. In frequency plans where signals are harmonically related, however, it may be impossible to distinguish CSO products from CTB products.



The DCVF-5 automated preselector tuner can be used manually or under computer control to improve the accuracy of CSO and CTB measurements.

The DCVF-5 automated preselector filter is so critical to CATV measurements because it allows the test signal source for CTB and CSO measurements to provide repeatable signals. Through the DCVF-5's programmable filters, test signals are clean and accurate, without excessive distortion that can be erroneously read by the SLM as in-channel signals.

The DCVF-5 automated preselector filter can be tuned automatically, under GPIB control from an external computer, or manually, from its front-panel keypad. The instrument-grade filter is tunable by CATV channel, with continuous tuning from 55 to 880 MHz. It includes an integrated preamplifier with 20-dB gain from 50 to 600 MHz and 16 dB at 1000 MHz for flexibility in measuring low-level signals. Standard units are equipped with 75-Ω input (I) and output (O) ports, although units are also available with 50-Ω I and O connections and frequency coverage of 50 MHz to 4 GHz for use with RF/microwave test equipment.

Measurements of CTB and CSO

characteristics in CATV systems require filters with optimum selectivity and shape factor. The DCVF-5 actually consists of fixed bandpass filters for T-7 through T-13 channels and four tunable filters covering octave bands of 55 to 110 MHz, 110 to 220 MHz, 220 to 440 MHz, and 440 to 880 MHz. The filters exhibit 30-dB-to-3-dB shape factors of 2.2:1 with selectivity equal to 1 percent of the center frequency. The variable filters are tuned through a stepper motor with an optical encoder.

The DCVF-5 is designed to handle input-power levels up to 0.5 W (+27 dBm, or 75.8 dBmV at 75 Ω). Signal routing is through an electromechanical switch that is rated for better than 1 million switching operations. Low-level signals are boosted through the integral post amplifier. The amplifier, which covers a total range of 50 to 1000 MHz, exhibits a noise figure of 5 dB across its frequency range. With the internal amplifier bypassed, the through-port bandwidth of the DCVF-5 is DC to 1000 MHz with 16-dB minimum return loss and 11.5-dB maximum insertion loss to 880 MHz.

Operation of the DCVF-5 is simple. The DCVF-5 is connected between a device under test (DUT) and the analysis instrument, either a spectrum analyzer or a SLM. Under either manual or GPIB control, the DCVF-5 is set to the bandwidth appropriate for the channel under test, allowing only the signal of interest to pass to the spectrum analyzer or SLM.

The DCVF-5 automated preselector filter is suitable for characterizing CATV signals and for evaluating the performance of fiber-optic networks and for checking IMD in broadband communications systems. It is software programmable for any 6-MHz channel. With modest modifications to the hardware, the filter can be adapted for 8-MHz PAL channels. When used manually, three front-panel light-emitting-diode (LED) alphanumeric displays report the status of various operating functions. Under remote control, status reporting occurs on the computer monitor.

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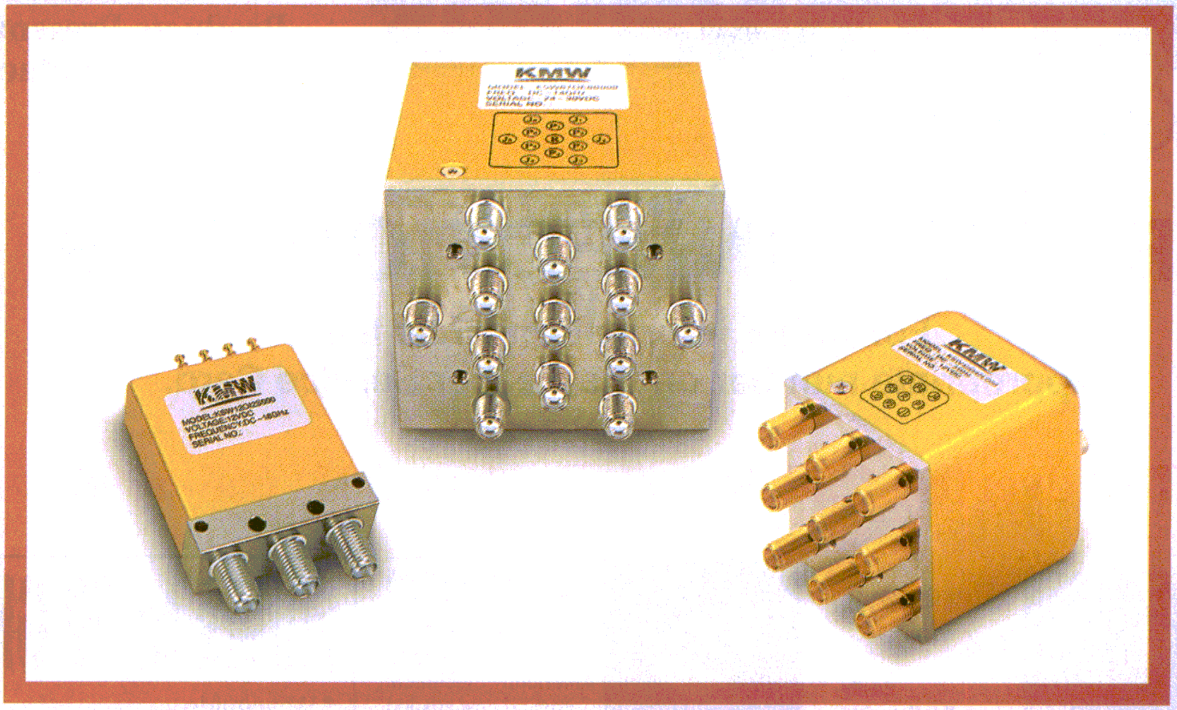
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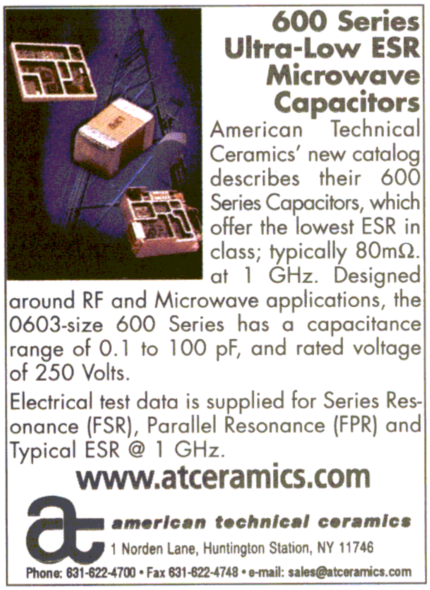

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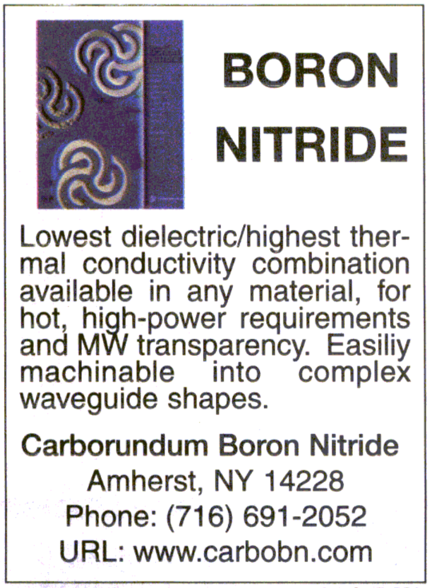

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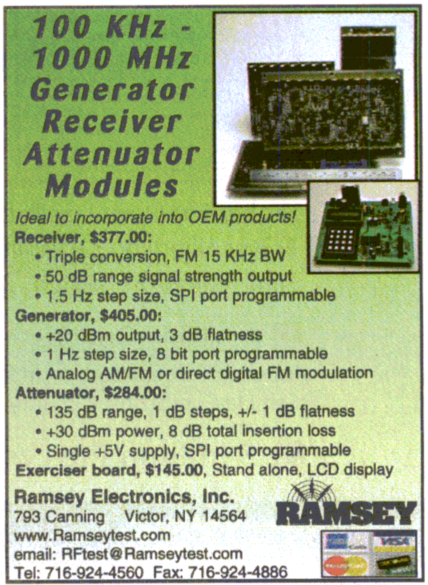

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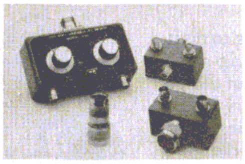

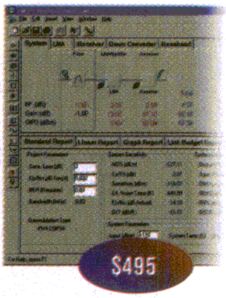
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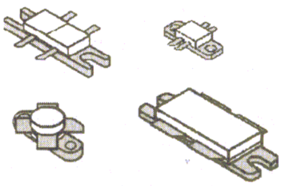

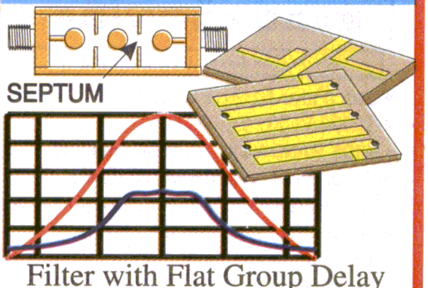
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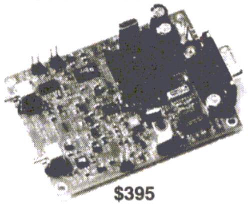

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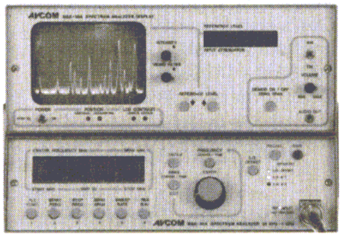

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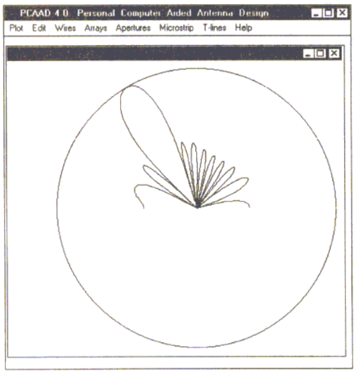

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Feedthrough connectors suit SMT

A line of 50-Ω feedthrough connectors, which transfer signals through chassis and housings at frequencies to 115 GHz, is now available for surface-mount applications. The connectors are available in several package configurations, including SMA, snap-ins, RF, and bias pins. The hermetic, surface-mount connectors exhibit a VSWR of less than 1.5:1 at frequencies to 15 GHz. The devices are available in aluminum (Al), copper (Cu), AlSiC, titanium (Ti), and Kovar. **Thunderline Z, Inc., 11 Hazel Dr., Hampstead, NH 03841; (603) 329-4050, FAX: (603) 329-4474, Internet: http://www.thunderlinez.com.**

CIRCLE NO. 62 or visit www.mwrf.com

MMIC amplifier boasts low noise

The model SGA-4486 silicon-germanium (SiGe), monolithic-microwave-integrated-circuit (MMIC) amplifier boasts a noise figure of 2.5 dB at 900 MHz. It is ideal for use in such applications as HomeRF, wireless local-area network (WLAN), and industrial-scientific-medical (ISM)-band spread spectrum. The amplifier's 1-dB compression point is +15 dBm, its gain is 19 dB, and its third-order intercept point (IP3) is +29 dBm. The device is offered in industry-standard miniature SOT363 and 85-mil surface-mount plastic packages. **Stanford Microdevices, Inc., 522 Alanor Ave., Sunnyvale, CA 94086; (800) 764-6642, FAX: (408) 739-0970, Internet: http://www.stanfordmicro.com.**

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Compact diplexer screens DCS and GSM signals

The model W9180DE cavity dual-band diplexer filters distributed-communication-system (DCS) and Global System for Mobile Communications (GSM) signals at power levels exceeding 50 W. The diplexer passes signals in the DCS band from 1690 to 1920 MHz and the GSM band from 860 to 980 MHz with less than 130-dBc intermodulation distortion (IMD). Insertion loss is less than 0.3 dB, return loss is better than −18 dB, and isolation between receive (Rx) and transmit (Tx) channels is better than 65 dB. The diplexer measures 1.5 × 3.0 × 5.0 in. (3.81 × 7.62 × 12.7 cm) and uses SMA or type-N connectors. **Wireless Technologies Corp., 4000 Haile Lane, Springdale, AR 72762; (501) 750-1046, FAX: (501) 750-4657, Internet: http://www.diplexers.com.**

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Non-toxic AlN termination handles high power

The 81-7172TC aluminum-nitride (AlN) termination handles 150 W at frequencies ranging from DC to 2 GHz. The termination is designed for high-power termination applications where toxic beryllia-ceramic substrates cannot be used. The termination has a DC resistance of 50 Ω ±2 percent and a VSWR of 1.15:1. The termination has a temperature coefficient of less than 200 PPM and can operate at temperatures from −55 to +100°C. **Florida RF Labs, Inc., P.O. Box 899, Stuart, FL 34995; (800) 544-5594, FAX: (561) 283-5286, Internet: http://www.rflabs.com.**

CIRCLE NO. 65 or visit www.mwrf.com

Software models toroid inductors

The Toroid v3.4 software package simulates the behavior of toroid inductors and helps engineers design toroids for use in filters, resonators, and other inductive circuits. The program can model the behavior of iron-powder-core toroids from DC to microwave frequencies, with an emphasis on frequencies from 1 to 200 MHz. The mouse- and arrow-key-driven menus support quick scrolling through core size, mix, and wire-gage menus and they automatically update information pertinent to the pre-selected inductance. Calculations include number of turns, self-resonance frequency (SRF), peak-Q frequency range, wire length and DC resistance, maximum turns S/L and 45-percent fill/wire gage, Gauss and Oersteds, true "AL" values, mean core length, as well as weight and volume of core + wire. Displays include color codes, iron composition, usable frequency range, permeability, temperature coefficients, manufacturers' cross references, core dimensions and tolerances, and wire diameter and circular mils. **J. Bellora & Assoc., 5347-B Colombia Rd., Colombia, MD 21044; (410) 381-5700 ext. 16, Internet: http://members.aol.com/toroids/johnindx.htm.**

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Single-balanced mixer MMIC spans 1.7 to 3.0 GHz

The model HMC272MS8 miniature single-balanced mixer monolithic microwave integrated circuit (MMIC) covers frequencies spanning 1.7 to 3.0 GHz. The passive mixer is constructed of gallium-arsenide (GaAs) Schottky diodes and a novel planar transformer balun integrated onto the chip. The RF port is balanced through the MMIC while the local-oscillator (LO) port is connected directly to the diodes. **Hittite Microwave Corp., 12 Elizabeth Dr., Chelmsford, MA 01824; (978) 250-3343, FAX: (978) 250-3373, Internet: http://www.hittite.com.**

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Phase shifters offer high resolution

A series of phase shifters boasts high resolution and high accuracy for applications from DC to 18 GHz. The units offer digital readout of phase that is calibrated in 0.01-deg./GHz increments accurate to ±0.1 deg. One member of the series operates from DC to 18 GHz with an insertion delay between 0.88 and 1.10 ns. It offers minimum phase adjustment of 60 deg./GHz, or a total of 360-deg. phase adjustment at 18 GHz. The maximum insertion loss for all members of the series is 0.5 dB from DC to 8 GHz and 1 dB from 8 to 18 GHz. The maximum VSWR is 1.3:1 from DC to 4 GHz and 1.6:1 from 4 to 18 GHz. The phase shifters can handle 100-W average power and 5-kW peak power. Standard units are supplied with SMA connectors. **ARRA, Inc., 15 Harold Court, Bay Shore, NY 11706-2296; (631) 231-8400, FAX: (631) 434-1116, Internet: http://www.arra.com.**

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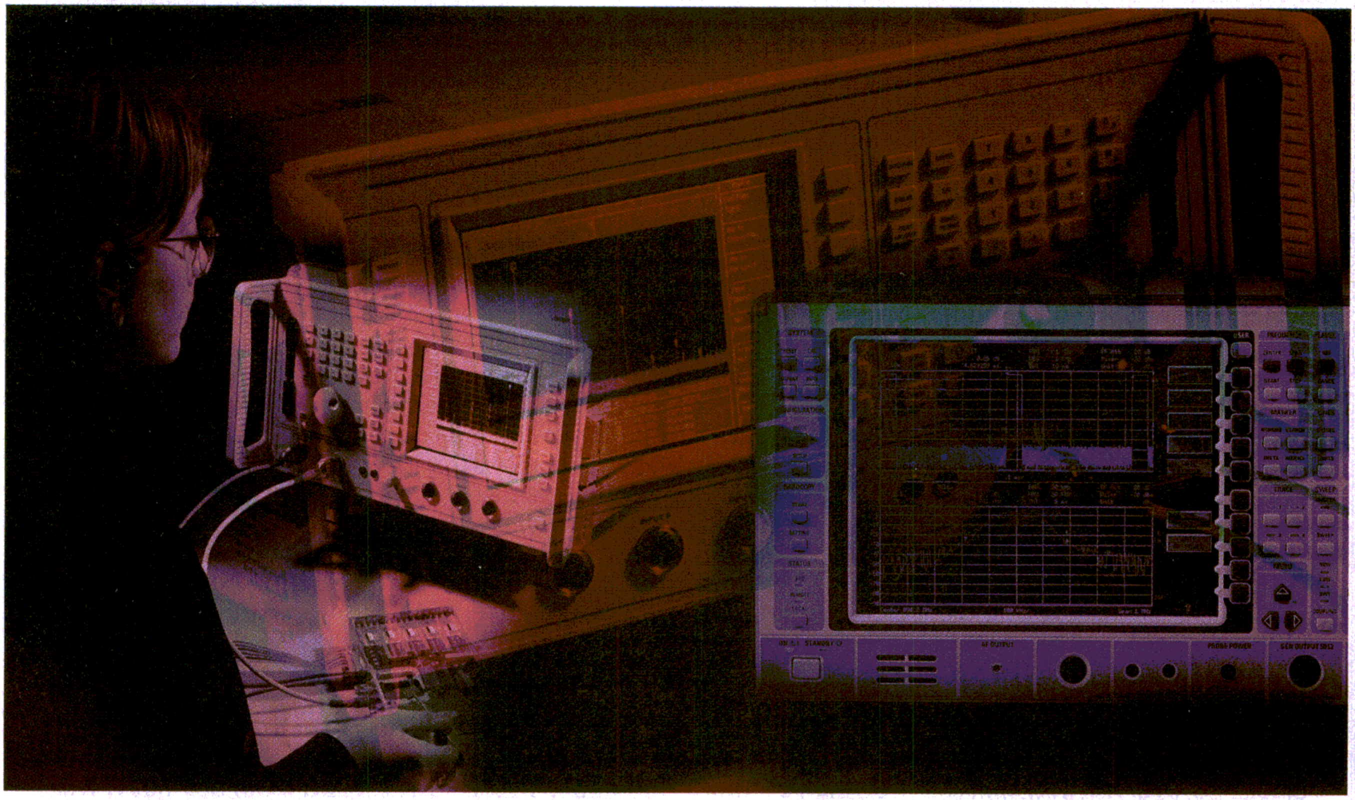

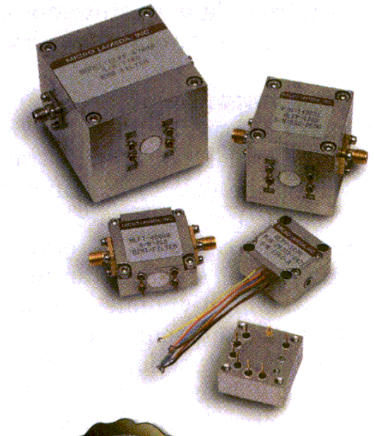

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CIRCLE NO. 218

GaAs amplifier boasts high dynamic range

The model AH4 gallium-arsenide (GaAs), metal-semiconductor-field-effect-transistor (MESFET) amplifier operates across the frequency range of 0.1 to 6.0 GHz and can deliver a third-order intercept point (IP3) of +41 dBm. The MESFET amplifier is suitable for wireless local-area-network (WLAN), wireless-local-loop (WLL), along with universal-national-information-infrastructure (UNII) receiver gain blocks and transmit lineups where high dynamic range is required. Its 1-dB compression point is +21 dBm and its small-signal gain is 13.5 dB. At 3.5 GHz, the GaAs MESFET amplifier has a noise figure of 3.5 dB. The GaAs amplifier has an input VSWR of 1.9:1 and an output VSWR of 1.4:1. The device draws 150 mA from a single +5-VDC power supply. It is housed in an industry-standard, 3 × 3, ball-grid-array (BGA) package. **Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, CA 94304; (650) 493-4141, Internet: http://www.wj.com.**

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RF shields prevent interference

A line of thin metal shields is designed to cover circuit-board components in order to prevent RF interference (RFI). The shields can be custom designed in rectangles (both square and non-square) as well as L shapes, and they are available as flat, hand-foldable plates or preformed, three-dimensional (3D) shapes. Shield materials include brass, copper (Cu), nickel (Ni), silver (Ag), or steel, and they are available with tin (Sn) plating. Special features include tuning holes and ventilation perforations. A collection of foldable square and non-square rectangular shields in any combination of 54 standard sizes can be pressed onto a 12 × 18-in. (30.48 × 45.72-cm) metal sheet. A prototype kit containing an assortment of more than two dozen foldable rectangular shields is also available. **Fotofabrication Corp., 3758 W. Belmont Ave., Chicago, IL 60618; (773) 463-6211, FAX: (773) 463-3387, Internet: http://www.fotofab.com.**

CIRCLE NO. 70 or visit www.mwrf.com

Software simulates RF circuits

The Spicycle Version 2 software package is a suite of application programs that allows analog, mixed-mode, and RF engineers to simulate circuits and design printed-circuit boards (PCBs). The two-dimensional (2D) drawing program has a range of tools for drawing schematic diagrams of electronic and other engineering schematics, and PCB layouts. Underlying its drawings is a data base that creates a net list in real time ready for simulation. Data flow to its data base is fully bidirectional with the drawings. This allows the user to import a SPICE netlist and have the corresponding schematic symbols ready connected. It also offers back annotation with simulation settings. The software's Active X controls provide interaction with other Windows programs and support standard OLE functions. **Those Engineers Ltd., 31 Birbeck Rd., London NW7 4BP, United Kingdom; +44 (208) 906-0155, FAX: +44 (208) 906-0969, Internet: http://www.spiceage.com.**

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PIM analyzers span wireless bands

A family of five passive intermodulation analyzers (PIMs) spans the major wireless bands to help wireless-equipment manufacturers maintain low intermodulation (IM). Model SI-800A covers the 869-to-894-MHz transmit (Tx) band and the 825-to-849-MHz receive (Rx) band. Model SI-900A covers the 935-to-960-MHz Tx band and the 890-to-915-MHz Rx band. Model SI-1800 spans the 1805-to-1880-MHz Tx band and the 1710-to-1785-MHz Rx band. Model SI-1900 spans the 1930-to-1990-MHz Tx band and the 1850-to-1910-MHz Rx band. And model SI-2000 covers the 2100-to-2170-MHz Tx band and the 1920-to-1980-MHz Rx band. The analyzers allow engineers to observe how PIM varies under mechanical and environmental stress, and how it changes as a function of frequency or power. **Summitek Instruments, Inc., P.O. Box 64, Parker, CO 80134; (303) 768-8080, FAX: (303) 768-8181, Internet: http://www.summitekinstruments.com.**

CIRCLE NO. 72 or visit www.mwrf.com

BWOs cover 1100 GHz

By using permanent magnets, electromagnets, and interchangeable tubes, a line of backward-wave oscillators (BWOs) generates frequencies that range from 33 to 1110 GHz. Permanent magnets provide the magnetic field for overlapping frequencies from 33 to 178 GHz. At these frequencies, the BWO provides a minimum of 6 mW. A solenoid electromagnet is used in conjunction with one of seven tubes to cover frequencies from 177 to 1100 GHz. Minimum RF output power is 1 mW through 850 GHz, and 0.5 mW from 850 to 1100 GHz. Accessories include separate power supplies for the BWO tube and the electromagnet, and a positioning device for the electromagnet. **Istok Microwave, 8200 South Memorial Pky., Huntsville, AL 35802; (256) 882-1344, FAX: (256) 880-8077, Internet: http://www.istom.com.**

CIRCLE NO. 73 or visit www.mwrf.com

TWT amplifier suits C-band

The model VZC-6967B4 traveling-wave-tube (TWT) amplifier boosts C-band signals up to 2.2 kW. It is ideal for fixed-satellite-service applications such as video transmission as well as high-volume international data and telephony. The amplifier employs a dual-depressed-collector helix TWT that is said to be 20 percent more efficient than conventional single-collector TWTs. Integrated microprocessor control allows users to adjust and monitor all operating parameters from one local or remote panel by using menu-driven commands. The amplifier is contained in a 19-in. (48.26-cm), rack-mount, dual-drawer housing. **CPI, Inc., Satcom Div., 811 Hanson Way, P.O. Box 51625, Palo Alto, CA 94303; (650) 846-3700, FAX: (650) 424-1744, Internet: http://www.cpii.com/satcom.**

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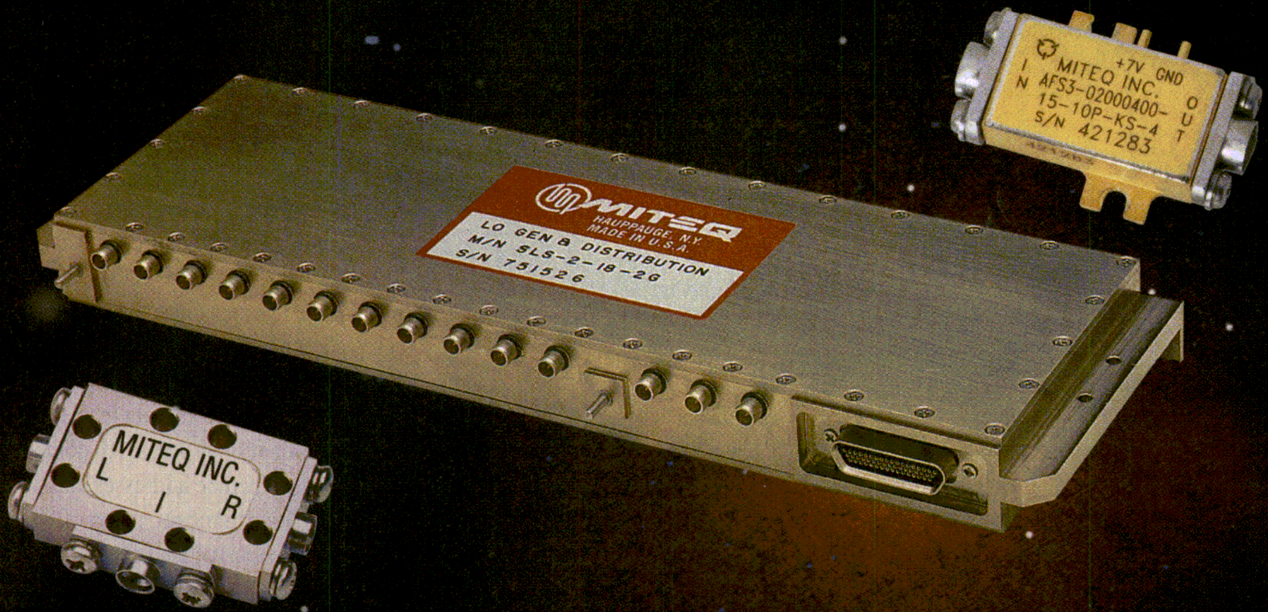

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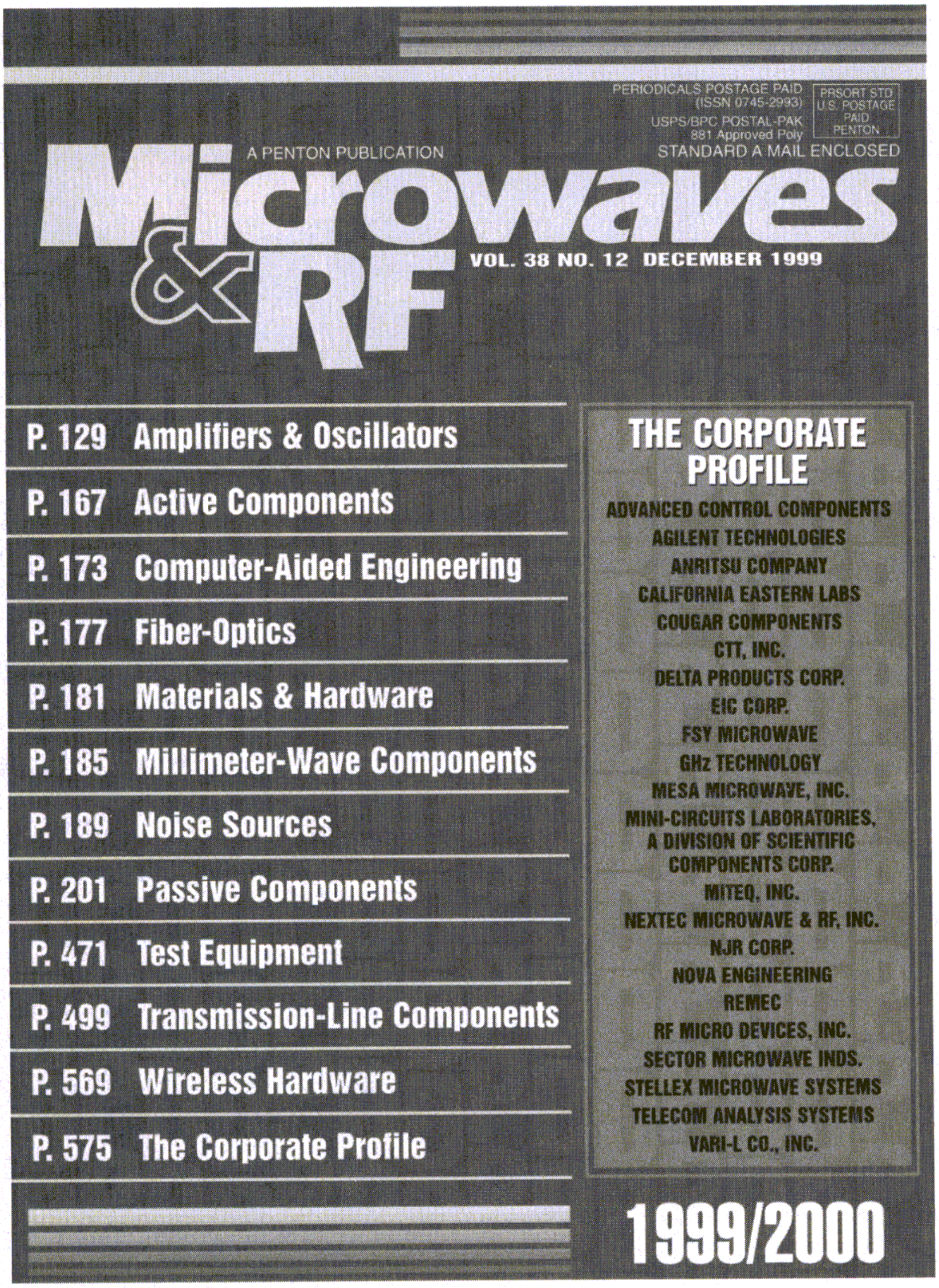

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Microwaves & RF

VOL. 38 NO. 12 DECEMBER 1999

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THE CORPORATE PROFILE

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The high-frequency industry's only complete buyer's guide works hard all year round. It provides instant access to information and solutions to design problems. Many specifiers begin and end their search for a product or service with the ***Microwaves & RF*** Directory Issue.

If you don't have a copy of the new 1999/2000 ***Microwaves & RF*** Directory Issue, don't waste time. Simply send a check or money order for $100 (plus $6.00 P&H) each (US, Canada, Mexico, and Central America), or $125 (plus $7.50 P&H) each (all other countries) to:

Microwaves & RF Directory Issue
Penton Media, Inc.
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Cable assemblies boast low loss

The UFA series of coaxial-cable assemblies exhibits insertion losses ranging from 0.11 dB/ft. at 1 GHz to 1.21 dB/ft. at 50 GHz. The five members of the series include the UFA147B, UFA210A, and UFA210B which operate at frequencies from DC to 26.5 GHz, the UFA147A which spans DC to 40 GHz, and the UFA125A which covers DC to 50 GHz. The assemblies have a patented connector attachment that claims high reliability as well as resistance to stress. The connector body, dielectric, and center contact are completely captivated in order to achieve a typical VSWR of 1.25:1 to 40 GHz. Applications include microwave transmission in commercial, military, and space-based environments. **Micro-Coax Corp., Box 993, 245 West 5th Ave., Collegeville, PA 19426-0993, (800) 223-2629, FAX: (610) 489-1103, Internet: http://www.micro-coax.com.**

CIRCLE NO. 75 or visit www.mwrf.com

BAW VCXO combines stability and pullability

The model CFPV-2365 bulk-acoustic-wave (BAW), voltage-controlled crystal oscillator (VCXO) operates at 622 MHz and combines frequency stability of ±20 PPM ranging from 0 to +70°C (or ±30 PPM from −25 to +85°C) with a frequency pullability that is between ±80 and ±120 PPM. Jitter is less than 2 ps between 12 kHz and 150 MHz from the output frequency. The VCXO oscillator operates from a +3.3-VDC power supply in order to facilitate its interface with emitter-coupled-logic (ECL) devices. It is designed for time-multiplexing applications in synchronous-digital-hierarchy (SDH) synchronous transmission module, level four (STM-4) and Synchronous Optical Network (SONET) synchronous transport signal, level 12 (STS-12). **C-MAC Frequency Products, 4222 Emperor Blvd., Suite 300, Durham, NC 27703-8466; (919) 941-0430, FAX: (919) 941-0530, Internet: http://cfpwww.com.**

CIRCLE NO. 76 or visit www.mwrf.com

Small crystal suits handheld computers

The model ILCX-13 crystal measures 3.2 × 2.5 × 0.8 mm and is available in frequencies ranging from 20 to 55 MHz with a tolerance of ±20 PPM at 25°C. The crystal's stability is ±20 PPM at operating temperatures spanning −40 to +86°C. The ILCX-13 crystal is ideal for ultra-small peripheral devices such as Portable Computer Memory Card International Association (PCMCIA) and handheld computer systems. **ILSI America, Inc., 5458 Louie Lane, Reno, NV 89511; (888) 355-4574, FAX: (702) 851-8882, Internet: http://www.ilsiamerica.com.**

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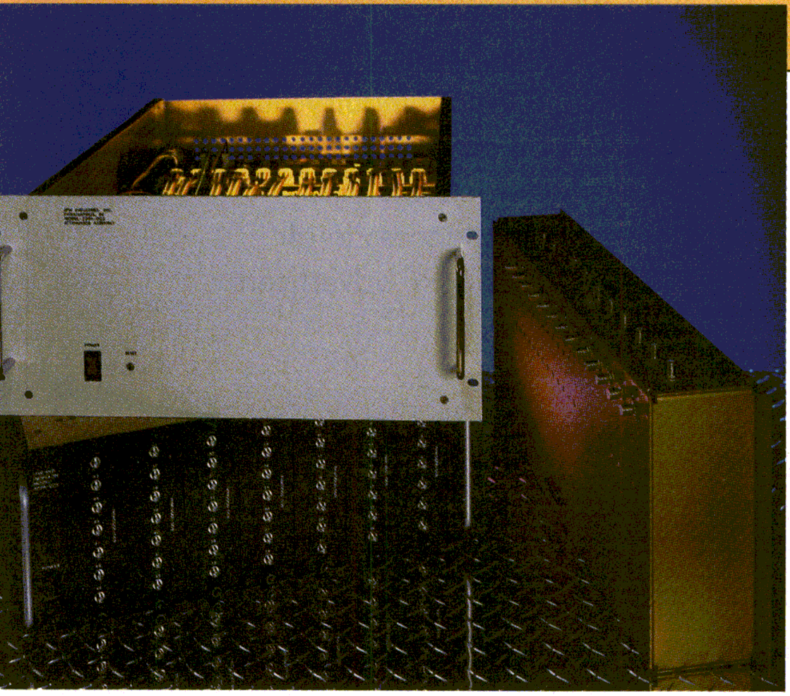

Transceiver monitors optical networks

The Snoop GBIC transceiver module is an upgrade to the company's previous gigabit-interface-converter (GBIC) transceiver for optical data communication over Fiber Channel and Gigabit Ethernet networks. In addition to transmitting and receiving data, the Snoop GBIC has an electrical test port in order to monitor network connections without interruption. Traditionally, engineers would debug and monitor network performance by shutting down the network, inserting test instrumentation into a network link, and restarting the network. The Snoop GBIC is designed for permanent installation on a link and it provides uninterrupted access. It supports data transmission rates to 1.25 Gb/s. **Finisar Corp., 1308 Moffett Park Dr., Sunnyvale, CA 94089; (408) 548-0857, FAX: (408) 543-0083, Internet: http://www.finisar.com.**

CIRCLE NO. 78 or visit www.mwrf.com

PIN and varactor diodes reach 10 GHz

The MicroPak series of positive-intrinsic-negative (PIN) and varactor diodes achieves operational frequencies to 10 GHz. The diodes are fabricated using monolithic-microwave-surface-mount (MMSM) package technology in order to eliminate the parasitic inductances and capacitances associated with wirebonds in conventional plastic or ceramic packages. Since the diodes cathode and anode connections are made using photolithographic techniques rather than wirebonds, the diodes exhibit a typical series inductance of less than 0.2 nH and a typical parasitic capacitance of 0.07 pF. Applications include high-speed switching, amplifier-protection circuitry, and low-voltage, wideband, voltage-controlled oscillators (VCOs). **Link Microtek Ltd., Intec 4.1, Wade Rd., Basingstoke, Hants RG24 8NE, United Kingdom; +(125) 635-5771, FAX: +(125) 635-5118, Internet: http://www.linkmicrotek.co.uk.**

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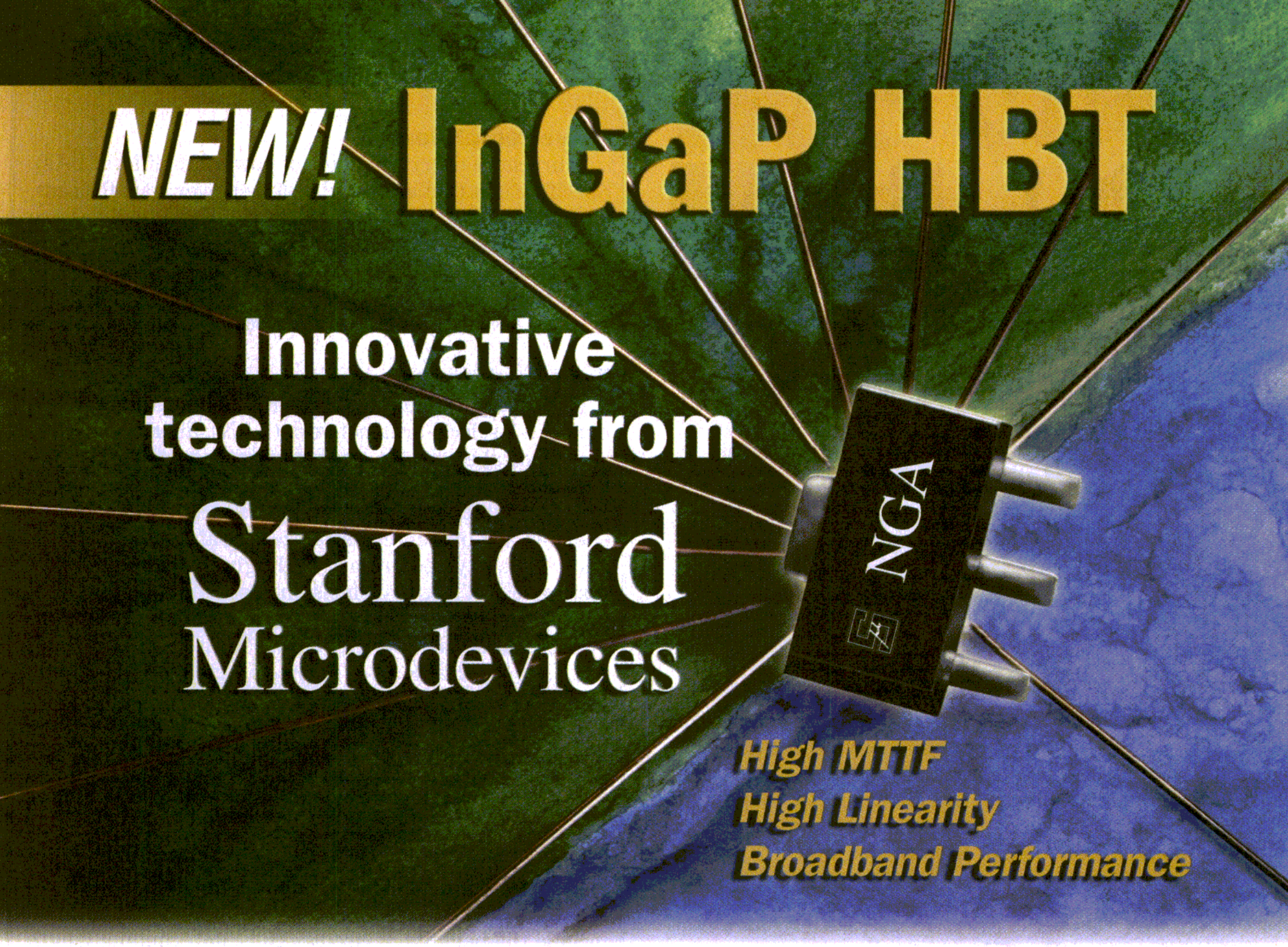

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NGA-489 DC-8 GHz

Designed with InGaP process technology for greater reliability, this Darlington configured, high gain, heterojunction bipolar transistor MMIC amplifier offers value and performance for all wireless and broadband communication applications. Outstanding features are:

- Cascadable 50Ω: 1.5:1 VSWR
- Low positive voltage supply
- Low thermal resistance package
- High linearity

SPECIFICATION MATRIX

	NGA-489	NGA-589
Frequency (GHz)	DC-8.0	DC -6.0
Gain (dB)	14.5	19.0
TOIP (dBm)	38.5	38.0
N.F. (dB)	4.5	4.5
P1dB (dBm)	17.5	19.0
Supply Voltage	4.2	5.0
Supply Current	80	80

All data measured at 900MHz and is typical.
MTTF @ 150C T_j = 2 million hrs. (R_{TH} = 110 C/W typ.)

NGA-589 DC-6 GHz

High gain and high output make this heterojunction bipolar transistor MMIC amplifier ideal for use in all wireless applications. InGaP HBT technology improves the reliability and performance and minimizes leakage current between junctions. Other features include:

- Cascadable 50Ω: 1.5:1 VSWR
- Low thermal resistance package
- High linearity
- High gain
- High P1dB

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CIRCLE NO. 379

Power amplifiers

A brochure describes a line of power amplifiers (PAs). Specifications that are listed include power, gain flatness, linearity, and dimensions. Descriptions and features are also provided. **Lambda RF Systems;** *(408) 653-1675, FAX: (408) 653-1660, e-mail: bruce_chinich@Lambdaaa.com.*

CIRCLE NO. 80 or visit www.mwrf.com

Test equipment

A 400-page catalog features products for the telecommunications, local-area-network (LAN), fiber-optic, wireless, medical-electronic, and computer industries. Component testers, digital multimeters (DMMs), frequency counters, function generators, oscilloscopes, and power supplies are presented. Analyzers, Category 5 testers, and continuity testers are highlighted. Bit-error-rate testers (BERTs), transmission test sets, optical time-domain reflectometers (OTDRs), and power meters are offered. **Specialized Products Co.;** *(800) 866-5353, FAX: (800) 234-8286, Internet: http://www.specialized.net.*

CIRCLE NO. 81 or visit www.mwrf.com

Delay lines

An application note (number 19) explains how to select coaxial delay lines for feedforward amplifiers. The main concerns when selecting coaxial delay lines—electrical length stability, tolerance, cost, configuration, and size—are discussed. Among the design considerations outlined include the benefits of circular coils, determining length based on electrical characteristics rather than physicality, cable types, and packaging of the delay lines. The application note also recommends system-design considerations and the importance of considering delay lines throughout the entire design process. **MICRO-COAX;** *(800) 223-2629, Internet: http://www.micro-coax.com.*

CIRCLE NO. 82 or visit www.mwrf.com

Personal monitors

A data sheet overviews a family of RF personal monitors. The data sheet features product descriptions and specifications, as well as an alarm threshold versus frequency graph. **Narda Microwave-East;** *(631) 231-1700, FAX: (631) 231-1711, e-mail: nardaeast@L-3COM.com, Internet: http://www.nardamicrowave.com.*

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OCXOs/TCXOs

A 162-page data book focuses on oven-controlled crystal oscillators (OCXOs), temperature-compensated crystal oscillators (TCXOs), voltage-controlled crystal oscillators (VCXOs), clocks, mini ovens, as well as crystal filters and crystal units. Application notes and general information are included. Outline drawings, specifications, applications, as well as features are provided. **Oak Frequency Control Group;** *(717) 486-3411, FAX: (717) 486-5920, e-mail: sales@ofc.com, Internet: http://www.ofc.com.*

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Antenna development

A guide is presented on antenna systems for developers and manufacturers who are designing portable computing devices using Bluetooth technology. Selection of the right antenna, antenna tuning and testing, as well as antenna choices for Bluetooth products are offered. Location, orientation, and attachment of the antenna are also discussed. **Centurion International, Inc.;** *(402) 467-4491, FAX: (402) 467-4528, e-mail: sales@centurion.com, Internet: http://www.centurion.com.*

CIRCLE NO. 85 or visit www.mwrf.com

Microwave components

A 34-page catalog highlights complete repeater modules, upconverters, downconverters, dual downconverters, low-noise amplifiers (LNAs), power-amplifier (PA) modules, and cable-television (CATV) modem RF transceivers. Inquiry sheets are included. Outline drawings, specifications, and dimensions are provided. **Microwave Communications & Components Corp.;** *+82-2-3424-0800, FAX: +82-2-3424-0808, e-mail: sales@mcck.com, Internet: http://www.mcck.com.*

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Cable-modem technologies

A publication discusses cable-modem technologies and applications. Information is provided on today's cable-modem market and suggests how cable companies, Internet service providers (ISPs), RBOCs, vendors, and analysts can capitalize on the opportunities of the future. The publication thoroughly examines all aspects of cable-modem deployment, including the physical layer, the network-routing layer, and security issues. **International Engineering Consortium;** *(312) 559-3730, FAX: (312) 559-4111, e-mail: publications@iec.org, Internet: http://www.iec.org/pubs.*

CIRCLE NO. 87 or visit www.mwrf.com

Rubidium standard

A data sheet contains information on a militarized rubidium (Rb) atomic-frequency standard. The data sheet includes technical characteristics and an outline drawing. **FEI Communications, Inc.;** *(516) 794-4500, FAX: (516) 794-4340, Internet: http://www.freqelec. com.*

CIRCLE NO. 88 or visit www.mwrf.com

T1/E1 analysis

A data sheet describes personal-computer (PC)-based T1/E1 analysis. Basic software, scripted-control software, optional software, and other products are listed. Specifications include physical interface, T1/E1 line interface, PCM channel transmitter, PCM channel receiver, facility data link, insert, and pattern generation. **GL Communications, Inc.;** *(301) 670-4784, FAX: (301) 926-8234, e-mail: gl-info@gl.com, Internet: http://www.gl.com.*

CIRCLE NO. 89 or visit www.mwrf.com

Planar scanners

A brochure overviews the capabilities of a family of planar scanners. Areas covered in the brochure include mechanical accuracy, electromagnetic (EM) performance, speed, reliability, planarity, and requirements growth. **Microwave Instrumentation Technologies LLC;** *(800) 848-7921, (678) 475-8300, FAX: (678) 475-8391, Internet: http://www.mitechnologies.com.*

CIRCLE NO. 90 or visit www.mwrf.com

Frequency mixers

A 196-page RF/intermediate-frequency (IF) designer's guide contains information on frequency mixers, high-power combiners/splitters, power splitters/combiners, attenuators, impedance matching pads, terminations, and amplifiers. Directional couplers, filters, frequency doublers, phase detectors, phase shifters, limiters, phase modulators, and voltage-controlled oscillators (VCOs) are also covered. **Mini-Circuits;** *(718) 934-4500, FAX: (718) 332-4661, e-mail: sales@minicircuits.com, Internet: http://www.minicircuits.com.*

CIRCLE NO. 91 or visit www.mwrf.com

Isolators and circulators

A 43-page product catalog describes several product lines. Features and specifications of multichannel-multipoint-distribution-systems (MMDS) fixed wireless transceivers, base-station expansion-rack systems, as well as isolators and circulators are highlighted. **Renaissance Electronics Corp.;** *(978) 263-4994, Internet: http://www.rec-usa.com.*

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Precision sources

A 672-page catalog provides information and specification for a range of hardware- and software-measurement products. Digital multimeters (DMMs), electrometers, precision sources, voltmeters, picoammeters, ohmmeters, source-measure units, power supplies, switching systems, and semiconductor characterization systems are offered. **Keithley Instruments, Inc.;** *(888) 534-8453, (440) 248-0400, FAX: (440) 248-6168, e-mail: product_info@keithley.com, Internet: http://www.keithley.com.*

CIRCLE NO. 93 or visit www.mwrf.com

Fiber-optic cables

A 64-page fiber-optic-cable product catalog features an introductory section on indoor/outdoor tight-buffer fiber-optic cables. The various types of cable with complete fiber and cable specifications, cross-sectional drawings, and termination diagrams are outlined. Technical articles, covering topics such as frequently asked fiber-optic-cable questions, are included. **Optical Cable Corp.;** *(800) 622-7711, FAX: (540) 563-9829, Internet: http://www.occfiber.com.*

CIRCLE NO. 94 or visit www.mwrf.com

Test system

A magazine breaks down products by application area, reflecting test equipment for different sectors including local loop, fiber optics, transport networks, enterprise networks, and digital broadcast. A modular test system for the local loop, a portable 10-Gb/s tester for synchronous digital hierarchy (SDH)/Synchronous Optical Network (SONET), and systems for integrated-services-digital-network (ISDN) installations are covered. **Wavetek Wandel Goltermann;** *+49 7121 86-1616, FAX: +49 7121 86-1333, e-mail: info@wwgsolutions.com, Internet: http://www.wwgsolutions.com.*

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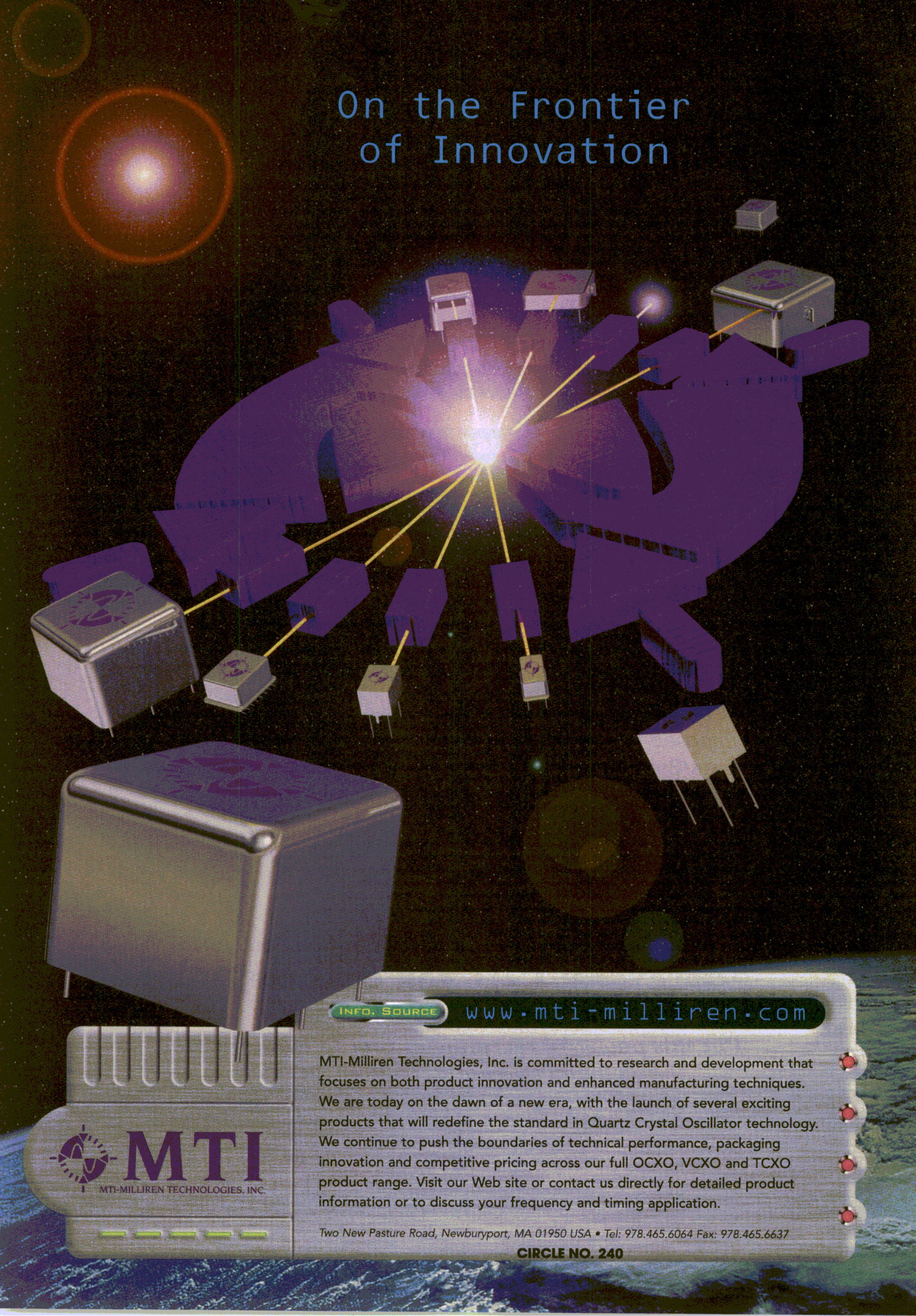
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DTV SOFTWARE DEVELOPER Successful candidates should possess a BSEE degree, MSEE preferred, with a minimum of 3 years' experience in embedded real-time software development and a good understanding of real-time kernel/OS concepts. Experience with WinCE/Windows interrupt and driver development would be a very strong plus. Knowledge in driver and communication bus protocols development such as 1394, PCI, IDE, ATAPI is also a plus. **Job Number 0072**

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

SALES ASSISTANT
Silvia Marrella
(201) 393-6229
e-mail: smarrella@penton.com

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

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San Jose Gateway
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NEW YORK, LONG ISLAND, NEW ENGLAND, CANADA
Jonathan Kummer
Regional Sales Manager
Penton Media, Inc.
611 Route #46 West
Hasbrouck Heights, NJ 07604
(201) 393-6271
FAX: (201) 393-6297
e-mail: jkummer@penton.com

SOUTHWEST, SOUTHEAST, SOUTHERN CA
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Regional Sales Manager
Penton Media, Inc.
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FAX: (407) 629-8715
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Regional Sales Manager
Penton Media, Inc.
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PRODUCTION
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Phone: 44-1268-711-560
FAX: 44-1268-711-567

GERMANY, AUSTRIA, SWITZERLAND
Friedrich K. Anacker
Managing Director
InterMedia Partners GmbH (IMP)
Deutscher Ring 40
42327 Wuppertal
Germany
Phone: 011-49-202-271-690
FAX: 011-49-202-271-6920

HOLLAND, BELGIUM
William J.M. Sanders, S.I.P.A.S.
Rechtestraat 58
1483 Be De Ryp, Holland
Phone: 31-299-671303
FAX: 31-299-671500

JAPAN
Hiro Morita
Japan Advertising
Communications, Inc.
Three Star Building
3-10-3 Kanda Jimbocho
Chiyoda-ku, Tokyo 101,
Japan
Phone: 81-3-3261-4591
FAX: 81-3-3261-6126

PORTUGAL
Paulo Andrade
Ilimitada-Publicidade
Internacional. LDA
Av. Eng. Duarte Pacheco
Empreedimento das
Amoreiras-Torre 2
Piso 11-Sala 11
1070 Lisboa, Portugal
Phone: 351-1-3883176
FAX: 351-1-3883283

EUROPEAN OPERATIONS
Paul Barratt, Mark Whiteacre,
David Moore
Phone: 44-1268-711-560
FAX: 44-1268-711-567
John Maycock
Phone: 44-1142-302-728
FAX: 44-1142-308-335
Hartswood, Maycock Media
Hallmark House
25 Downham Road
Ramsden Heath
Billericay, Essex
CM11. 1PU. U.K.

CZECH REPUBLIC
Robert Bilek
Production International
Slezska 61, 13000 Praha 3
Czech Republic
Phone: 011-42-2-730-346
FAX: 011-42-2-730-346

KOREA
BISCOM
Jo Young Sang
Rm. 521 Midopa Bldg. 145
Dan Ju-Dong
Chongno-Gu
Seoul 110-071 Korea
Phone: 027397840
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Almost 16 years ago, the Spokane (WA) Division of Hewlett-Packard Co. (now Agilent Technologies) unveiled a signal generator with spurious and phase-noise performance once possible only with cavity-type signal generators. The 8642A/B signal generators operated to 2115 MHz using surface-acoustic-wave (SAW) resonators as part of the signal-generation process.

Microwaves & RF May Editorial Preview

Issue Theme: Radar & Antennas/MTT-S Preview

News

The May issue of *Microwaves & RF* will offer several newsworthy features, including a specifier's guide to antennas and a Special News report on the current state of communications antenna technologies. In addition, May will cover the technical presentations and expected new products to be revealed at the MTT-S Symposium & Exhibition, coming to Boston, MA this June.

Design Features

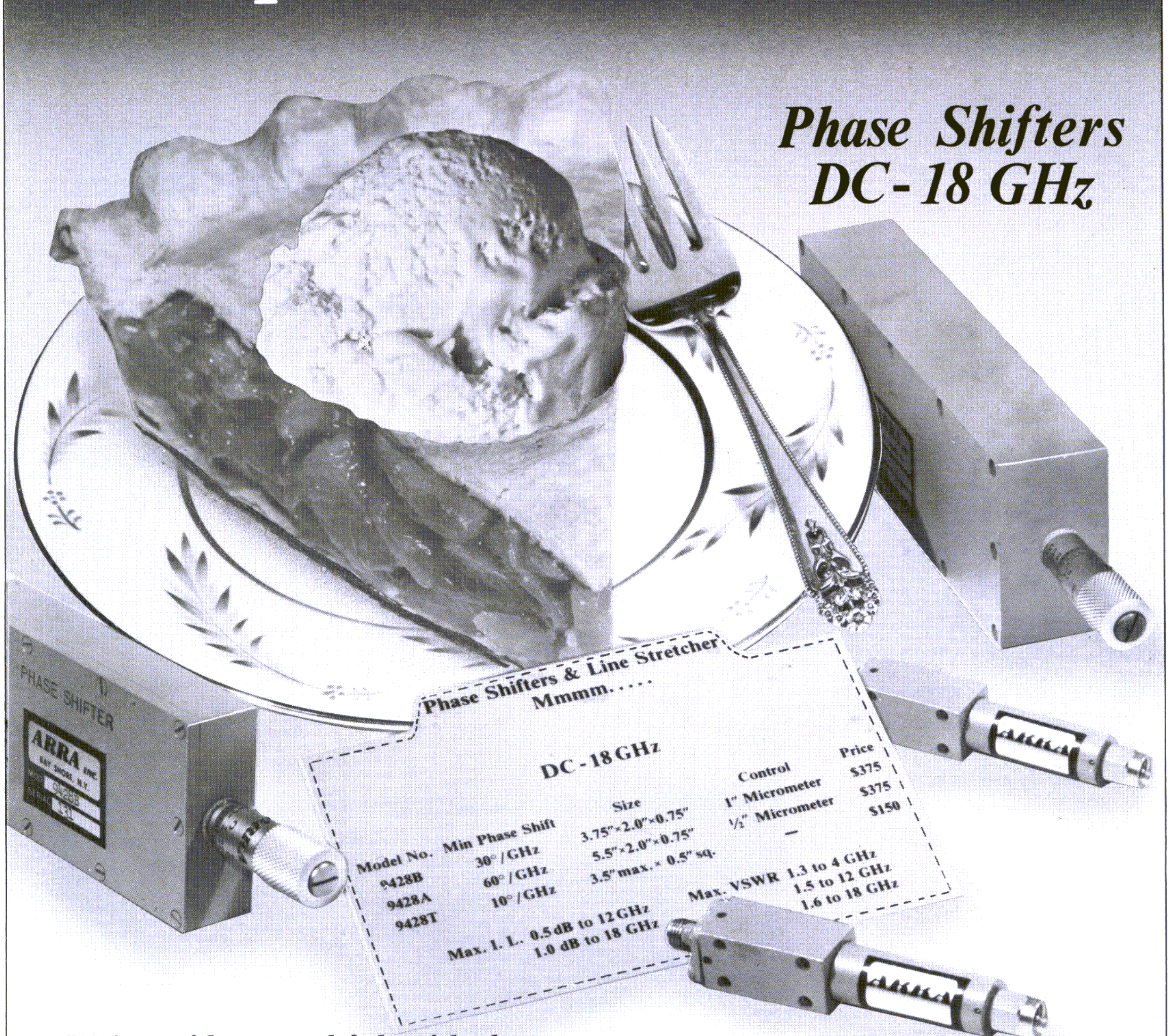
May's contributed technical articles will examine design techniques for the components of radar and communications systems. Two articles on amplifier design will address techniques for optimizing output power and linearity, as well as an approach for using lossy matching networks in power amplifiers (PAs). Two multiple-part articles will continue in May: one on the computer-aided design (CAD) of phase-locked loops (PLLs), the other on the use of computer software to optimize oscillator performance.

Product Technology

May's Product Technology section will launch a number of hot new components and test instruments, including a line of notch filters for communications applications, a line of gallium-arsenide (GaAs) components for optical transmissions exceeding 10 Gb/s, and a series of general-purpose oscilloscopes that provides digital power but analog appearance.

Get a piece of the ARRA pie...

Phase Shifters DC-18 GHz



Phase Shifters & Line Stretcher
Mmmm. . . .

DC-18 GHz

Model No.	Min Phase Shift	Size	Control	Price
9428B	30° / GHz	3.75"×2.0"×0.75"	1" Micrometer	$375
9428A	60° / GHz	5.5"×2.0"×0.75"	½" Micrometer	$375
9428T	10° / GHz	3.5" max. × 0.5" sq.	—	$150

Max. I. L. 0.5 dB to 12 GHz
1.0 dB to 18 GHz

Max. VSWR 1.3 to 4 GHz
1.5 to 12 GHz
1.6 to 18 GHz

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- Burr-free manufacturing
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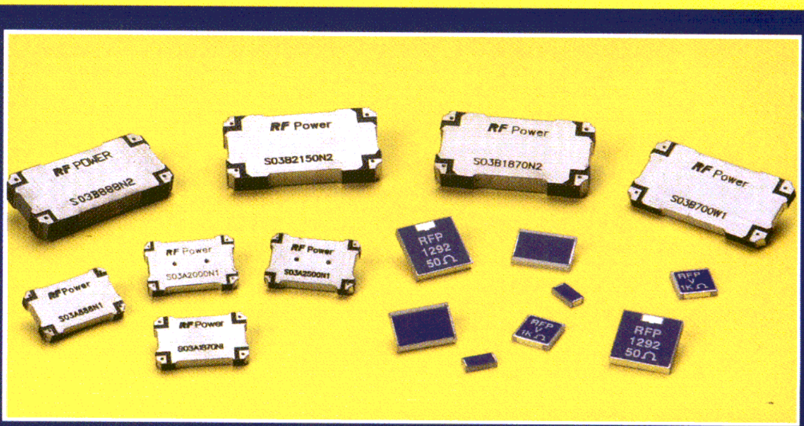
- Non-Nichrome resistor for low IMD



90° HYBRID COUPLERS

Model Number	Freq. Range (Mhz)	Power Watts. (CW)	Amp. Bal Max	Phase Bal. Deg Max	Isolation Min	VSWR	Insertion Loss Max.
S03B700W1	400-1000Mhz	200W	+/-0.65dB	+/-1.5	20dB	1.20:1	0.25dB
S03A888N1	815-960Mhz	100W	+/-0.30dB	+/-1.5	20dB	1.25:1	0.25dB
S03B888N2	815-960Mhz	200W	+/-0.30dB	+/-1.5	20dB	1.25:1	0.20dB
S03A1870N1	1750-1990Mhz	100W	+/-0.30dB	+/-1.5	20dB	1.25:1	0.25dB
S03B1870N2	1750-1990Mhz	200W	+/-0.30dB	+/-1.5	20dB	1.25:1	0.20dB
S03A1960N1	1930-1990Mhz	100W	+/-0.20dB	+/-1.5	20dB	1.25:1	0.25dB
S03B1960N2	1930-1990Mhz	200W	+/-0.10dB	+/-1.5	20dB	1.25:1	0.20dB
S03A2000N1	1500-2500Mhz	100W	+/-0.30dB	+/-2	20dB	1.20:1	0.25dB
S03B2150N2	2000-2300Mhz	200W	+/-0.20dB	+/-2	20dB	1.25:1	0.20dB
S03A2250N1	2000-2500Mhz	100W	+/-0.30dB	+/-2	20dB	1.20:1	0.25dB
S03A2500N1	2000-3000Mhz	100W	+/-0.35dB	+/-2	20dB	1.20:1	0.30dB
S03D3500NR5	3000-4000Mhz	50W	+/-0.30dB	+/-2	18dB	1.30:1	0.30dB

TERMINATIONS (CASE STYLE Z)

Reference	Watts	VSWR	Frequency
RFP-100200-4Z50-2	10	1.25:1	3 GHz
RFP-250250-4Z50-2	16	1.25:1	2 GHz
RFP-250250-6Z50-2	16	1.25:1	3 GHz
RFP-250375-4Z50-2	25	1.20:1	2 GHz
RFP-375375-6Z50-2	30	1.25:1	3 GHz

Surface Mount

Terminations
90° Hybrid Couplers
Attenuators
Combiners/Dividers
Directional Couplers

Resistors

10-800 Watts, DC - 6 Ghz, SMD, flanged, coaxial

Attenuators

8-150 Watts, DC - 4 Ghz, SMD, flanged, coaxial

90° Hybrid Couplers

100-2000 Watts, 50 - 4200 Mhz, SMD, caseless, coaxial

Directional Couplers

100-2000 Watts, 4 - 6000 Mhz, SMD, caseless, coaxial

Combiners/Dividers

50-1500 Watts , 25 - 2000 Mhz, SMD, caseless, resistive, coaxial

Custom Devices

Custom devices and assemblies

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