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DECEMBER 2000
VOL. 43, NO. 12

CONTROL DEVICES

BEHAVIORAL MODELING OF HIGH POWER AMPLIFIERS

RF & HYPER TECHNICAL PROGRAM

2000 EDITORIAL INDEX

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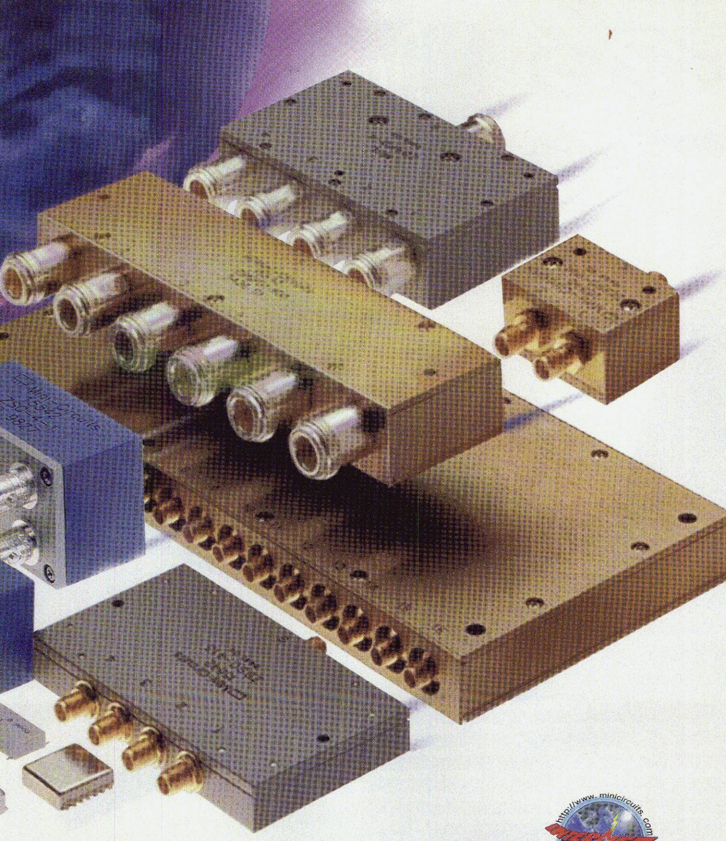
Founded in 1958

horizon house

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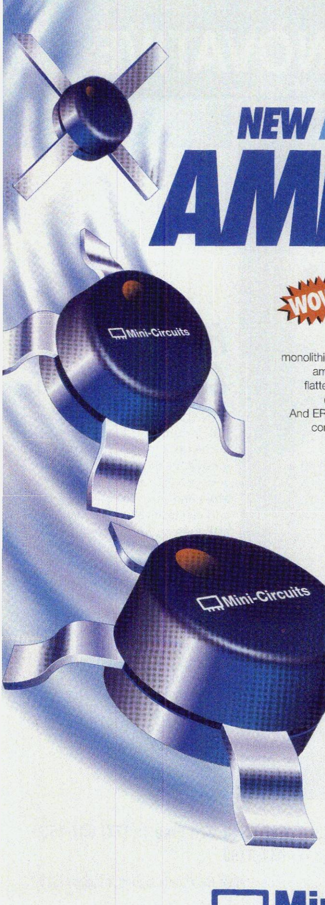

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Model	*Freq. (MHz)	Gain (dB)	Max. Power Out (dBm, @ 1dB Comp)	Dynamic Range NF(dB)	Dynamic Range IP3(dBm)	@Device Current(mA)	①Price $ ea. (10 Qty.)
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ERA-1SM	DC-8000	11.8	11.3	5.5	26.0	40	1.85
ERA-2	DC-6000	15.6	12.8	4.7	26.0	40	1.95
ERA-2SM	DC-6000	15.2	12.4	4.6	26.0	40	2.00
ERA-3	DC-3000	20.8	12.1	3.8	23.0	35	2.10
ERA-3SM	DC-3000	20.2	11.5	3.8	23.0	35	2.15
ERA-4	DC-4000	13.5	▲17.0	5.5	▲32.5	65	4.15
ERA-4SM	DC-4000	13.5	▲16.8	5.2	▲33.0	65	4.20
ERA-5	DC-4000	18.8	▲18.4	4.5	▲33.0	65	4.15
ERA-5SM	DC-4000	18.5	▲18.4	4.3	▲32.5	65	4.20
ERA-6	DC-4000	11.3	▲18.5	8.4	▲36.5	70	4.15
ERA-6SM	DC-4000	11.3	▲17.9	8.4	▲36.0	70	4.20

Note: Specs typical at 2GHz, 25°C. Exception: ▲ indicates typ. numbers tested at 1GHz.
* Low frequency cutoff determined by external coupling capacitors.
① Price (ea.) Qty.1000: ERA-1 $1.19, -2 $1.33, -3 $1.48, -4, -5 or -6 $2.95. SM option same price.

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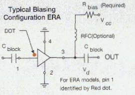
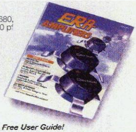
80x50	10, 22, 47, 68, 100, 220, 470, 680, 1000, 2200, 4700, 6800, 10,000 pf
120x60	.002, .047, .068, .1 µf





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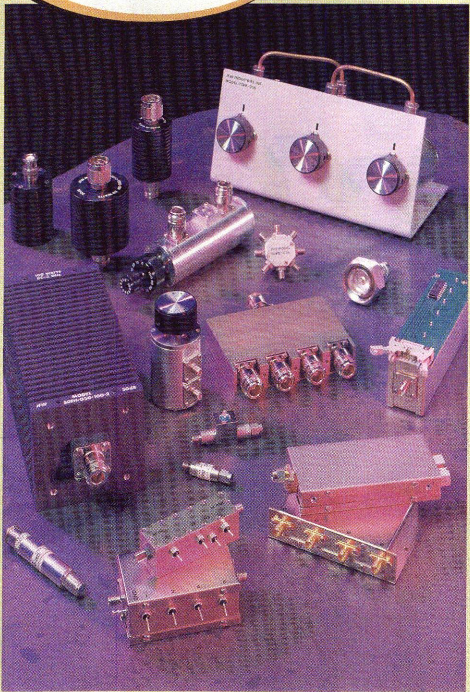

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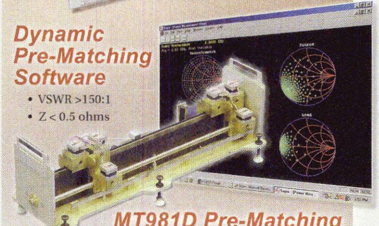

MT981D

MT981D Pre-Matching Automated Tuner

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APPLICATION NOTE

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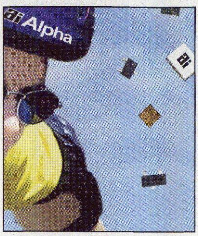

ON THE COVER

Discrete and GaAs IC components to lower costs and improve wireless and broadband performance are featured on this month's cover

Cover art courtesy of Alpha Industries Inc.

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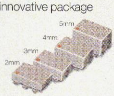

ADE Mixers...Innovations Without Traditional Limitations!

ADE* TYPICAL SPECIFICATIONS:

Model	Height (mm)	Freq. (MHz)	LO (dBm)	Conv. Loss Midband (dB)	L-R Isol. Bandwide (dB)	IP3 (dBm) @ Midband	Price ($ea.) Qty. 10-49
ADE-1L	3	2-500	-3	5.2	55**	16	3.95
ADE-3L	4	0.2-400	-3	5.3	47**	10	4.25
ADE-1	4	0.5-500	+7	5.0	55**	15	1.99
ADE-1ASK	3	2-600	+7	5.3	50**	16	3.95
ADE-2ASK	3	1-1000	+7	5.4	45**	12	4.25
ADE-6	5	0.05-250	+7	4.6	40	10	4.95
ADE-12	2	50-1000	+7	7.0	35	17	2.95
ADE-4	3	200-1000	+7	6.8	53**	16	4.25
ADE-14	2	800-1000	+7	7.4	32	17	3.25
ADE-901	3	800-1000	+7	5.9	32	13	2.95
ADE-5	3	5-1500	+7	6.6	40**	15	3.45
ADE-13	2	50-1600	+7	8.1	40**	11	3.10
ADE-20	3	1500-2000	+7	5.4	31	14	4.95
ADE-18	3	1700-2500	+7	4.9	27	10	3.45
ADE-3GL	2	2100-2600	+7	6.0	34	17	4.95
ADE-3G	3	2300-2700	+7	5.6	36	13	3.45
ADE-28	3	1500-2800	+7	5.1	30	8	5.95
ADE-30	3	200-3000	+7	4.5	35	14	6.95
ADE-32	3	2500-3200	+7	5.4	29	15	6.95
ADE-35	3	1600-3500	+7	6.3	25	11	4.95
ADE-18W	3	1750-3500	+7	5.4	33	11	3.95
ADE-30W	3	300-4000	+7	6.8	35	12	8.95
ADE-1LH	4	0.5-500	+10	5.0	55**	15	2.99
ADE-1LHW	3	2-750	+10	5.3	52**	15	4.95
ADE-1MH	3	2-500	+13	5.2	50**	17	5.95
ADE-1MHW	4	0.5-600	+13	5.2	53**	17	6.45
ADE-12MH	3	10-1200	+13	6.3	45**	22	6.45
ADE-25MH	3	5-2500	+13	6.9	34**	18	6.95
ADE-35MH	3	5-3500	+13	6.9	33**	18	9.95
ADE-42MH	3	5-4200	+13	7.5	29**	17	14.95
ADE-1H	4	0.5-500	+17	5.3	52**	23	4.95
ADE-10H	3	400-1000	+17	7.0	39	30	7.95
ADE-12H	3	500-1200	+17	6.7	34	28	8.95
ADE-17H	3	100-1700	+17	7.2	36	25	8.95
ADE-20H	3	1500-2000	+17	5.2	29	24	8.95

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January 14–17, 2001
Santa Clara, CA

Sponsor: Telecommunications Industry Association (TIA). Conference Partner: International Engineering Consortium (IEC). Topics: change drivers, enabling technologies, market opportunities and deployment hurdles that are involved in making the next-generation broadband network a reality. Conferences: IEC Executive Forum—Communications Investor Focus. Additional information is available at www.supernet2001.com. Contact: (312) 559-3866 or e-mail: info@supernet2001.com.

International Symposium on Advanced Packaging Materials: Processing, Properties and Interfaces
March 11–14, 2001
Braselton, GA

Sponsors: IMAPS, IEEE Components, Packaging and Manufacturing Technology Society, and the Packaging Research Center, Georgia Institute of Technology. Participating Societies: American Society of Metals, The American Ceramic Society, Society of Plastic Engineers and the Material Research Society. Topics: adhesives, bumping materials and processing, consumer electronic material issues (cellular phones), integral passive materials, interfacial adhesion, manufacturing process control, mechanics of materials, microwave materials, on-chip interconnect materials, optoelectronics substrates, HEI and dielectrics, thermal management materials, and underfills and encapsulant materials. Contact: IMAPS, 1850 Centennial Park Dr., Suite 105, Reston, VA 20191 (888) 464-6277 or (703) 758-1060, fax (703) 758-1066. Additional information is available at www.imaps.org.

IEEE Sarnoff Symposium
March 21, 2001
Trenton, NJ

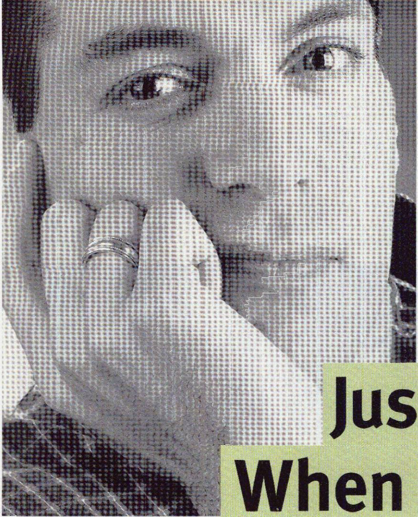
Sponsors: IEEE Microwave Theory and Techniques Society, IEEE Princeton Section, The College of New Jersey (TCNJ) Student Branch and the TCNJ Engineering Department. Symposium focus: Advances in wired and wireless communications. Contact: Bernard D. Geller, Sarnoff Corp., 201 Washington Rd., Princeton, NJ 08540 (609) 734-2629, fax (609) 734-2050 or e-mail: b.geller@ieee.org.

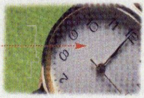
MIOP (The German Wireless Week)
May 8–10, 2001
Messe Stuttgart, Germany

Congress and exhibition is held in cooperation with IEEE MTT/AP and VDE/ITG. Topics: active/passive microwave components, antennas/feeding networks/filters, MMICs, new semiconductor technologies and materials, modern CAD tools, simulation/linear and non-linear modeling, field theory, integration/assembly and interconnects, microwave measurements, reliability, electromagnetic compatibility, commercial/industrial subsystems/sensors, MEMS, biological/medical applications, quasi-optics, microwave, millimeter-wave and terahertz photonics, optically controlled phased-array antennas, optical communications, optical sensors, optical measurements and microwave/optics related topics. Contact: Christine Vesche, NETWORK-OSE GmbH +49 (0) 50 33 70 57, fax +49 (0) 50 33 79 44 or e-mail: vesche@networkgmbh.de.

2001 IEEE Radio Frequency Integration Circuits Symposium
May 20–22, 2001
Phoenix, AZ

Original work in RFIC design, fabrication, testing and packaging to support RF applications in areas such as wireless transceivers, communications RFIC, emerging technologies, IC design, integrated modules and functions, high frequency technologies and RF de-





vices technology. A microwave exhibition, a historical exhibit, the RFIC Symposium and the ARFTG Conference will be held during Microwave Week 2001. For symposium information, contact: Sayfe Kiaei, technical program chair, Motorola Inc. (512) 996-4404 or e-mail: Sayfe@att.net.

2001 IEEE MTT-S International Microwave Symposium and Exhibition
May 20–25, 2001
Phoenix, AZ

Topics: research, development and application of RF and microwave theory and techniques. Complete information on how to register for the conference, as well as other important information, can be found at www.ims2001.org. A microwave exhibition and historical exhibit, the RFIC Symposium and the ARFTG Conference will also be held during Microwave Week 2001. For symposium information, contact: Vijay Nair, technical program chair, Motorola Inc. (408) 413-5922, fax (408) 413-5934 or e-mail:vnair@ieee.org. For exhibition information, contact: Kristen Dednah, Horizon House Publications, 685 Canton St., Norwood, MA 02062 (781) 769-9750 or e-mail: kdednah@mwjournal.com.

2001 International Conference on GaAs Manufacturing Technology
May 21–24, 2001
Las Vegas, NV

Conference focus: to support all aspects of manufacturing from devices to final product delivery. Topics: manufacturing, processing, test and reliability, device technologies, optical devices, packaging, competing technologies and materials. "Nuts and bolts" technical sessions, an intensive four-topic workshop, papers and exhibitors will be featured at the conference. Additional information is available at www.gaasmantech.org or e-mail: info@GaAsMantech.org.

2001 Virginia Tech Symposium on Wireless Personal Communications
June 6–8, 2001
Blacksburg, VA

Sponsors: Virginia Tech's Mobile and Radio Research Group (MPRG) and The Division of Continuing Education. Topics: novel wireless products, applications of DSP techniques to wireless communications, propagation measurement and prediction, diversity and multiple access techniques, simulation and performance analysis of wireless systems, network issues, supporting technologies for wireless systems and business opportunities in wireless telecommunications. Contact: Jenny Frank, MPRG/Virginia Tech, 432 NED, Mail Code 0350, Blacksburg, VA 24061 (540) 231-2971 or e-mail: mprg@vt.edu.

2001 International Microwave and Optoelectronics Conference (IMOC)
August 6–10, 2001
Belem, Brazil

Sponsors: Brazilian Microwave and Optoelectronics Society (SBMO) and IEEE. **Call for papers.** Works addressing advancements and describing innovations in the fields of microwave and optoelectronics. All papers must be in English and submitted via e-mail. **Deadline: February 2, 2001.** Additional information and a topic list are available at www.imoc2001.com.br. Short course given by a group of specialists on a wide range of timely and interesting subjects, as well as special sessions on technological development and state-of-the-art advancements will also be held during IMOC 2001. Contact: Prof. Dr.-Ing. Joao Tavares Pinho, general chair, PO Box 8605-66.075-900, Belem, Para, Brazil 55-91-211-1299, fax 55-91-211-1977 or e-mail: info_imoc2001@amazon.com.br.

WORKSHOPS & COURSES

High Speed Interconnect Modeling Using TDR

■ **Topics:** Operation and accuracy issues for Agilent and Tektronix TDR instruments, interconnect probing and fixing, interconnect modeling and model validation. Fee: $395.
■ **Site:** Portland, OR
■ **Date:** January 15, 2001
■ **Contact:** TDA Systems Inc., 11140 SW Barbur Blvd., Suite 100, Portland, OR 97219 (503) 246-2272, fax (503) 246-2282.

Introductory RF & Microwaves

■ **Topics:** Introduction to the field of RF and microwaves, S-parameters, transmission lines, forward and reflected waves, RF and microwave test equipment and measurements, computer automated testing, calibration concepts, RF and microwave test techniques, and tips. Fee: $800.
■ **Site:** Orlando, FL
■ **Dates:** January 18–19, 2001
■ **Contact:** R.A. Wood Associates, 1001 Broad St., Suite 450, Utica, NY 13501 (315) 735-4217, fax (315) 735-4328 or e-mail: RAWood@rawood.com.

RF Power Amplifiers, Classes A through S

■ **Topics:** This course provides a detailed explanation of the various classes of RF power amplifiers and where each class is used in today's wireless designs. Fee: $800.
■ **Site:** Orlando, FL
■ **Dates:** January 25–26, 2001
■ **Contact:** R.A. Wood Associates, 1001 Broad St., Suite 450, Utica, NY 13501 (315) 735-4217, fax (315) 735-4328 or e-mail: RAWood@rawood.com.

Wireless Digital Communications Systems: Components, Specification, Test and Evaluation

■ **Topics:** Coherent review of the basic parameters, specifications and test criteria encountered in wireless digital communications.
■ **Site:** Research Triangle Park, NC
■ **Dates:** January 29–31, 2001
■ **Contact:** Anita Hellstrom, Organizational Effectiveness Institute (800) 683-7267, fax (301) 871-4942 or e-mail: Anita.Hellstrom@oei-edu.com.

CDMA IS-95 System Operation and Technology

■ **Topics:** An overview of the practical aspects of the IS-95 (cdmaOne) system.
■ **Site:** Princeton, NJ
■ **Dates:** February 14–16, 2001
■ **Contact:** Anita Hellstrom, Organizational Effectiveness Institute (800) 683-7267, fax (301) 871-4942 or e-mail: Anita.Hellstrom@oei-edu.com. Additional information is available at www.oei.edu.com.

RF Test Equipment Operation (Laboratory Course)

■ **Topics:** Latest RF test equipment, including spectrum analyzers and signal generators in a hands-on laboratory environment, and measurement of device RF characteristics, including return and insertion loss, S parameters and harmonics power. Fee: $595.
■ **Site:** Mountian View, CA
■ **Date:** February 20, 2001
■ **Contact:** Besser Associates, 201 San Antonio Circle, Bldg. E, Suite 280, Mountain View, CA 94040 (650) 949-3300, fax (650) 949-4400 or e-mail: info@bessercourse.com.

RF CMOS Design

■ **Topics:** Tradeoffs in CMOS receiver designs, strategies and techniques for developing CMOS receiver designs, with a heavy emphasis on process requirements, isolation and integration. A background in linear or nonlinear circuit design is desirable.
■ **Site:** Mountain View, CA
■ **Dates:** March 1–2, 2001
■ **Contact:** Besser Associates, 201 San Antonio Circle, Bldg. E, Suite 280, Mountain View, CA 94040 (650) 949-3300, fax (650) 949-4400 or e-mail: info@bessercourse.com.

Ceramic Technologies for Microwave

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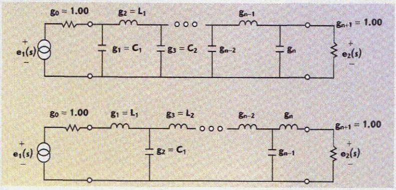
RIDE THE

A General Design Procedure for Bandpass Filters Derived from Low Pass Prototype Elements: Part I

Bandpass filters serve a variety of functions in communication, radar and instrumentation subsystems. Of the available techniques for the design of bandpass filters, those techniques based upon the low pass elements of a prototype filter have yielded successful results in a wide range of applications. The low pass prototype elements are the normalized values of the circuit components of a filter that have been synthesized for a unique passband response, and in some cases, a unique out-of-band response. The low pass prototype elements are available to the designer in a number of tabulated sources [1,2,3] and are generally given in a normalized format, that is, mathematically related to a parameter of the filter prototype.

This article presents a general design procedure for bandpass filters derived from low pass prototype filters, which have been synthesized for a unique filter parameter. A number of illustrated examples are offered to validate the design procedure.

Fig. 1 Circuit topologies of low pass prototype filters.



LOW PASS PROTOTYPE FILTERS

Low pass prototype filters are lumped element networks that have been synthesized to provide a desired filter transfer function. The element values have been normalized with respect to one or more filter design parameters (cutoff frequency, for example) to offer the greatest flexibility, ease of use and tabulation. The elements of the low pass prototype filter are the capacitors and inductors of the ladder networks of the synthesized filter networks as shown in ***Figure 1***. This diagram also depicts

Bandpass filters serve a variety of functions in communication, radar and instrumentation subsystems.

[Continued on page 24]

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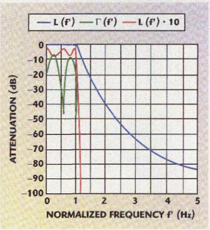

Fig. 2 Low pass Chebyshev filter prototype response.

the two possible implementations of the low pass prototype filter topologies. In both cases, the network transfer function is

$$T(s) = \frac{e_2(s)}{e_1(s)}$$

where

$s = \sigma + j\omega$, the Laplace complex frequency variable

Clearly, the transfer function, T(s), is a polynomial of order n, where n is the number of elements of the low pass filter prototype.

The illustrated circuit topologies represent a filter prototype containing an odd number of circuit elements. To represent an even number of elements of the prototype filter, simply remove the last capacitor or inductor of the ladder network.

For purposes of illustration, an example representing a Chebyshev filter is offered. The power transfer function of the Chebyshev filter may be represented by

$$T(f') = 10\log\{1 + \varepsilon\cos^2[n\cos^{-1}(f')]\}$$

$$\text{for } f' \le 1.0$$

$$T(f') = 10\log\{1 + \varepsilon\cosh^2[n\cosh^{-1}(f')]\}$$

$$\text{for } f' \ge 1.0$$

and

$$\varepsilon = \log^{-1}\left(\frac{r_{dB}}{10}\right) - 1$$

where

r_{dB} = inband ripple factor in decibels

These equations represent the power transfer function of the Chebyshev low pass prototype filter with normalized filter cutoff frequency f' of 1.0 Hz. A graphical representation of the power transfer function of the Chebyshev low pass prototype filter is shown in ***Figure 2***.

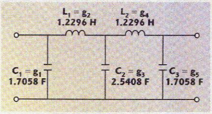

Fig. 3 Low pass prototype filter schematic.

The low pass prototype filter parameters for the low pass Chebyshev filter example are

$$n = 5$$

$$R'_0 = 1.0\ \Omega$$

and

$$r_{dB} = 0.5$$

A schematic representation of the prototype Chebyshev filter is shown in ***Figure 3***. The prototype elements are from Matthaei, Young and Jones[1] where the normalized cutoff frequency is given in the radian format $\omega'_1 = 1.0 = 2\pi f'_1$.

If this five-section prototype filter were constructed from available tables of elements and a circuit simulation performed, the transfer function would be exactly as represented in the schematic. To construct the filter at another frequency (1.0 GHz, for example) and circuit impedance level ($R_0 = 50\ \Omega$), the element values must be adjusted (de-normalized) in accordance with

$$C_1 = \frac{R'_0}{R_0}\frac{1}{2\pi 10^9}g_1$$

$$L_1 = \frac{R_0}{R'_0}\frac{1}{2\pi 10^9}g_2$$

$$C_2 = \frac{R'_0}{R_0}\frac{1}{2\pi 10^9}g_3$$

$$L_2 = \frac{R_0}{R'_0}\frac{1}{2\pi 10^9}g_4$$

$$C_3 = \frac{R'_0}{R_0}\frac{1}{2\pi 10^9}g_5$$

In addition to the tabulated data of low pass prototype filter elements, the values may be computed via exe-

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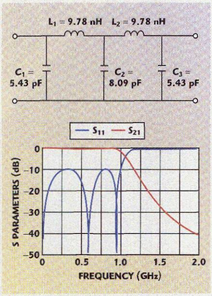
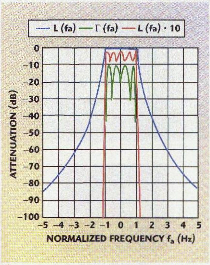


▲ *Fig. 4 Chebyshev low pass filter with a 1.0 GHz cutoff.*

cution of the equations found in Matthaei, et al.[1], and repeated in ***Appendix A*** for convenience.

The schematic of the filter, which was derived from Chebyshev, the low pass prototype elements and the associated frequency response are shown



▲ *Fig. 5 Chebyshev bandpass filter transfer function.*

in ***Figure 4***. Note that the 0.5 dB in-band ripple results in a return loss of −10 dB as expected.

A low pass filter may be converted to a bandpass filter by employing a suitable mapping function. A mapping function is simply a mathematical change of variables such that a transfer function may be shifted in frequency. The mapping function may be intuitively or mathematically derived. A known low pass to bandpass mapping function may be illustrated mathematically as

$$f' = \frac{f_0}{\Delta f}\left(\frac{f}{f_0} - \frac{f_0}{f}\right)$$

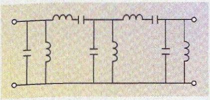
where

$$f_0 = \sqrt{f_1 f_2}$$
$$\Delta f = f_2 - f_1$$

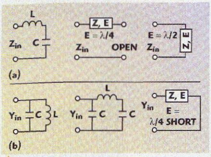
and f_0, f_1 and f_2 represent the center, lower cutoff and higher cutoff frequencies of the corresponding bandpass filter, respectively. If the substitution of variables is made within the Chebyshev power transfer function, the power transfer function of the corresponding bandpass filter may be determined as shown in ***Figure 5***.

The schematic diagram of the bandpass filter, which was derived from the low pass prototype filter via the introduction of complementary elements and producing shunt and se-

[Continued on page 28]



▲ *Fig. 6 Chebyshev bandpass filter schematic.*



▲ *Fig. 7 Typical resonant circuit; (a) series and (b) shunt resonators.*

TABLE I

RESONATOR SLOPE PARAMETERS

Resonator Type	Reactance Slope, α	Susceptance Slope, β
Series LC	$\omega_0 L$ or $\frac{1}{\omega_0 C}$	
Shunt LC		$\omega_0 C$ or $\frac{1}{\omega_0 L}$
Shunt π		$2\omega_0 C$
λ/2 line (short)	$\frac{\pi Z_0}{2}$	
λ/2 line (open)		$\frac{\pi Y_0}{2}$
λ/8 line (short+C)		$\frac{Y_0}{2}\left(\cot\theta_0+\theta_0\csc^2\theta_0\right)$
λ/4 line (short)		$\frac{\pi Y_0}{4}$
λ/2 WG line (short)	$\left(\frac{\pi Z_0}{2}\right)\left(\frac{\lambda_{g0}}{\lambda_0}\right)$	

ries resonators, is shown in ***Figure 6***. This is a basic low pass to bandpass transformation, and unfortunately sometimes leads to component values, which are not readily available or have excessive loss. As described later, the mapping function need not be considered as part of the bandpass filter design procedure. It is presented here as a supplement to the filter theory.

It bears repeating that the low pass prototype filter elements, that is, the g-values, are the result of network synthesis techniques to produce a desired characteristic of the prototype filter transfer function. These desired characteristics might include a flat amplitude response, maximum out-of-band rejection, linear phase response, Gaussian or other amplitude response, minimum time sidelobes and matched signal filters.

RF AND MICROWAVE RESONATORS

RF and microwave resonators are lumped element networks or distributed circuit structures that exhibit minimum or maximum real impedance at a single frequency or at multiple frequencies. The resonant frequency f_0 is the frequency at which the input impedance or admittance is real. The resonant frequency may be further defined in terms of a series or shunt mode of resonance; the series mode is associated with small values of input resistance at the resonant frequency, while the shunt mode is associated with large values of resistance at the resonant frequency. Some typical lumped and distributed resonators are shown in ***Figure 7***.

Resonators may be characterized by their unloaded quality factor Q_u, which is the ratio of the energy stored to the energy dissipated per cycle of the resonant frequency. Resonators are also characterized with respect to their reactance α or susceptance β slope parameters, which are defined, respectively, as

$$\alpha = \frac{\omega_0}{2}\frac{dX(\omega)}{d\omega}\bigg|_{\omega=\omega_0}$$

and

$$\beta = \frac{\omega_0}{2}\frac{dB(\omega)}{d\omega}\bigg|_{\omega=\omega_0}$$

These are important resonator parameters because they influence Q_u and the coupling factor between resonators in multiple resonator filters. ***Table 1*** provides the reactance and susceptance slope parameters of some common lumped element and distributed resonators.

Q_u may also be defined in terms of the reactance or susceptance slope parameter as

$$Q_u = \frac{\alpha}{R_{se}} = \beta R_{sh}$$

where

R_{se} = resonator series resistance
R_{sh} = resonator shunt resistance

Together these resistances represent the resonator loss. The bandpass filter design examples will illustrate the utility of the slope parameters.

In many bandpass filter applications, particularly those applications where the filter is deployed at the front end of a receiver, it is important to know the Q_u for the resonators in order to accurately estimate the insertion loss of the filter. The insertion loss of a single transmission resonator can be mathematically represented as

$$L(f) = -10\log\left[\frac{1+\left(2Q_l\frac{f-f_0}{f_0}\right)^2}{\left[1-\left(\frac{Q_l}{Q_u}\right)\right]^2}\right]$$

At $f = f_0$, this equation may further reduce to

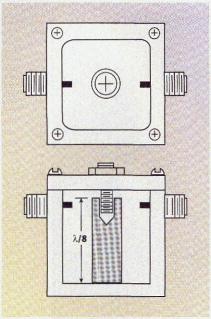
$$L(f) = -10\log\left[\frac{1}{\left[1-\left(\frac{Q_l}{Q_u}\right)\right]^2}\right]$$

Solving for Q_u, yields

$$Q_u\left[\frac{Q_l}{1-10^{\frac{L(f_0)}{20}}}\right]$$

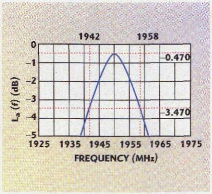
Therefore, a measurement of the single resonator insertion loss at the resonant frequency $L(f_0)$ and the –3 dB bandwidth Δf is sufficient to accurately determine Q_u of any resonant

[Continued on page 30]



▲ *Fig. 8 A single resonator at 1960 MHz.*

structure. The loaded quality factor Q_l may be determined from a measurement of the resonant frequency and the –3 dB bandwidth from the equation



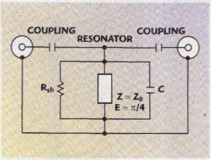
▲ *Fig. 9 The single resonator's measured performance.*

$$Q_l = \frac{f_0}{\Delta f}$$

where

Δf = –3 dB bandwidth

This measurement technique may also be employed to compare the quality factors (Q_u) of different types of resonant structures or as a method of comparing various plating or manufacturing techniques for the filter if insertion loss is a critical parameter.



▲ *Fig. 10 The single resonator's equivalent circuit.*

Consider an example. A PCS1900 transmit filter was required with minimum insertion loss and minimum size as critical design parameters. Rectangular, coaxial λ/8 resonators were determined to offer the minimum volume in an eight-resonator filter consistent with the maximum insertion loss requirement of less than 1.0 dB at the center frequency of 1960 MHz. A single resonator was constructed of the type anticipated to be used within the filter. The single resonator is shown in ***Figure 8***.

A single resonator structure was fabricated and plated with silver in order to obtain the maximum Q_u. The resonant structure was tuned to the desired center frequency and the insertion loss $L(f_0)$ and –3 dB bandwidth were measured. The measurement data is shown in ***Figure 9*** where

$$L(f_0 = 1.950 \text{ GHz}) = 0.533 \text{ dB}$$

$$\Delta f = 14.50 \text{ MHz}$$

$$Q_u \; 2250.$$

In executing the measurement, three notes of caution are required in the interest of accuracy: The coupling probes to the cavity should be equal and minimized to avoid load and source resistance across the resonator; the source and load SWRs should be kept low; and the input SWR at f_0 should be minimized to avoid mismatch loss.

The equivalent circuit of the single resonator is shown in ***Figure 10***. Note that the circuit element, which represents the resonator loss R_{sh}, has been included. The value of R_{sh} may be determined with the aid of the susceptance slope parameter β from

$$Q_u = \beta R_{sh}$$

[Continued on page 34]

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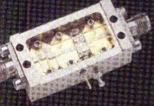
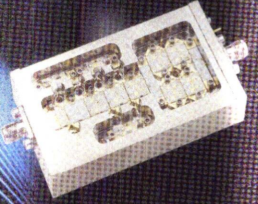


ULTRA BROAD BAND

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

MULTI OCTAVE AMPLIFIERS



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

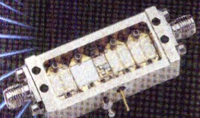
MEDIUM POWER AMPLIFIERS

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

LOW NOISE OCTAVE BAND LNA'S

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

NARROW BAND LNA'S



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

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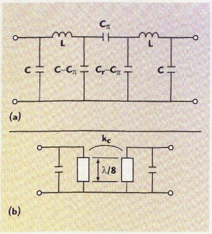


Fig. 11 Coupled (a) π-type LC resonators and (b) λ/8 distributed resonators.

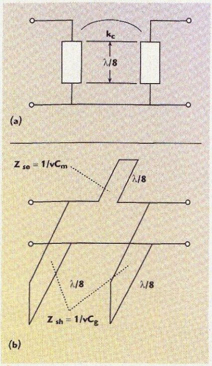


Fig. 12 The coupled λ/8 transmission line resonator's (a) proximity coupled line and (b) equivalent circuit.

where

$$\beta = \frac{Y_0}{2}\left[\cot(\theta_0) + \theta_0 \csc^2(\theta_0)\right] = 0.01836$$

$$\text{for } \theta_0 = \frac{\pi}{4} \text{ and } Y_0 = \frac{1}{70} \text{ Mhos}$$

or

$$R_{sh} = 122.5 \text{ k}\Omega$$

This measurement technique for estimating the value of Q_u is completely general and applies to lumped element and distributed resonators.

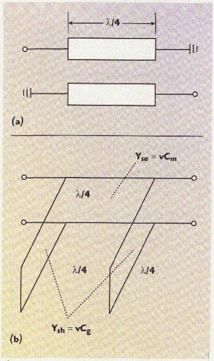


Fig. 13 The symmetrical λ/4 coupled resonator's (a) proximity coupled λ/4 line and (b) equivalent circuit.

RESONATOR COUPLING

Resonator coupling represents one of the most significant factors affecting filter performance. There are several methods to couple resonators. For ease of manufacturing and tuning, a common resonator type and coupling method is generally preferable. Matthaei[1] proposes what have been termed J (admittance) and K (impedance) inverters both to permit a common type of resonator and to serve as coupling elements for the resonators.

The J inverters may be represented as the admittance of the element or the value of the characteristic admittance of a quarter-wavelength line in the equivalent circuit that couples the resonators. Similarly, the K inverters may be represented as the impedance of the element or the value of the characteristic impedance of a quarter-wavelength line that couples the resonators. This permits the general expression of the coupling between resonators to be mathematically written as

$$k_{i,i+1} = \frac{J_{i,i+1}}{\beta}$$

and

$$k_{i,i+1} = \frac{K_{i,i+1}}{\alpha}$$

for shunt-type and series-type resonators, respectively, where the coupling between the i^{th} and the i^{th+1} resonators is represented by $k_{i,i+1}$.

A similar approach to the general design of bandpass filters employing common types of resonators proposes specific coupling elements in the case of lumped resonator bandpass filters or specific proximity methods of coupling in the case of distributed resonator bandpass filters. To illustrate, consider the coupled π-type of L-C resonators and the coupled λ/8 transmission line distributed resonators shown in **Figure 11**.

In the case of the coupled π-type L-C resonators, a series capacitor is inserted between the resonators to perform the coupling function, in which case the coupling coefficient is

$$k_\pi = \frac{\omega_0 C_\pi}{\beta} = \frac{\omega_0 C_\pi}{2\omega_0 C} = \frac{C_\pi}{2C}$$

In the case of the coupled λ/8 transmission line resonators, the equivalent circuit shown in **Figure 12** is useful in determining the coupling coefficient. The coupling coefficient may be determined from the capacitive matrix parameters associated with the coupled lines, that is, the capacitance per unit length to ground C_g and the mutual capacitance per unit length between the conductors C_m, where ν is the velocity in the dielectric medium. The coupling coefficient may be written as

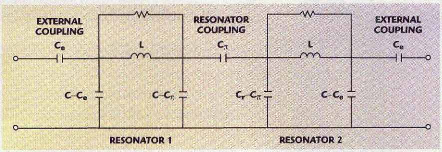
$$k_c = \frac{Y_{sh}\cot(\theta_0)}{\beta} = \frac{Y_{sh}\cot(\theta_0)}{\frac{Y_{se}}{2}\left[\cot(\theta_0) + \theta_0 \csc^2(\theta_0)\right]}$$

For the special case where $\theta_0 = \pi/4$, the coupling may be written as

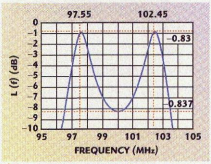
$$k_c = \frac{2Y_{sh}}{Y_{se}\left(1+\frac{\pi}{2}\right)} = \frac{2\upsilon C_m}{\upsilon C_g\left(1+\frac{\pi}{2}\right)} = \frac{2C_m}{C_g\left(1+\frac{\pi}{2}\right)}$$

Another very popular type of resonator, which is frequently used in microwave bandpass filters, is the quarter-wavelength resonator. **Figure 13** illustrates the coupling of sym-

[Continued on page 36]



▲ *Fig. 14 Lumped element symmetrical resonators.*



▲ *Fig. 15 Symmetrical resonator's response.*

metrical λ/4 resonators and the equivalent circuit. Note that λ/4 resonators must be grounded at opposite ends to prevent the null coupling condition caused by cancellation of the electric and magnetic field modes.

The coupling coefficient for this configuration may be written as

$$k_c = \frac{\upsilon C_m}{\beta} = \frac{\upsilon C_m}{\frac{Y_0 \pi}{4}} = \frac{4\upsilon C_m}{\pi \upsilon C_g} = \frac{4C_m}{\pi C_g}$$

For a given coupled line geometry, the λ/4 lines offer closer coupling than the comb-line configuration.

The input, output and adjacent resonator coupling in a multi-element bandpass filter are the parameters that determine the amplitude, phase and SWR over the passband of the filter. This statement understates the importance of resonator coupling to the bandpass filter parameters.

Recall that the elements of the low pass prototype filter, from which the bandpass filter is derived, determine completely the characteristics of the resulting filter. This fact will become evident when the coupling between resonators is disclosed to be a function only of the fractional bandwidth and the low pass filter prototype elements. Fortunately, a measurement technique is available to verify the coupling values of symmetrical resonators, and may also be utilized in multi-resonator filters. That measurement technique will now be explored.

The amplitude response of any pair of symmetrical resonators may be represented by[1]

$$L(f) = -10\log \left[\left[\frac{\left(1+\frac{Q_e}{Q_u}\right)^2}{2kQ_e} + k\frac{Q_e}{2}\right]^2 + 2\left[\frac{\left(1+\frac{Q_e}{Q_u}\right)^2}{k^2} - Q_e^2\right]\left(\frac{f-f_0}{f_0}\right)^2 + 4\left(\frac{Q_e}{k}\right)^2\left(\frac{f-f_0}{f_0}\right)^4 \right]$$

In the equation, k is the coupling coefficient between the symmetrical resonators, Q_u is the unloaded quality factor of each resonator and Q_e is the external quality factor. The external quality factor is defined to differentiate the source and load coupling and loss from the losses associated with the individual resonators (Q_u).

If the overcoupled condition is satisfied such that

$$k > \frac{1}{Q_e} + \frac{1}{Q_u}$$

it is possible to determine the resonator coupling coefficient from

$$k_c = \sqrt{\left(\frac{f_b - f_a}{f_0}\right)^2 + \left(\frac{1}{Q_e} + \frac{1}{Q_u}\right)^2}$$

where f_0, f_a and f_b are subsequently defined.

The utility of the equations will be demonstrated by two examples. Consider the symmetrical, lumped element resonators in the schematic shown in ***Figure 14*** where two, π-type, L-C resonators are coupled by the capacitor C_π, and the external source and load are coupled to the respective resonators by capacitor C_e. Note also the Q_u of each resonator is

$$Q_u = \frac{R}{\omega_0 L}$$

The following variables have been assigned

$$Q_u = \frac{R}{2\pi f_0 L} = 1000$$

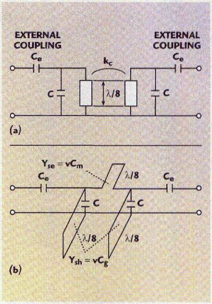
$$Q_e = \left[1 + \left(\frac{1}{2\pi f_0 C_e R_s}\right)^2\right]\frac{50}{2\pi f_0 L} = 100$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{2}{LC}} = 100\,\text{MHz}$$

$$k = \frac{C_\pi}{2C} = 0.050$$

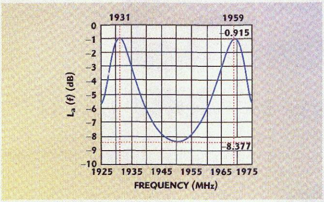
With the assigned variables, the amplitude response is shown in ***Figure 15***. The two peaks in the amplitude response correspond to the frequencies f_a and f_b. Using the assigned variables, the calculated coupling coefficient is $k_c = 0.05033$.

A second illustrative example using coupled λ/8 resonators is shown in ***Figure 16***. An equivalent circuit representation of the coupled lines,



▲ *Fig. 16 λ/8 symmetrical coupled resonator; (a) schematic and (b) equivalent circuit.*

[Continued on page 38]



▲ *Fig. 17 Symmetrical resonator's response.*

external coupling and resonator loss is required in order to quantify the coupling factor.

The variables have been assigned as

$$Q_u = \beta R = \frac{RY_0}{2\left(1+\frac{\pi}{2}\right)} = 2250$$

$$Q_e = \left[1+\left(\frac{1}{2\pi f_0 C_e R_s}\right)^2\right]\frac{50}{Z_0 \tan\theta_0} = 250$$

$$f_0 = \frac{1}{2\pi Z_0 \tan\theta_0 C} = 1950\,\text{MHz}$$

$$k = \frac{2C_m}{C_g\left(1+\frac{\pi}{2}\right)} = 0.020$$

With the assigned variables, the amplitude response is shown in ***Figure 17***. The two peaks in the amplitude response correspond to the frequencies f_a and f_b. Using the assigned variables, the calculated coupling coefficient is k_c = 0.01999. Part II explores how to use the preceding principles and data to design bandpass filters using a variety of lumped and distributed element resonators.

ACKNOWLEDGMENT

The principal reference for the content of this article is the work of Matthaei, Young and Jones.[1] Many of the concepts within this reference have been investigated and interpreted in order to provide a greater intuitive understanding of the bandpass filter design process. This text is strongly recommended for those having little familiarity with this work. ■

References

1. G.L. Matthaei, L. Young and E.M.T. Jones, *Microwave Filters, Impedance-matching Networks and Coupling Structures*, McGraw-Hill, New York, 1964.
2. E.G. Cristal, "Coupled Circular Cylindrical Rods Between Parallel Ground Planes," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-12, July 1964, pp. 428–439.
3. W.J. Getsinger, "Coupled Rectangular Bars Between Parallel Plates," *IRE Transactions on Microwave Theory and Techniques*, Vol. MTT-10, January 1962, pp. 65–72.
4. A. Zverev, *Handbook of Filter Synthesis*, John Wiley and Sons, New York, 1967.
5. G.L. Matthaei, "Interdigital Band Pass Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-10, No. 6, November 1962.
6. G.L. Matthaei, "Comb-line Bandpass Filters of Narrow or Moderate Bandwidth," *Microwave Journal*, Vol. 6, No. 8, August 1963.
7. S.B. Cohn, "Parallel-coupled Transmission-line Resonator Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-6, No. 2, April 1958.
8. R.M. Kurzrok, "Design of Comb-line Bandpass Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-14, July 1966, pp. 351–353.
9. M. Dishal, "A Simple Design Procedure for Small Percentage Round Rod Interdigital Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-13, September 1965, pp. 696–698.
10. S.B. Cohn, "Dissipation Loss in Multiple-coupled Resonator Filters," *Proceedings of the IRE*, Vol. 47, No. 8, August 1959, pp. 1342–1348.

Kenneth V. Puglia *holds the title of Distinguished Fellow of Technology at the M/A-COM division of Tyco Electronics. He received the degrees of BSEE (1965) and MSEE (1971) from the University of Massachusetts and Northeastern University, respectively. He has worked in the field of microwave and millimeter-wave technology for 35 years, and has authored or co-authored over 30 technical papers in the field of microwave and millimeter-wave subsystems. Since joining M/A-COM in 1971, he has designed several microwave components and subsystems for a variety of signal generation and processing applications in the field of radar and communications systems. As part of a European assignment, he developed a high resolution radar sensor for a number of industrial and commercial applications. This sensor features the ability to determine object range, bearing and normal velocity in a multi-object, multi-sensor environment using very low transmit power. Puglia has been a member of the IEEE, Professional Group on Microwave Theory and Techniques since 1965.*

APPENDIX A

CALCULATION OF THE CHEBYSHEV LOW PASS PROTOTYPE ELEMENTS

For Chebyshev filters with resistive terminations and pass band ripple, r_{dB}, g_o = 1.00, and ω'_1 = 1.0, the low pass prototype elements may be computed using the following procedure.

Define:

$$\beta = \ln\left[\coth\left(\frac{r_{dB}}{17.37}\right)\right]$$

$$\gamma = \sinh\left(\frac{\beta}{2n}\right)$$

$$a_k = \sin\left[\frac{(2k-1)\pi}{2n}\right],\ \text{for } k = 1,2,\ldots n$$

$$b_k = \gamma^2 + \sin^2\left[\frac{k\pi}{n}\right],\ \text{for } k = 1,2,\ldots n$$

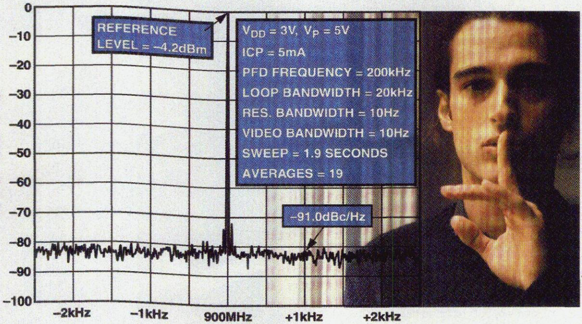
Then calculate:

$$g_1 = \frac{2a_1}{\gamma},\ g_k = \frac{4a_{k-1}a_k}{b_{k-1}g_{k-1}},\ \text{for } k = 2,3,\ldots n,$$

$$g_{n+1} = 1.00,\ \text{for n odd,}$$

$$g_{n+1} = \coth^2\left(\frac{\beta}{4}\right),\ \text{for n even.}$$

Shhh!



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Excalibur Development Continued

The US Army has awarded Raytheon a $100 M contract modification for the continued development of the Excalibur, XM982 precision-guided, extended-range artillery projectile program. The Excalibur family of guided missiles is designed to permit current and future Army and Marine Corps digitized howitzers to overcome the range disadvantage they now have against many threat artillery systems while gaining lethality improvements of three to six times against current projectiles.

The Global Positioning System/Inertial Measurement Unit-guided 155mm artillery projectile program was rebaselined and funded through a unique acquisition process known as "Alpha contracting," by which the Army and Raytheon jointly determined the major program parameters of technical risk, schedule and cost. Following full funding of the program for FY 2001, the Army reaffirmed its objective to develop and field this class of precision-guided projectiles to its interim, legacy and objective force artillery units.

The first gun launches of the Excalibur guidance electronics were conducted during September of this year. Two guidance packages were recovered using a Soft Recovery Vehicle projectile system in which gun launches at 15,000 gs are returned to earth by parachute for laboratory analysis of their functioning. Programmed maneuver flights are scheduled for next year.

Industry Team to Conduct Global Positioning System III Architecture Study

A team of four global information companies has been assembled by The Boeing Company to conduct a Global Positioning System (GPS) III study that will help define the path for the future of navigation and timing. Boeing will head a team composed of Hughes Space and Management & Data Systems (M&DS) and Raytheon Co.

The GPS III architecture study will assess mission needs and requirements of the existing satellite-based navigation system and will validate their achievability by developing innovative architecture recommendations. The program will evolve into the next-generation GPS satellite, ground control and user equipment segments. GPS III is expected to provide future users with unprecedented navigation and timing accuracy, system availability and enhanced user services, particularly for civil users. Work on the program, whose objective is to develop a flexible solution which will satisfy the needs of military and civilian users for the next 30 years, was scheduled to begin late this year.

Light Tactical Vehicle Intercom Contract Awarded

The US Army's Communications and Electronics Command (CECOM) has awarded a contract to outfit the service's light tactical vehicles with the Light Vehicle Variant (LV2) intercom system to a team composed of Northrop Grumman Corp. and BAE Systems. The award continues the two companies' long-standing relationship with CECOM during which time more than 10,000 vehicle intercom systems have been supplied for use on high mobility multipurpose wheeled vehicles (HMMWVs) and others.

Under the five-year, firm fixed-price, indefinite delivery/indefinite quantity contract, Northrop Grumman's Electronic Sensors and Systems Sector (ES3), based in Baltimore, and BAE System's Avionics Tactical Products Division in Blackburn, UK, will provide an initial quantity of 639 LV2 systems with deliveries scheduled for completion by June of next year.

The LV2 intercom system consists of two units, a dual full function crew station and a master control station. The system is compatible with all current Army headsets including the improved combat vehicle crewman active noise reduction headset. The LV2 provides full duplex intercom communication and access to on-board radios. The system can operate in hands-free or voice activated modes. Its basic configuration serves two-crew, two-radio installations, but up to six radios may be connected to a system and a maximum of eight crew members can be served.

Air Force Awards Command and Control Modernization Program Contract

The US Air Force has selected a Lockheed Martin-led team to modernize its air, missile and space command and control (C2) systems in a 15-year program valued at approximately $1.5 B.

Under the Integrated Space Command and Control (ISC2) program, the team will integrate approximately 40 systems into a common, ineroperable C2 information technology infrastructure, giving commanders at the North American Aerospace Defense Command (NORAD) and US Space Command (USSPACECOM) a new flexibility to handle mission responsibilities. ISC2 is to be a "virtual command center" providing warfighters a common operational picture of the global battlefield derived from shared real-time data available anytime and anywhere in the world for specified users.

The ISC2 modernization will replace the Air Force's collection of older, stand-alone systems which function well individually but are not seamlessly coordinated to give users comprehensive C2 capabilities and access to information. The new system will enhance commanders' capabilities to synchronize their C2 operations and improve strategic and tactical coordination among forces. A major program challenge involves the migration of existing systems to the new ISC2 architecture without disrupting the Air Force operations at Cheyenne Mountain, the location of most of the NORAD and OSSPACECOM operations.

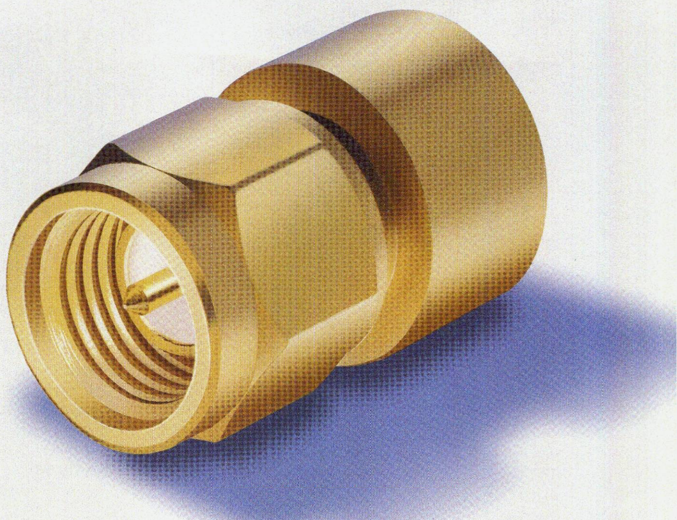
Lockheed Martin team members include The Boeing Co., Aerojet, General Dynamics, DynCorp and Wang Government Services for system integration and technology partners, Computer Sciences Corp., Logicon/INRI, Autometric Inc., Microsoft Corp., Cisco Systems, Oracle Corp., AT&T, Neon and BEA Systems.

UCAV System Previewed

Under a $131 M contract shared by the Defense Advanced Projects Research Agency (DARPA) and the US Air Force, the Boeing Phantom Works R&D division is developing an Unmanned Combat Aerial Vehicle (UCAV) advanced technology demonstration system. Following completion of the manufacture and assembly of the major system elements, including the first of two unmanned air vehicles, a mission control center and storage container, the system was recently previewed in a display in St. Louis, MO.

Awarded to Boeing in March of last year, the program is designed to prove the technical feasibility of multiple UCAVs autonomously performing very dangerous and high priority combat missions to augment the manned fighter strike force. The first such mission is the suppression of enemy air defenses. Considering their small size, lack of pilot interfaces and training requirements, reusability and long-term storage capability, UCAVs are projected to cost up to 65 percent less to produce than future manned fighter aircraft and up to 75 percent less to operate and maintain than current systems.

The UCAV air vehicle has a stealthy, tailless, 27-foot-long airframe with a 34-foot wingspan. It weighs 8000 pounds empty and can carry a 3000 pound payload. The reconfigurable mission control station has satellite-relay and line-of-sight communications links for distributed control. Flight testing of the first vehicle is scheduled to begin in the spring of next year. Testing of both air vehicles in simulated suppression of enemy air defense missiles is scheduled to begin in mid-2002. If the advanced technology demonstration program is successful, the Air Force could employ UCAV weapon systems some time after 2010. ■



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DC to 6	28

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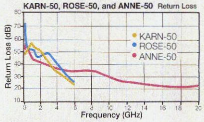
Note: Power ratings at 70°C: ANNE-50 and ROSE-50 is 0.50W, derate linearly at 0.005W/°C from 70°C to .35W at 100°C. KARN-50 is 2W, derate linearly at 0.025W/°C to 1.25W at 100°C.



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Martin Streetly, International Correspondent

UK Mobiles to Carry Radiation Warnings

Following a year-long, government sponsored enquiry, the UK has decided to include a radiation level warning on all new mobile telephones from 2001 onwards and to leaflet users on the wisdom of children under 16 using such devices for essential communications only. The concern over youth use of mobile telephones relates to the high usage rate amongst British children and speculation that the radiation emitted by mobiles could be harmful to the young because of their thinner skulls (when compared with adults), higher tissue conductivity (again, when compared with adults) and developing nervous systems. In this context, it should be stressed that to date, no conclusive evidence has been found to suggest that mobile telephones are injurious to health. The UK's Electronics Industry Federation supports the move (on the grounds that it supports the general concept of providing consumers with as much product information as possible) and that Cenelec (the body responsible for mobile telephone technical standards within Europe) intends to publish a standardised methodology for calculating specific absorption ratings for mobile telephone handsets.

Europe Features Strongly in FY 01 FCT Programme

The European electronics feature strongly in the US Department of Defense's Fiscal Year (FY) 2001 Foreign Comparative Testing (FCT) programme. Looking at some of the FY 01 FCT new starts and continuations by service, the US Army is to carry out an FCT evaluation of non-developmental communications antenna masts from manufacturers in Finland (Mast Systems), France (LERC), Germany (the European Aeronautic, Defence and Space (EADS) Company), Sweden (WIDE) and the UK (ARA and Clark Mast Systems) in connection with its ongoing digitisation programme. Elsewhere, the service will test Thomson Racal Defence (UK) and Tadiran (Israel) signals intelligence systems that are capable of detecting and locating conventional and low probability-of-intercept signals. Here, the programme is in connection with the Prophet Ground effort and a major area of interest is the two equipments' ability to detect and locate frequency-hopping radios.

For its part, the US Navy is continuing its evaluation of a Raytheon Systems Ltd. (UK) anti-jam Global Positioning System (GPS) antenna (for use in day one strike warfare applications) and a stealth screening material developed by French contractor Societe Nouvelle des Ateliers et Chantiers de Havre. Here, the material takes the form of a wire mesh and is being tested as a method of matching the radar cross section signature of the Remote Mine Hunting Systems (RMHS) installed aboard the service's Arleigh Burke class destroyers to that of the ship's structure around it.

US Air Force new starts include evaluation of an infra-red/ultra-violet threat simulator produced by UK contractor Elettronica Systems Ltd. and an unattended ground imager (for base security applications) developed by Israeli contractor Seraphim Optronics. Programmes carried over from FY 1999 include continuing trials of a large aircraft infra-red decoy flare produced by German contractor BUCH Neue Technologie and a wideband klystron power amplifier developed by UK contractor TMD Ltd. In the first instance, the decoy flare trials are in connection with the provision of an improved defensive aids capability for the C-17 strategic transport aircraft while the power amplifier is being tested as a possible means of improving power amplifier reliability in the AN/APY-1/2 search radar fitted aboard the Boeing E-3 Sentry Airborne Warning And Control System (AWACS) platform.

Lastly, the US Special Operations Command is to evaluate a series of lightweight, portable and/or hand-held electronic warfare components that have been developed by France's Metravib, Sweden's FLIR Systems and an as yet unidentified Russian research institute. The effort is in connection with the Command's Joint Threat Warning System that is intended to provide an all-weather detection capability against ground, air and, in particular, maritime and riverine traffic.

Philips Teams with WIDCOMM Inc. to Develop Bluetooth Products

Netherlands contractor Philips Semiconductors has formed a strategic alliance with US contractor WIDCOMM Inc. to speed up the development of Bluetooth technology and provide customers with a complete range of Bluetooth solutions, supported by a reliable support infrastructure. Bluetooth has been developed to provide a low cost, radio-based, open standard technology for short-range, cableless data transmission in applications such as server to visual display units within an office environment. As of this writing, the technology is noted as having demonstrated its compatibility with a range of devices that includes mobile telephones and laptop computers, and as being capable of revolutionising connectivity in 'many' other electronic applications.

Current Philips Bluetooth (a trademark of Telefonaktiebolager L M Ericsson) products include the VWS26002 Bluetooth baseband processor, the Bluetooth developer's kit V 2.0 platform, the single chip UAA3558 transceiver and the BGA2450 power amplifier. For its part, WIDCOMM is described as a software and product design house that focuses on Bluetooth networking solutions and has a product portfolio that includes Bluetooth full protocol stack software, the BlueConnect expansion module, the BlueCard laptop card and the BlueShare personal computer wireless adapter. Overall, the new alliance is intended to provide customers with a one-stop resource that can supply them with complete, optimised Bluetooth solutions involving integrated circuits, software, system design and support at all stages of development.

German-Chinese Team Promotes TD-SCDMA

German contractor Siemens Information and Communication Mobile has teamed with China's Academy of Telecommunications Technology (CATT) and the Huawei Technologies Company to promote the use of Time Division Synchronous Code Division Multiple Access (TD-SCDMA) technology in third generation mobile communications networks originating in the People's Republic. The teaming agreement takes the form of a Memorandum of Understanding (MoU) and builds on work undertaken jointly by CATT and Siemens to develop TD-SCDMA technology as a means of capitalising on a potential Chinese telecommunications market of over 60 million Global System for Mobile communications (GSM) subscribers. The main challenge being addressed is the need to integrate symmetric circuit switched services (speech and video) with asymmetric packet switched requirements such as mobile Internet access. Here, the TD-SCDMA approach is claimed to be able to meet the requirement through the use of a Time Division Multiple Access (TMDA) subsystem and an adaptive Code Division Multiple Access (CDMA) component operating in synchronous mode. Within this arrangement, the TMDA segment handles transmission of different data in serial (needed for packet-switched mobile Internet applications), while the CDMA element is used for the transmission of large numbers of signals in parallel (typically, voice). Again, TD-SCDMA is billed as facilitating optimum utilisation of allocated radio spectra by virtue of its ability to operate in unpaired spectra.

In terms of the specific TD-SCDMA MoU referred to above, the agreement foresees close cooperation in the international promotion and standardisation of TD-SCDMA technology, the joint development of products and the launch of pilot TD-SCDMA projects in China starting in the early part of next year. Elsewhere, the three partners (together with Motorola, Nortel and mobile providers China Mobile and China Unicom) have founded an international TD-SCDMA forum to foster adaption of the technology by vendors, operators and national regulators. ■

Lucent Technologies and Verizon Wireless Sign $1.5 B Letter of Intent

Verizon Wireless and Lucent Technologies have signed a letter of intent potentially worth up to $1.5 B which names Lucent as a primary supplier of network infrastructure to the newly-formed wireless venture. The agreement will allow the largest US wireless carrier to increase its coverage and capacity in key markets and to offer third generation (3G) high speed mobile Internet and other enhanced data and voice services to business and residential customers.

The parties expect to enter into a purchase agreement that would set the stage for continued close collaboration begun with Bell Atlantic Mobile on commercializing next-generation CDMA digital wireless technology for introduction into the national Verizon Wireless network. Earlier this year, Lucent and QUALCOMM Inc. reported the first live laboratory demonstration of the 3G data transmission technology which was planned for initial deployment in Verizon Wireless' Philadelphia area network earlier this year. The technology supports peak data transmission rates of 153 kbs. When deployed, the technology will have the additional benefit of doubling network voice capacity without the need for new basestations.

The letter of intent covers a broad range of Lucent products including those supporting high speed data and mobile Internet applications. Verizon Wireless is expecting to deploy a variety of mobile Internet services including intelligent network and unified messaging and two-way Short Message Service Center (SMSC) service developed jointly with Telecommunications Systems of Annapolis, MD.

Agreement to Establish Personalized Delivery of Interactive Broadband Services

EchoStar Communications Corp. and Geocast Network Systems Inc. have signed an agreement under which Geocast will deliver its personalized broadband services to PC users via dedicated bandwidth on one of EchoStar's primary direct broadcast satellites. The agreement will permit Geocast to reach a nationwide audience and allow DISH Network to deliver new PC services to its subscribers.

Geocast will deliver content from EchoStar's satellite to DISH Network customers who have a DISH Network satellite TV system with a GeoBox, a personal broadband server, connected to their PC. The GeoBox contains a 40 gigabyte hard drive and will store the personalized content delivered via DISH network at speeds up to 12 Mbs. The GeoBox will permit PC users to receive and store high quality audio, TV-like video images and software downloads at very high speeds. The Geocast service is expected to be available to DISH Network customers in the third quarter of next year when it will begin to provide instant access to personalized selections of information from local and national sources, entertainment and e-commerce offerings.

Quad-band Antenna Can be Embedded in Notebook Computer Hinge

RangeStar Wireless has announced a quad-band antenna for notebook computer applications which can be embedded in the notebook's hinge. The antenna supports three types of wireless service, general packet radio services (GPRS), Bluetooth applications and 802.11A unlicensed applications. The antenna supports both vertical and horizontal polarization and provides hemispherical coverage permitting the antenna to operate when the notebook is open or closed and when it is in a docking station or briefcase.

The antenna offers a peak gain of +1 dbi in the 900 MHz band, 0 dbi in the 1800 MHz band, +3 dbi in the 2.4 and 5.2 GHz bands. The unit weighs one gram and measures 131 × 7.8 × 1.5 mm.

European Cell Phone Users to Abandon Fixed Telephone Service

A recent report from Strategy Analytics based on detailed interviews with cellular users in six European markets, Wireless 2000: European End-user Market Dynamics, forecasts that 40 percent of cellular users in Western Europe expect to use their cellular phones for all voice traffic in the future. Only one third of those interviewed remained convinced that they will still use fixed telephones. The report also notes that cellular service pricing can contribute significantly to this move. Pricing remains the most common complaint of cellular users in the region and is responsible for 50 percent of subscriber churn.

The youth portion of the market is taking the lead in depending solely on cellular phones. Almost 50 percent of those in the 16–24 year age bracket are planning to abandon their fixed phone service while only one-third of users over 45 have the same plans. The younger age group uses short messaging services (SMS) and e-mail much more heavily than the older segment, and are more comfortable with the mobile phone for all forms of communications. Pricing will ultimately determine how deeply the cellular operators are able to convert users to cellular-only habits. European cellular users are very willing to change services in response to cost advantages. For additional information, contact: Phil Kendall, Strategy Analytics, +44 0 1582 589813, fax: +44 0 1582 454828.

THE COMMERCIAL MARKET

DBS to Reach 25 Million Subscribers by 2005

A new report from the Yankee Group, Direct Broadcast Satellite: Growth in New Directions, forecasts that, driven by the addition of local channels and new services like Internet access and interactive TV, the Direct Broadcast Satellite (DBS) subscriber count in the US will grow to 25 million over the next five years.

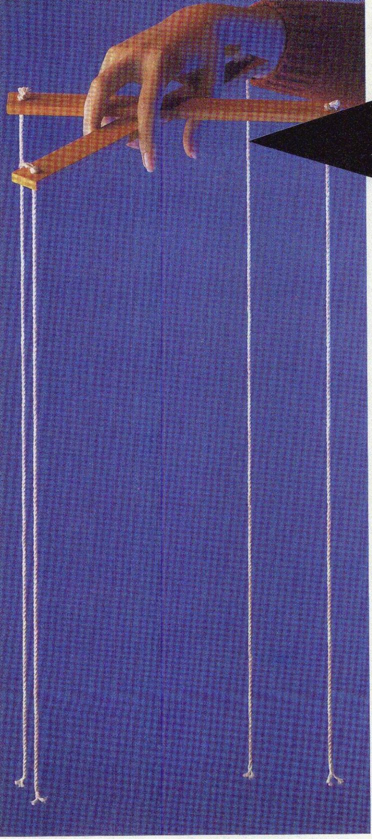
The report notes that, historically, DBS has been strongest in rural areas without access to cable television and among those seeking more movies, sports and improved picture and sound quality. Recent legislation permitting satellite delivery of local stations has strengthened its ability to compete with cable in urban and suburban markets. In addition, new service offerings like high speed Internet access, satellite receivers equipped with digital video recorders and Interactive TV will significantly contribute to its growth.

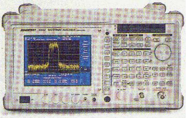
Among the report's findings, within households acquiring DBS service during the first three months of this year, 70 percent have access to cable but only 17 percent subscribe to cable. In that same group, only eight percent with local station coverage by their satellite package also subscribe to cable. While satellite TV hardware prices have fallen from $300 to $150 this year, subscription prices have remained at $40 per month. Customer satisfaction remains high with 79 percent of DBS subscribers recommending the service to others. For additional information, contact: Kim Vranas, The Yankee Group (617) 880-0214.

$525 M Greater China Wireless Contracts Awarded

Nortel Networks has received contracts worth an estimated $525 M for new wireless network build-out which is expected to serve up to 17 million subscribers in Greater China, and will provide next generation Wireless Internet and data services.

The awards include $250 M for expansion of Chunghwa Telecom Taiwan-wide GSM 900/1800 MHz dual-band digital cellular network and $275 M in new networks and expansions by China Unicom in the People's Republic of China (PRC). More than 1900 new GSM 900/1800 MHz basestations will be installed in Taiwan to support dual-band roaming and a General Packet Radio Service (GPRS) software upgrade will support high speed Wireless Internet services. The PRC work is concerned with the implementation of GPRS infrastructure and software. ■





R3267 Spectrum Analyzer

AROUND THE CIRCUIT

INDUSTRY NEWS

Frank Floyd Jr. died on October 16 after a long battle with ALS. He was 62. He was the founder and manager of the Massachusetts division of Standford Telecom after spending 25 years working at MIT-Lincoln Laboratories on the design and construction of communications satellites.

■ **3M** has entered into a definitive merger agreement to acquire **Robinson Nugent Inc.**, New Albany, IN, for approximately $115 M, including the assumption of debt. The merger is structured as a tax-free, stock-for-stock transaction, in which each outstanding Robinson Nugent common share will be exchanged for $19 of 3M common stock, subject to certain caller provisions.

■ **New Focus Inc.**, a supplier of fiber-optic products for next-generation optical networks under the Smart Optics for Networks™ brand, has signed a definitive agreement with **JCA Technology Inc.** under which New Focus will acquire JCA in a transaction valued at $600 M. The merger consideration is composed of $575 M of New Focus common stock and $25 M in cash. The merger will be accounted for as a purchase transaction and will result in significant goodwill based on the underlying book value of JCA's assets.

■ **Illinois Superconductor Corp. (ISCO)** has entered into an agreement to acquire **Lockheed Martin Canada**'s Adaptive Notch Filtering (ANF) business unit. The purchase of the ANF business involves the acquisition by Lockheed Martin Canada of 2.5 million shares of ISCO common stock, and is subject to certain closing conditions.

■ **Heraeus Inc.** is incorporating the former precious metals powders business activities of **PGP Industries** into the existing product line offered by its Circuit Materials Division. The action follows upon the recent acquisition of selected PGP assets by **W.C. Heraeus GmbH & Co. KG**. In related news, the US-based Heraeus Inc., Circuit Materials Division and the company's PDF Group, Hanau, Germany, have been awarded QS 9000 certification.

■ **TRAK Communications**, a Tech-Sym company announced the acquisition of **Tech-Sym Corp.** by **The Veritas Capital Fund LP**, a New York-based investment firm. Sold at $30 per share, TRAK Communications is now a privately held company, but remains the parent management company to its four subsidiaries: TRAK Microwave Corp., TRAK Microwave Ltd. (TRAK Europe), Tecom Industries Inc. and TRAK Ceramics Inc. (TCI).

■ **Centurion Wireless Technologies Inc.**, Lincoln, NE, (formerly Centurion International Inc.) has acquired **Xertex Technologies Inc.**, Broomfield, CO, in a merger transaction. Xertex will operate as a division of Centurion Wireless Technologies.

■ **Everett Charles Technologies (ECT)**, Pomona, CA, has acquired **Vitech Services B.V.**, Geleen, the Netherlands. The acquisition of Vitech will further augment ECT's role as a global provider of PCB test services and supply additional support to its worldwide customer base.

■ **REMEC Inc.** has combined its Toronto-based Nanowave operation with **Ascentia**, Dallas, TX, to form a new advanced technology company that will design and produce custom MMICs, critical modules and integrated subassemblies for fiber-optic and broadband wireless communications systems. REMEC owns a 75 percent ownership in the new company.

■ **EMS Wireless**, a division of **EMS Technologies Inc.**, is establishing operations in Brazil, to offer a complete range of PCS/cellular basestation antenna products to the fast-growing South American market. A wholly owned subsidiary, **EMS Wireless do Brasil**, has been organized, and is expected to begin manufacturing operations in Curitiba, Parana, Brazil in January of next year.

■ **Huber + Suhner Inc.**, Essex, VT, is investing $5 M in construction and new equipment to expand its manufacturing facility by 43,000 square feet. The company has experienced tremendous growth in the past several years necessitating the expansion.

■ **SEMX Corp.'s Materials Group** has completed a facility expansion for its ceramic packaging operation, which was acquired in April of this year by **Polese Co.**, San Diego, CA. The new Materials Group headquarters is home to the ceramics division, which includes a modern clean room and support facilities.

■ **Corning Frequency Control Inc.**, a division of **Corning Inc.**, has begun construction on a 40,000 square foot expansion of its operations facility in Mount Holly Springs, PA. The expansion is scheduled for completion early next year.

■ **Ansoft Corp.** has opened two Advanced Training Centers and a new support office in Shanghai, China. These new offices will allow the company to increase the number of highly trained engineers to develop next-generation RF, wireless and telecommunications products.

■ **Microwave Communications Corp. (MCC)**, Valencia, CA, has completed recapitalization and alignment with **Springboard Capital LLC**, Los Angeles, CA, and London, UK. Part of this new partnership includes incorporating the new company and changing its name to **Microwave Communications Co. Inc.** It will continue to operate from its headquarters in Valencia.

■ **Tanner Research Inc.** and **MOSIS** have formed a strategic alliance that allows Tanner to offer quick-turn and low cost IC design and fabrication services. Under the partnership, Tanner has committed to provide design tools, services and IP products to customers, while MOSIS will provide prototyping and small volume production services.

[Continued on page 54]

■ **Micronetics Wireless Inc.** has entered into a strategic joint venture with **Hollis Electronics Co.** to co-develop its next generation Wave3G Communications Testing Platform.

■ **Analog Devices Inc.** has signed an agreement with **Nortel Networks** to mutually develop integrated optical MEMS switching elements for Nortel's high port-count photonic cross connect switches.

■ **NurLogic Design Inc.** has signed an agreement with **IBM** to offer high performance standard cell and I/O components to customers of IBM's SiGe, 0.25-micron process technology. This technology is an ideal solution for building many of the essential chips used in wired and wireless communications products.

■ **Racal Instruments Inc.**, Irvine, CA, has formed a strategic alliance with **PX Instrument Technology Ltd.**, Bray, Ireland, for worldwide turnkey system integration of PX Instrument Technology's PXI bus-based products. This agreement partners two members of the PXI Systems Alliance.

■ **Windward Technologies Inc.**, **Tellumat Ltd.** and **Plessey** have expanded their distribution agreement to have Windward distribute the Tellumat HighReach™ Narrow Band Microwave products and Plessey Spread Spectrum products in the US.

■ **Motorola SPS** and **Atmel** have signed a licensing agreement that will enable the companies to provide a reliable supply of RF BiCMOS technology.

■ **TRW**'s new production line for indium phosphide (IP) integrated circuits will include one of **Temescal**'s latest innovations in electron beam evaporation systems, the model FCE-2700A. TRW's new facility is the world's first high volume InP production line.

■ **NEC Electronics Inc.** and **Luxxon Corp.** have signed a strategic alliance agreement to develop streaming multimedia solutions for wireless Internet devices. The solutions will accelerate the development and adoption of wireless devices and enable universal multimedia communication.

■ **Agilent Technologies Inc.** and **SynTest Technologies Inc.** have signed a memorandum of understanding (MOU) to provide chip design consulting services. SynTest will initially work with Agilent customers as they design chips with multiple function blocks, which are capable of being tested concurrently instead of sequentially, resulting in a significant cost-of-test reduction.

■ **Alpha Industries** is expanding its distribution relationship with **Insight Electronics** to include Europe and Asia. The partnership will allow Alpha to reach a greater number of customers with enhanced efficiency and responsiveness. In related news, Alpha has been named to *Forbes* magazine's annual list of the 200 Best Small Companies in America. Alpha ranked 138th overall on the list, which requires companies to exceed specific financial requirements based on value and growth.

[Continued on page 58]

ANNOUNCING A NEW PRODUCT LINE!

HBT AMPLIFIERS WITH InGaP GaAs Technology

- DC TO 7 GHz PERFORMANCE
- 10 dB to 20 dB GAIN
- +12 dBm to 24 dBm OUTPUT 1dBcp
- LOW COST, HIGH RELIABILITY InGaP GaAs HBT PROCESS

Performance Table

Part Number	Freq. Range (GHz)	Vcc (V)	Icc (mA)	Output P1dB (dBm)	Output IP3 (dBm)
HMC313	DC - 6.0 DC - 6.0	5.0 7.0	47 82	13.6 19.3	28.9 33.0
HMC314	0.7 - 4.0	5.0	185	18.0	29.5
HMC315	DC - 7.0 DC - 7.0	5.0 7.0	31 50	12.0 16.5	26.8 31.0
HMC323 & HMC324	DC - 3.0	7.5	57	16.8	30.0
HMC326MS8G	3.4 - 3.6	5	125	24	36.0

HBT DARLINGTON AMPLIFIER

16 dB GAIN

HMC313

HBT AMPLIFIER w/ POWER DOWN

10 dB GAIN

HMC314

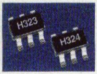
HBT DARLINGTON AMPLIFIER

12 dB GAIN

HMC315

HBT DRIVER & DUAL DRIVER AMPLIFIER

11 - 12 dB GAIN



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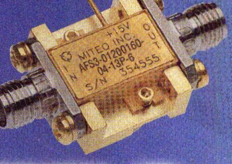

AMPLIFIERS

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
TEMPERATURE COMPENSATED AMPLIFIERS								
AFS3-01000200-15-TC-6	1–2	36-40	1.00	1.5	2.0:1	2.0:1	+5	125
AFS2-02000400-15-TC-6	2–4	22-26	1.00	1.5	2.0:1	2.0:1	+5	125
AFS3-02000400-15-TC-6	2–4	22-26	1.00	1.5	2.0:1	2.0:1	+5	125
AFS2-04000800-20-TC-2	4–8	18-22	1.00	2.0	2.0:1	2.0:1	+5	100
AFS3-04000800-18-TC-4	4–8	26-30	1.00	1.8	2.0:1	2.0:1	+8	150
AFS2-02000800-40-TC-2	2–8	14-19	1.50	4.0	2.0:1	2.0:1	+5	100
AFS3-02000800-30-TC-4	2–8	22-27	1.50	3.0	2.0:1	2.2:1	+8	150
AFS2-08001200-30-TC-2	8–12	12-16	1.00	3.0	2.0:1	2.0:1	+5	100
AFS3-08001200-22-TC-4	8–12	24-28	1.00	2.2	2.0:1	2.0:1	+8	150
AFS4-12001800-30-TC-8	12–18	22-26	1.00	3.0	2.0:1	2.0:1	+8	250
AFS4-06001800-35-TC-6	6–18	22-26	1.00	3.5	2.0:1	2.0:1	+8	250
AFS6-06001800-35-TC-8	6–18	30-34	1.00	3.5	2.0:1	2.0:1	+8	400
AFS4-02001800-45-TC-5	2–18	18-24	1.50	4.5	2.2:1	2.2:1	+8	175

Note: All specifications guaranteed -54 to +85°C.
Many other frequencies, noise figures and gain windows are available.

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
HIGHER POWER AMPLIFIERS								
AFS4-00050100-25-25P-6	0.5–2	36	1.50	2.5*	2.0:1	2.5:1	+25	325
AFS3-00100100-23-25P-6	.1–1	38	2.00	2.3	2.5:1	2.5:1	+25	280
AFS3-00100200-25-27P-6	.1–2	33	1.50	2.5	2.0:1	2.5:1	+27	300
AFS3-00100300-25-23P-6	.1–3	25	1.50	2.5	2.0:1	2.5:1	+23	300
AFS3-00100400-26-20P-4	.1–4	26	1.50	2.6	2.0:1	2.0:1	+20	250
AFS4-00100600-25-20P-4	.1–6	32	1.50	2.5	2.0:1	2.0:1	+20	300
AFS4-00100800-28-20P-4	.1–8	30	1.50	2.8	2.0:1	2.0:1	+20	300
AFS4-00101200-40-20P-4	.1–12	20	1.50	4.0	2.0:1	2.0:1	+20	300
AFS4-00501800-60-20P-6	.5–18	25	2.75	6.0	2.5:1	2.5:1	+20	350
AFS5-00102000-60-18P-6	.1–20	25	3.00	6.0	2.5:1	2.5:1	+18	360
AFS3-01000200-20-27P-6	1–2	33	1.50	2.0	2.0:1	2.0:1	+27	350
AFS3-02000400-30-25P-6	2–4	28	1.50	3.0	2.0:1	2.0:1	+25	250
AFS3-04000800-40-20P-4	4–8	20	1.00	4.0	2.0:1	2.0:1	+20	200
AFS4-08001200-50-20P-4	8–12	22	1.25	5.0	2.0:1	2.0:1	+20	200
AFS6-12001800-40-20P-6	12–18	28	2.00	4.0	2.0:1	2.0:1	+20	375
AFS6-06001800-50-20P-6	6–18	23	2.00	5.0	2.0:1	2.0:1	+20	365
AFS4-02001800-60-20P-6	2–18	23	2.50	6.0	2.5:1	2.0:1	+20	350

*Noise figure degrades below 100 MHz. Please consult factory for details.
Note: Noise figures increase below 500 MHz in bands wider than .1-10 GHz.

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Model Number	Frequency Range (GHz)	Gain (Min.) (dB)	Gain Flatness (±dB)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
MODERATE BAND AMPLIFIERS								
AFS2-00700080-05-10P-4	.7–.8	30	0.50	0.45	1.5:1	1.5:1	+10	90
AFS2-00800100-05-10P-4	.8–1	30	0.50	0.45	1.5:1	1.5:1	+10	90
AFS3-01200160-05-13P-6	1.2–1.6	40	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-01400170-05-13P-6	1.4–1.7	40	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-01500180-04-13P-6	1.5–1.8	40	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-01500250-06-13P-6	1.5–2.5	36	0.50	0.60	2.0:1	2.0:1	+13	150
AFS3-01700190-04-13P-6	1.7–1.9	36	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-01800220-05-13P-6	1.8–2.2	36	0.50	0.50	1.5:1	1.5:1	+13	150
AFS3-02200230-04-13P-6	2.2–2.3	36	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-02300270-05-13P-6	2.3–2.7	34	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-02700290-05-13P-6	2.7–2.9	32	0.50	0.50	1.5:1	1.5:1	+13	150
AFS3-02900310-05-13P-6	2.9–3.1	32	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-03100350-06-10P-4	3.1–3.5	29	0.50	0.6	1.5:1	1.5:1	+10	150
AFS4-03400420-06-13P-6	3.4–4.2	40	0.50	0.60	1.5:1	1.5:1	+13	225
AFS3-04400510-07-5P-4	4.4–5.1	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-04500480-07-5P-4	4.5–4.8	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05200600-07-5P-4	5.2–6	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05400590-07-5P-4	5.4–5.9	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05800670-07-5P-4	5.8–6.7	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-07250775-06-5P-4	7.25–7.75	30	0.50	0.60	1.5:1	1.5:1	+5	100
AFS3-07900840-07-5P-4	7.9–8.4	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS4-08500960-08-5P-4	8.5–9.6	32	0.75	0.80	1.5:1	1.5:1	+5	125
AFS3-09001100-09-5P-4	9–11	26	0.50	0.90	1.5:1	1.5:1	+5	100
AFS4-09001100-09-5P-4	9–11	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS4-10951175-09-5P-4	10.95–11.75	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS4-11701220-09-5P-4	11.7–12.2	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS2-12201280-10-8P-4	12.2–12.8	14	0.75	1.00	1.5:1	1.5:1	+8	80
AFS4-12201280-10-12P-4	12.2–12.8	27	0.75	1.00	1.5:1	1.5:1	+12	200
AFS4-12701330-13-10P-4	12.7–13.3	27	0.75	1.30	1.5:1	1.5:1	+10	175
AFS4-13201400-14-10P-4	13.2–14	24	0.75	1.40	1.5:1	1.5:1	+10	175
AFS4-14001450-14-10P-4	14–14.5	24	0.75	1.40	1.5:1	1.5:1	+10	175
AFS4-20202120-20-8P-4	20.2–21.2	20	1.00	2.00	1.5:1	1.5:1	+8	175
AFS4-21202400-22-10P-4	21.2–24	18	1.00	2.2	2.0:1	2.0:1	+10	100
OCTAVE BAND AMPLIFIERS								
AFS3-00120025-09-10P-4	.12–.25	38	0.50	0.9	2.0:1	2.0:1	+10	175
AFS3-00250050-08-10P-4	.25–.5	38	0.50	0.8	2.0:1	2.0:1	+10	125
AFS3-00500100-05-10P-6	.5–1	38	0.75	0.5	2.0:1	2.0:1	+10	150
AFS3-01000200-05-10P-6	1–2	38	1.00	0.5	2.0:1	2.0:1	+10	150
AFS3-01200240-05-10P-6	1.2–2.4	34	1.00	0.5	2.0:1	2.0:1	+10	175
AFS3-02000400-06-10P-4	2–4	30	1.00	0.6	2.0:1	2.0:1	+10	125
AFS3-02600520-10-10P-4	2.6–5.2	28	1.00	1.0	2.0:1	2.0:1	+10	150
AFS3-04000800-07-10P-4	4–8	30	1.00	0.7	2.0:1	2.0:1	+10	125
AFS3-08001200-09-10P-4	8–12	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS3-08001600-15-8P-4	8–16	26	1.00	1.5	2.0:1	2.0:1	+8	80
AFS4-12002400-25-10P-4	12–24	20	2.00	2.5	2.0:1	2.0:1	+10	85
AFS4-12001800-18-10P-4	12–18	26	1.00	1.8	2.0:1	2.0:1	+10	125
AFS4-18002650-28-8P-4	18–26.5	18	1.75	2.8	2.5:1	2.2:1	+8	150
MULTIOCTAVE BAND AMPLIFIERS								
AFS1-00040200-12-10P-4	.04–2	15	1.50	1.2	2.5:1	2.0:1	+10	75
AFS3-00300140-08-10P-4	.3–1.4	33	1.00	0.8	2.0:1	2.0:1	+10	150
AFS2-00400350-12-10P-4	.4–3.5	22	1.50	1.2	2.0:1	2.0:1	+10	80
AFS3-00500200-08-15P-4	.5–2	38	1.00	0.8	2.0:1	2.0:1	+15	125
AFS3-01000400-09-10P-4	1–4	30	1.50	0.9	2.0:1	2.0:1	+10	125
AFS3-02000800-09-10P-4	2–8	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS4-02001800-23-10P-4	2–18	25	2.00	2.3	2.0:1	2.0:1	+10	175
AFS4-06001800-22-10P-4	6–18	24	2.00	2.2	2.0:1	2.0:1	+10	150
AFS4-08001800-22-10P-4	8–18	26	2.00	2.2	2.0:1	2.0:1	+10	150
ULTRA WIDEBAND AMPLIFIERS								
AFS3-00100100-09-10P-4	.1–1	38	1.00	0.9	2.0:1	2.0:1	+10	150
AFS3-00100200-10-15P-4	.1–2	38	1.00	1.0	2.0:1	2.0:1	+15	150
AFS3-00100300-11-10P-4	.1–3	32	1.00	1.1	2.0:1	2.0:1	+10	150
AFS3-00100400-13-10P-4	.1–4	28	1.00	1.3	2.0:1	2.0:1	+10	150
AFS3-00100600-13-10P-4	.1–6	28	1.25	1.3	2.0:1	2.0:1	+10	125
AFS3-00100800-14-10P-4	.1–8	25	1.50	1.4	2.0:1	2.0:1	+10	125
AFS4-00101200-22-10P-4	.1–12	28	1.50	2.2	2.0:1	2.0:1	+10	175
AFS4-00101400-23-10P-4	.1–14	24	2.00	2.3	2.5:1	2.5:1	+10	200
AFS4-00101800-25-10P-4	.1–18	25	2.00	2.5	2.5:1	2.5:1	+10	175
AFS4-00102000-30-10P-4	.1–20	20	2.50	3.0	2.5:1	2.5:1	+10	175
AFS4-00102650-40-8P-4	.1–26.5	18	2.50	4.0	2.5:1	2.5:1	+8	175

Note: Noise figure increases below 500 MHz in bands greater than 0.1-10 GHz.

3 YEAR WARRANTY

NQA ISO 9001 REGISTERED COMPANY

AROUND THE CIRCUIT

■ **REMEC** has received an initial deployment order for hub antennas for a wireless access system from **Lucent Technologies**. In related news, REMEC has been accepted as an "Adopter" member of the Broadband Wireless Internet Forum (BWIF). The BWIF is a consortium of companies that have joined together to establish and promote an open broadband fixed wireless standard based on Vector Orthogonal Frequency Division Multiplexing.

■ The crew of NASA's Space Shuttle Discovery will install a **EMS Technologies Inc.** Ku-band communications antenna during its mission to the International Space Station. The antenna is capable of automatically tracking NASA's Tracking and Data Relay Satellite System communication satellites while transmitting at data rates up to 75 mbps.

■ According to a new study by **ElectroniCast Corp.**, the global filter optic communication connector/mechanical splice consumption is driven by a dramatic increase in bandwidth demand beyond the limits of copper. The consumption in 1999 was $716.5 M, and this value will increase at an annual growth rate of 18.9 percent per year over the next five years to $1.7 B in 2004.

■ **RF Industries Ltd.**, San Diego, CA, has been named one of the 200 Best Small Companies by *Forbes* magazine.

■ **Advanced Power Technology** has received the Boeing International Space Station Exceptional Company Performance Award. The award recognizes outstanding performance by companies from across the US that provide the products and services to support the International Space Station.

FINANCIAL NEWS

■ **STMicroelectronics Inc.** reports sales of $2.04 B for the third quarter, ended September 30, compared to $1.27 B for the same period last year. Net income was $415.3 M (45¢/diluted share), compared to $135.3 M (15¢/diluted share) for the third quarter of 1999.

■ **Cree Inc.** reports record sales of $37.6 M for the first quarter of FY 2001, compared to $20.7 M for the same period last year. Net income was $12.66 M (34¢/diluted share), compared to $4.55 M (14¢/diluted share) for the first quarter of FY 2000.

■ **Microwave Power Devices Inc.** reports sales of $13.008 M for the third quarter, ended September 30, compared to $16.417 M for the same period last year. Net income was $277 K (3¢/diluted share), compared to $345 K (3¢/diluted share) for the third quarter of 1999.

■ **Superconductor Technologies Inc.** reports sales of $1.6 M for the third quarter, ended September 30, compared to $659 K for the same period last year. Net loss was $4.1 M (23¢/share), compared to $2.9 M (43¢/share) for the third quarter of 1999.

[Continued on page 60]

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6P7T

When it comes to quality, we offer you the world.

KMW RF Switches

- Compact Size
- Superior Switching Time
- High Power Handling
- Field Proven Quality

KMW conducted an extensive 12-month product reliability study to perfect our Electromechanical Switches. From this intensive R&D research, KMW switches evolved into a product with even higher reliability. In addition, more efficient methods of production were developed which enables KMW to offer these switches at greatly reduced prices.

Special offer... SPDT Switch
Up to 3GHz Only $69.99 (1 to 2,999 pcs)

■ SPDT Specification (KSW12OI2S000)

Frequency Range	DC ~ 3GHz	3 ~ 8 GHz	8 ~12 GHz	12.4 ~ 18 GHz
Insertion Loss (max.)	0.2 dB	0.3 dB	0.4 dB	0.5 dB
VSWR (max.)	1.15:1	1.3:1	1.4:1	1.5:1
Switching Time (max.)	10 ms			
Operating Mode	TTL Latching with Self Cut-Off & Indicating Circuitry			
Dimension (W*D*H)	34.0*13.4*40.0mm			
I/O Port Connector	SMA (F) / SMA(F)			

Locations: Korea USA China Japan

http://www.kmwinc.com

KMW
RF & Microwave Products

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Tel: +82-31-370-8674 Fax: +82-31-376-9588
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KMW U.S.A. Inc.
13921 Artesia Blvd., Cerritos, CA. 90703, U. S. A.
Tel: 562-926-2033 Fax: 562-926-6133
E-mail: vchung@kmwinc.com

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CIRCLE 55 ON READER SERVICE CARD

■ **Merrimac Industries Inc.** and **Micro-Multifunction Modules (MMFM)** have closed a private placement of common shares and warrants for aggregate cash proceeds of $4.6 M. The company issued to the investors 360,000 units at a price of $12.80 per unit, each unit consisting of a share of common stock and a three-year, non-redeemable detachable warrant to purchase an additional share of common stock exercisable at a price of $21.25.

■ **Illinois Superconductor Corp.** has received a $5 M equity investment from **Elliott Associate LP** and another institutional investment firm under common management. This investment took the form of a common stock purchase at $2.75 per share.

■ **Murata Electronics North America** announced record sales for its Contract Electronics Manufacturing (CEM) group. Formed in 1997, the group's sales have risen from $30 M a year to nearly $175 M over the fiscal year ending March 31, 2000.

CONTRACTS

■ **M/A-COM SIGINT Products**, Hunt Valley, MD, has been awarded a contract by the Naval Surface Warfare Center (NSWC), Virginia Beach, VA, to supply a large quantity of collection microwave receivers over a five-year period. Under the terms of the contract, SIGINT Products will supply an estimated 30 to 45 receivers per year for use in the US Navy's Cluster Spectator, Cluster Snoop and Cluster Robin microwave collection systems. Financial terms of the contract were not disclosed.

■ **Gabriel**, Scarborough, ME, was awarded a contract to supply 1000 26 GHz subscriber antennas to Israeli system provider Floware Wireless Systems Ltd., Yehuda, Israel. This award is the first stage of a much larger contract.

■ **Gulfstream Aerospace Corp.**, a wholly owned subsidiary of General Dynamics, has selected **EMS Technologies Inc.**, Atlanta, GA, to supply universal radomes for its IV-SP aircraft. The radomes support both direct broadcast television and satellite communications, and will be installed for customers who elect those options. Financial terms were not disclosed.

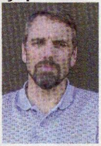
PERSONNEL

▲ Richard Mumford

■ *Microwave Journal* welcomes **Richard Mumford** as European Editor. The creation of the new position acknowledges the European microwave industry's valuable contribution to the global market and Richard will be dedicated to reporting fully on the activity of European manufacturers, research institutes, test houses and industry associations. He began his working career as an electrical engineering technician apprentice with the Ministry of Defense in England before gaining a Bachelor of Engineering degree in Electrical and Electronic Engineering at the University of Wales Institute of Science and Technology (UWIST). Richard made the transition from engineer to journalist when joining INSPEC, the technical information arm of the Institute of Electrical Engineers in London, using the experience to gain a senior position at a business-to-business publishing house where he spent 13 years editing and developing various engineering titles. As European Editor, Richard is keen to develop new contacts and receive information on new products and services, news items, and exhibitions and conferences relevant to the European microwave market. He will be commissioning technical articles and looking to publish exclusive technical papers. If you can contribute in any of these areas then please contact: Richard Mumford, *Microwave Journal*, Horizon House Publications, 46 Gillingham Street, London SW1V 1HH, UK. Tel: +44 20 7596 8700; Fax: +44 20 7596 8739; Email: rmumford@mwjournal.com.

▲ Jim Hjerpe Kaskade

■ Incep Technologies, San Diego, CA, has named **Jim Hjerpe Kaskade** president. Previously, Kaskade was VP of marketing and sales. In related news, the company named **James E. Dietz** VP of marketing and sales. Most recently, Dietz was director of product management for Teradata Systems at NCR Corp., San Diego, CA.



▲ Jim Dietz

■ TRiMEGA Electronics LLC, turnkey provider of process critical materials, systems and services for the worldwide electronics industry, has appointed **Robert M. Nolan** president.

■ Paratek Microwave Inc. has appointed **Peter Nohren** chief operating officer. Most recently, Nohren was VP of broadband networks for Ericsson.

▲ Charles R. Nicholas

■ The Andrew Corp. board of directors elected **Charles R. Nicholas** to the board and appointed him vice chairman. Nicholas was formerly executive VP, administration and finance, as well as chief financial officer.

■ East Coast Microwave Distributors Inc. has promoted **Betsey Ginz** to VP of sales. Previously, Ginz served as the company's top outside sales person.

▲ Lynn K. Giles

■ IFR Systems Inc. has named **Lynn K. Giles** VP of human resources. Giles will serve on the company's senior management team and participate in setting strategic direction for the company, with responsibility for leading all global human resource and organizational development activities. In related news, the company appointed **Deborah Stockman** marketing com-

▲ Deborah Stockman

[Continued on page 62]

munications manager. Stockman brings 16 years experience in marketing and marketing communications to the company, and most recently was with Newer Technology.


▲John C. Wilber

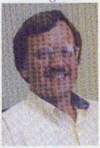

▲Jeffrey A. Fordham


▲Syed Tariq

■ MI Technologies has announced a series of personnel appointments. **John C. Wilber** has been appointed VP of the Custom Systems business. Wilber is responsible for the overall development of the Custom Systems business and the day-to-day management of a number of strategic programs for the company, which require the coordination and integration of numerous products, systems and services. **Syed Tariq** has been appointed VP of applications engineering. Most recently, Tariq served as the VP of engineering. Finally, **Jeffrey A. Fordham** has been named VP of engineering. Previously, Fordham was the engineering project manager at the company.

■ Integration Associates, a leading supplier of semiconductor products for the communications, medical, industrial and automotive markets, has appointed **Jan Nilsson** VP, marketing. Previously, Nilsson served as director of marketing for Vishay Intertechnology Inc.'s Siliconix power IC and Telefunken infrared data communications business units.


▲Roger Wieting


▲Stephen A. Coffey

■ VertexRSI has named **Roger L. Wieting** VP and general manager of its Rockaway, NJ facility. Wieting will be responsible for the overall direction of the facility's Electronics Products business. Most recently, Wieting served as VP and general manager of the Vertex Control System Division (VCSD). In related news, the company appointed **Stephen A. Coffey** manager, customer service. Previously, Coffey served in a variety of managerial roles at CommScope Inc.

■ Excellon Automation has appointed **Jim Morrison** director of market research and business development. Morrison brings 15 years of experience in manufacturing solutions to the company.

[Continued on page 64]

AROUND THE CIRCUIT

▲ Craig Oldaker

■ TRAK Microwave Corp., a TRAK Communications company, has named **Craig Oldaker** director of programs for TRAK Microwave subsystems business. Previously, Oldaker was manager of contracts and marketing with Metric Systems Corp., a sister subsidiary to TRAK Microwave. In related news, the company appointed **David Alonzi** sales and marketing manager for the Timing product line. Alonzi will be responsible for the product sales, marketing and overall growth of TRAK Timing products. Most recently, Alonzi was national sales manager for Spectracom Corp.

▲ David Alonzi

■ NEC electronics has named **Yukio Kabeya** general manager of the company's Automotive Strategic Business unit, Dallas, TX. Kabeya transferred from the company's 3rd System LSI division in Japan, where he was a senior manager of the System LSI Operations unit.

■ Lambda Electronics Inc. has appointed **Jeffrey M. Frank** general manager. Previously, Frank was in a similar position with Deltec Electronics.

■ Taconic has promoted **Suzanne Seymour** to internal sales manager of the Advanced Dielectric Division (ADD). Previously, Seymour held various positions in manufacturing, quality and technical sales within the ADD business.

■ Champion Technologies has named **Cor van den Heuvel** European sales and marketing manager. Cor brings a background in the electronics industry to Champion, having held several product management positions with ACAL Netherlands.

▲ Mark Page

■ ITT Industries, Cannon has named **Mark Page** manager of cable assemblies. Page was business operations and product marketing manager at Thomas & Betts Corp.

■ Micro Networks Corp. has appointed **Timothy E. Flynn** corporate controller. Flynn will assume the responsibility of cost accounting, budgeting and financial reporting for the company.

REP APPOINTMENTS

■ **Universal Microwave Corp.**, Odessa, FL, has named three firms to represent its products in the US. **dBm Technical Sales** will cover New England, **Youngewirth & Olenick** will cover Arizona and New Mexico, while **Trionic Associates** will cover Long Island, Metro New York and New Jersey.

■ **SV Microwave© Inc.**, West Palm Beach, FL, and its Commercial Products Group has appointed new representatives and distributors to sell its microwave products in the North American territories. **Blackhart Sales Inc.** will cover Arizona, New Mexico, Clark County, Nevada and El Paso County, Texas. **CTC Sales Corp.** will cover Oregon, Washington and British Columbia and **Micro Sales** will handle Ohio, Indiana, Illinois, Kentucky, West Virginia and Michigan. **N&W Sales Inc.** is the representative for Arkansas, Louisiana, Oklahoma and Texas, while **Wavelink Associates** will cover Florida, Georgia, Alabama, Mississippi, Tennessee and South Carolina.

■ **Brush Wellman's Powder Metal Products group** has appointed several new manufacturing representatives due to increased market demand for copper/tungsten heat sinks in telecommunication and optoelectronic applications. The group has expanded its representation in the US to include **Scientific Devices**, Flourtown, PA, **M&S Sales**, Palatine, IL, **Dossett Industrial Sales**, Burleson, TX, **Micro Marketing**, Apopka, FL, **O&S Sales**, New Bedford, MA, and **Charles Reed Enterprises**, Placentia, CA. Additional sales support offices are located in Japan and Europe.

NEW MARKET ENTRY

■ **Universal Microwave Corp. (UMC)** designs and manufactures high performance voltage controlled oscillators, ceramic resonator oscillators and synthesizers for the wireless market. UMC is located at 2339 Destiny Way, Odessa, FL 33556 (877) 375-9332, fax (727) 376-7271.

WEB SITES

■ **Texas Instruments Inc. (TI)** has launched e-commerce capabilities on its Web site, www.tiris.com, offering customers an easy, convenient way to purchase its radio frequency identification products (RFIP) online. TI is initially offering ten of its field-proven, low frequency RFID products.

■ **BURLE INDUSTRIES INC.** has launched an updated International Web site, www.burle.com, that offers convenient purchase of its most popular Power Tube and Channeltron® products over the Internet. The site offers thousands of pages of technical data, and contains an e-commerce system that allows products to be purchased in US and Euro dollars.

■ **Berkeley Nucleonics Corp. (BNC)** has launched version 1.5 of its corporate Web site, www.berkeleynucleonics.com. The BNC site now offers user-specific online training seminars on nuclear spectroscopy systems, new product application content and a fast-link to the customer service department.

■ **MicroJoin Inc.** has launched its new Web site, www.microjoin.com. The site is quick to load, features a drop-down main menu bar, easy navigation, dynamic graphics and animation. Visitors are self-guided through photos and informational tables along three paths: applications, processes and products, to select the product or technology that fits their needs.

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CNIT Paris la Défence from 16–18 January 2001

A CONFERENCE DEDICATED TO EMERGING TECHNOLOGIES FOR THE COMMUNICATIONS MARKET

For the first time, two of the world's leading technology magazines, *Telecommunications®* and *Microwave Journal*, join together during RF & Hyper Europe 2001 to present a comprehensive industry conference covering three vital communication techniques: RF & Microwave Technology, Wireless Applications and Optical Technologies. The conference sessions are designed to provide engineers charged with implementing such technologies in communications applications with the most up-to-date industry information and analysis.

The conference tracks will cover:

RF & Microwave Technology as it applies to telecommunications, commercial applications and military applications. The track will focus on devices, subsystems and systems from the perspective of the design engineer.

Wireless Applications for communications techniques from antenna assemblies, base station architecture, microwave links and wireless broadband access up to 3G.

Optical Technologies covering components such as transmission, switching, IC componentry, wide area network and long haul applications and IP requirements.

Conference Program Schedule

Tuesday

Time	Room 1	Room 2
7:00–12:20	Registration	
13:30	Opening Plenary Overview of Driving Technologies, Market Directions and Opportunities in Microwave, Wireless and Optical Technologies for the Communications Industry	
15:00–15:45	Microwave 1 The System Technologies Requirements for Microwave Systems	Wireless 1 Analysis of Signal Processing Techniques
1545–16:15	Coffee Break	Coffee Break
16:15–17:05	Microwave 2 High Power IC-like Design Methods	Optical 1 All Optical Networks – Defining and Partitioning the Hardware and Software Elements
17:10–18:00	Wireless 2 The System Technologies and Requirements from GSM to 3G Migration	Microwave 3 Micro/Millimeter-wave Transceivers for Mass Production
18:00	Close of Conference Tuesday	

Wednesday

Time	Room 1	Room 2
7:00–8:30	Registration	
8:30–9:20	Wireless 3 SAW Devices Supporting GPRS/UMTS and Improvement of Linearity of TWT	Optical 2 State-of-the-art in Optical Devices
9:30–10:20	Wireless 4 MMIC-based Amplifiers for Satellites Communications and Integrated High Power Silicon MMIC	Microwave 4 Microwave and Photonic Applications of MEMs
10:30–11:20	Optical 3 Advances in Optical Switching and Cross Connects	Microwave 5 RF Front-end Architectures
11:30–12:20	Wireless 5 NZIF Architecture for GSM and Future Standard and EDGE Radio Performance	Microwave 6 Silicon/Germanium BiCMOS Processes and Circuit Techniques for RFICs
12:20–15:00	Lunch and Exhibition Floor Visit	
15:00–15:45	Optical 4 Optical Signal Processing and Transmission	Wireless 6 Bluetooth and How to Go to the Bluetooth Qualification
15:45–16:15	Coffee Break	Coffee Break
16:15–17:05	Microwave 7 High Frequency Packaging Techniques	Wireless 7 Frequency Allocations and Implications
17:10–18:00	Microwave 8 Emerging Technology for High Power (> 100 W) Amplifiers	Optical 5 Theory and Techniques for Optical Networks
18:00	Close of Conference Wednesday	

THURSDAY

Time	Room 1	Room 2
7:00–8:30	Registration	
8:30–9:20	Optical 6 Optical Network Monitoring, Restoration and Management	Wireless 8 Wireless LANs and System Level Simulation for Wireless Telephony
9:30–10:20	Microwave 9 Test and Measurement for Microwave Systems	Wireless 9 Monitoring and Testing of Wireless Networks

Time	Room 1	Room 2
10:30–13:30	Closing Plenary Round Table What the Future Holds in Microwave, Wireless and Optical Technologies for Communciations Applications	
13:30	Close of Conference	

Preliminary Technical Program

Opening Plenary

Tuesday, 16 January, 13:30–15:00

Overview of Driving Technologies, Market Directions and Opportunities in Microwave, Wireless and Optical Technologies for the Communications Industry

Dr. Kai-Yeung (Sunny) Siu, Chief Scientist, Raza Foundries, Inc. (US)

The Rebuilding of the Global Telecommunication Infrastructure

The explosive growth of Internet traffic in recent years has sparked the rapid development of broadband communications infrastructure. At the same time, deregulation of the telecommunication industry worldwide has created fierce competition among new and existing carriers that have been constantly looking for new ways to cut costs and create more revenue. This in turn has created a huge demand for new communication technologies and network equipment that provide tremendous bandwidth at low cost and enable new applications and services. This presentation discusses emerging broadband technologies and architectures, including optical networks based on DWDM, broadband wireless technologies, and terabit switching fabric with QoS guarantee.

Closing Plenary

Thursday, 18 January, 10:30–13:30

What the Future Holds in Microwave, Wireless and Optical Technologies for Communications Applications

Jim Crescenzi, Principal Scientist, UltraRF (US)

Progress in microwave technology in support of wireless infrastructure has far surpassed the predictions of most observers, and there is no end in sight! New technology has been developed on a demand-pull basis, which is in great contrast to the defense era of the 1980s. The greatest progress has been made in handset technology, where transceiver functions have become more efficient, wider bandwidth, lower cost and more integrated. The battle for dominance in material technology between Si, SiGe and III-V compounds (GaAs, pHEMTs, etc.) will continue unabated, although it appears that SiGe has the momentum in its favor.

This presentation discusses base station issues and progress in component technology and cost structures and their applications.

Professor Ke Wu, Ecole Polytechnic Montreal

Bertrand Clesca, Product Manager, Optical Networking, Alcatel Optics Group (France)

Benefits and Challenges of the Optical Networking Layer

This presentation offers an overview of the current status of wavelength division multiplexing (WDM) transmission systems and discusses short-term evolution: an introduction of optical protection and the increase in the transport capacity. Benefits to move to wavelength routing, classification of cross-connects for the optical layer, technical challenges related to optical switching technologies and supervision and management of optical cross-connects are presented.

Microwave 1

Tuesday, 16 January, 15:00–15:45

The System Technologies and Requirements for Microwave Systems

J.P. Bardon & F. Vignaud, Temex

Microwave 2

Tuesday, 16 January, 16:15–17:05

Efficiency and Linearity Enhancement Methods for Portable RF/MW Power Amplifiers

John Sevic (US)

Microwave 3

Tuesday, 16 January, 17:10–18:00

Micro/Millimeter-wave Transceivers for Mass Production

David Miller, Director of Engineering, EESA (US)

Optimization of the Production Processes Aimed at a More Profitable Business in the Microwave Module Manufacturing

This session describes the techniques adopted in EESA Inc., which allows the mass production of microwave transceivers at very competitive prices with good gross profit figures. The session describes the involvement of engineering not just in the product development but also in the design of the manufacturing processes to assemble and test the units. A description of the manufacturing software tools developed by engineering and used in production to make the tuning and testing of the modules automatic is discussed. The impact of this approach on designing more complex modules, the efficiency of the manufacturing processes and the finances of the company is also reported. Finally, a couple of examples of units designed and presently tested with these techniques is reported with the relevant production flow and time chart, manufacturing cost and gross profit percentage.

Marc Rocchi, CTO, OMMIC

Millimetrewave and High Speed Optical Interfacint Circuits – Which Technologies for the Future? PHEMT, MHEMT or InP?

Microwave 4

Wednesday, 17 January, 9:30–10:20

Microwave and Photonic Applications of MEMs

Dr. Hector De Los Santos, Principal Scientist, Microcosm Technologies (US)

Micromachined and Microelectromechanical Systems (MEMS) Devices for Microwave/Wireless Communication Systems

An overview of micromachined and microelectromechanical systems (MEMS) devices for use in microwave/wireless communication systems is presented. A typical wireless communications system front-end block diagram is highlighted identifying the components targeted for replacement by micromachined or MEMS devices. These devices are described focusing on the unique methods required for successful design, and the miniaturization, cost reduction, increased performance and novel architectures enabled by these devices. Among the specific devices described are micromachined transmission lines, high Q inductors, cavity resonators, thin film bulk acoustic resonators (FBAR) and microelectromechanical varactors, low loss switches and high Q micromechanical vibrating resonators.

Microwave 5

Wednesday, 17 January, 10:30–11:20

RF Front-end Architectures

Thomas Müller, Dipl.-Ing., DaimlerChrysler Research, Ulm (Germany)

The fundamental receiver architectures and structures are presented, including the direct conversion and superheterodyne receivers, an up-down mixing concept, the IF and direct sampling receivers. Each of these receiver architectures will be discussed regarding their suitability for high dynamics, phase-truth, analog or digital modulation schemes and the design of multimode/multistandard receiver architectures. The fundamentals of the main er-

[Continued on page 70]

ror sources such as the influence of phase noise, filtering, group delay variations in the reception path and nonlinearities will be briefly explained. Since nearly every modern receiver uses analog-to-digital conversion somewhere in the reception path, the influence of faulty time and amplitude discretisation will be presented. Some important types of analog-to-digital converters and their abilities to sample baseband signals or IF signals will be presented.

For RF- and IF-sampling receivers, digital signal processing influences the design of the RF hardware. Cost effective digital parts will lead to specific structures in the RF part. These structures, as well as actual possibilities in the digital signal processing, are presented and discussed. The presentation closes with realized examples of digital receivers for different standards.

Dr. Heinrich Daembkes, President and CEO, United Monolithic Semiconductors (UMS) (France)

Broadband Wireless Communication Systems: Influence of Architectures and Packaging Concepts of mm-wave Front-ends on Time-to-Market and Cost

Broadband wireless radio links are today's best choice for connecting the users to very broadband backbones as a result of cost and time to use advantages. Emerging new systems such as LMDS, MVDS and VSAT will find their way to a volume market only if the cost for the customer premises entity (CPE) is sufficiently low. The RF-front-end today represents a major portion of the cost. By the use of higher integration concepts (MFCs), zero tuning architectures and low cost surface mount packaging technologies the cost of RF-front-ends will be reduced by a factor of more than two versus today's status. An example will be given using the UMS family of packaged LMDS MMICs.

Microwave 6

Wednesday, 17 January, 11:30–12:20

Silicon/Germanium BiCMOS Processes and Circuit Techniques for RFICs

Vida Ilderem, Motorola (US)

A Low Cost 90 GHz SiGe:C BiCMOS Technology for RF/IF Applications

Silicon germanium (SiGe) technology is fast becoming the technology of choice for various wireless applications. SiGe offers the opportunity for integrating a high performance HBT with CMOS analog and digital functions on a single chip along with all the necessary passives for RF/IF applications.

This presentation reports on a 0.35 um SiGe: C BiCMOS designed for RF/IF applications. This technology supports a suite of passives including seven resistors, 1.6 fF/um^2 MIM cap, 4 fF/um^2 double poly capacitor, varactors and electroplated copper inductors. The advantages of carbon for the SiGe HBT will be reviewed. A peak f_T/f_{max} of 48/90 GHz is obtained for this typical HBT device. This technology provides excellent high performance at low bias current for low power applications. A 40 GHz f_{max} at 20μA is obtained on the optimized minimum device. The high base doping, combined with the low collector-base capacitance, gives the high f_{max}/f_T ratio.

Microwave 7

Wednesday, 17 January, 16:15–17:05

Millimeter-wave Packaging

David Lynch, Design Engineer, Farran Technology

Millimetre-wave MMIC Multi-chip Module Design

The issues that face the designer of MMIC multi-chip modules in the 18 to 100 GHz frequency range will be discussed. Modeling and simulation will be considered in detail, including modeling of the external interface and individual mm-wave module components and modeling and simulation of the module as a stand-alone unit. Other areas that will be discussed are design for test and design for manufacture. A design study of a Ka-band up- and down-converter unit based on MMICs will be used as an illustration.

Alain Michel, Application Engineer, Ansoft

Modeling the Parasitic Effects of Low Cost Packages on High Frequency Integrated Circuits with Ansoft EM Tools

Many high frequency circuit designers base their simulations on 50 Ω terminations. The parasitics associated with low cost packages can

[Continued on page 72]

make this simplification yield undesirable results. Ansoft's products offer many ways of analyzing package effects on circuit performance, providing designers an opportunity to compensate for electromagnetic effects. This presentation describes the old measure and fit method for package characterization and a new, more powerful design methodology for synthesizing circuits, rapidly simulating them, and fully verifying them accounting for all of the parasitic effects to prevent having to redesign. A differential VCO circuit is designed and simulated using this new methodology. By combining a rigorous verification procedure that accounts for all of the high frequency parasitic effects, along with tools that accelerate the initial design process, high frequency circuit engineers can successfully minimize their designs more quickly and easily than ever before.

Microwave 8

Wednesday, 17 January, 17:10–18:00

Emerging Technology for High Power (>100W) Amplifiers

Dr. Fred Myers, Manager, RF and Foundry Div., Caswell Technology, Marconi Caswell (UK)

High power, high efficiency solid state amplifiers are essential for the operation of many systems. The existing devices (MESFETs, HEMTs and HBTs) have many parameters that differ but are all essentially limited to around 10W of power at 10GHz. It has been known for some time that wide band-gap semiconductors will allow a quantum leap in power capability. Compounds based on gallium nitride (GaN) and silicon carbide (SiC) offer at least an order of magnitude improvement.

Caswell Technology, UK, has been working for several years on wide band-gap semiconductors. This work is supported by a number of agencies (Company, UK MoD, European Union and BNSC) and is addressing the range of activities necessary to develop devices. In conjunction with various European partners, development efforts are underway in material growth, theoretical modeling, process technology, circuit design and packaging.

The material base chosen for this work is GaN. This material and its heterostructures is less mature then SiC but offers theoretically better performance. There is also a large effort worldwide to mature the material base driven by the optical requirements for short wavelength lasers. It is expected that the microwave applications will feed off this activity. This presentation offers an overview of the work at Caswell in these areas and compares these accomplishments with world results.

Microwave 9

Thursday, 18 January, 9:30–10:20

Test and Measurement for Microwave Systems

Jin Bains, Agilent

An Improved Network Analyzer for Measuring High Dynamic Range (> 100 dB) Devices with Speed and Accuracy

The dynamic range of the network and analyzer is a critical parameter in a large variety of device measurement situations. The various definitions of dynamic range are explained here. This paper provides a description of a network analyzer receiver block diagram that allows for maximum dynamic range. The use of mixers vs. samplers is considered. Ways to reduce noise floor are explained and compared in terms of their impact on dynamic range and their effect on measurement speed. Additionally, test set configurations that maximize dynamic range are described.

John McManus, IFR

To be announced.

Wireless 1

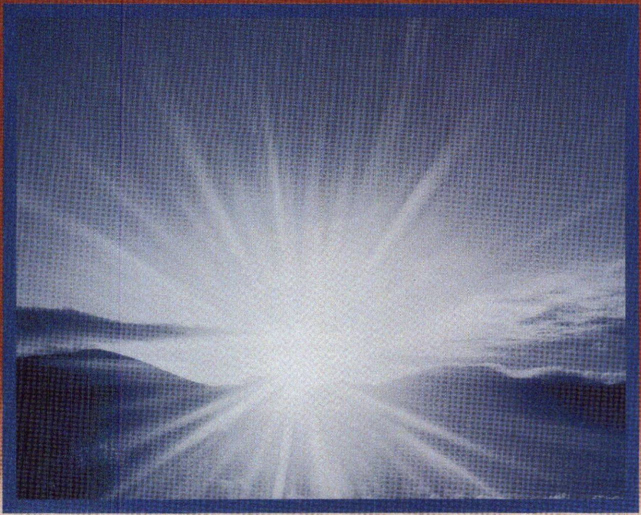
Tuesday, 16 January, 15:00–15:45

Analysis of Signal Processing Techniques

Jean-Yves Moliner, Texas Instruments

Analysis of signal processing techniques (Signal Processing Applications and technology for wireless handsets and infrastructures) is presented. A description of a wireless digital cellular handset general block diagram and 2G handsets baseband architecture is offered along with typical DSP algorithms in 2G handsets. 2G handset performance evolution and 2G-to-3G evolution: mobile voice to mobile multimedia processors evolution (performance, power consumption) is presented. Multimedia applications are described and the Open Multimedia Applications Platform (OMAP) is discussed. In addition, supporting process technologies, wireless infrastructure solutions and 2G-to-3G infrastructure evolution are presented, and the presentation concludes with DSP for wireless applications.

[Continued on page 75]



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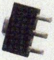
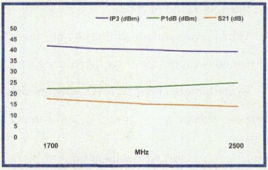


With power to spare, giving you freedom from design constraints, this amplifier was designed and manufactured using state-of-the-art Gallium Arsenide heterojunction bipolar transistor (GaAs HBT) process technology. These devices are ideal for use as a driver stage for power amplifiers installed in cellular PCS infrastructure equipment and conform to TDMA, CDMA and PCS 1900 modulation standards. The SXT-289 operates from a single 5VDC supply and offers exceptional linearity performance in a small form-factor plastic SOT-89 with backside ground.

For more information on the SXT-289 or any of our other products, visit our website today and experience RF Innovation from Stanford Microdevices.



Typical device performance. Bias =5V @ 110mA typ.

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Wireless 2

Tuesday, 16 January, 17:10–18:00

The System Technologies and Requirements from GSM to 3G Migration

Jean Christophe (J.C.) Nanan, Motorola

3G Creates New Requirements for BST Power Amplifier

The third generation of mobile phone standards will introduce more complex modulation schemes to gain spectral efficiency and increase the data rate at the user interface. Some considerations about the W-CDMA signal's random nature and characterization (CCDF, code domain...) will be discussed. Definition of system specifications and measurements, and the need for linear BST power amplifiers to limit the distortion will also be presented.

A new LDMOS family is introduced to address this application. A nonlinear model is used to simulate the LDMOS devices under complex signal conditions. Validation and characterization, the influence of the Quiescent current on intermodulation/ACP, pulse measurements, CCDF measurements and signal clipping influence will be shown. Different W-CDMA line-ups: single carrier, dual carrier and multi-carrier will be presented.

Martin Hallerdt, Ericsson, France

The history of 3G standardization, new features of mobile communications in the third generation, UMTS system requirements, new system requirements in UMTS networks and UMTS migration scenarios for GSM network operators will be presented.

Wireless 3

Wednesday, 17 January, 8:30–9:20

SAW Devices Supporting GPRS/UMTS and Improvement of Linearity of TWT

Gerhard Fischerauer, Epcos

SAW Devices Supporting Advanced Handset Technologies

Topics covered in this presentation include progress in SAW component technology (miniaturization, enhanced functionalities, integration, packaging) and filters for advanced cellular phone systems (GPRS, CDMA, UMTS).

Francis Payen and Georges Faillon, Thomson Tubes

Wireless 4

Wednesday, 17 January, 9:30–10:20

MMIC-based Amplifiers for Satellite Internet Services and Integrated High Power Silicon MMICs

Gordon Railton, Pascall Electronics

Topics covered in this presentation include expansion in broadband services for video, Internet and mobile communications; new transponders in the K and Ka bands; and direct-to-home provision demands for consumer-priced microwave network elements. MMIC-based amplifier technology with innovative multi-layer circuit techniques are required, geared to low cost volume production. Traditional discrete packaged GaAs FET approaches fail to meet the performance and cost demands at these higher frequencies. Transmission powers required are in the 1 to 10 W range. However, the MMICs available are limited to approximately 1 W for linear applications. Circuit power combining techniques are required. An example of an 18 GHz 4 W combined MMIC amplifier for point to point or Satellite uplinks is presented, along with a discussion of RF line-up, circuit techniques and thermal considerations. A brief example of an 18 GHz VSAT transceiver used for Internet services with L-Band IF input is described, and other frequencies and trends are discussed.

Gerard Bouisse, Principal Staff Engineer, Motorola Semiconducteur, Toulouse

This paper presents the different technical aspects of fully integrated high power silicon MMICs for wireless base stations in the 0.9 to 2.2 GHz arena. Motorola's silicon MOSFET LDMOS technology, and more specifically its integrated version HVIC, is presented. The technical challenges linked to high power silicon multi-stage power amplifiers are emphasized and solutions to these new problems are proposed. The performance of two circuits, a three-stage 30 W 900 MHz power amplifier and a three-stage 10 W 1.8 GHz, using the proposed solutions, demonstrate the design concept.

Wireless 5

Wednesday, 17 January, 11:30–12:20

NZIF Architecture for GSM and Future Standard EDGE Radio Performance

Yvan Droinet, International Product Marketing Manager, GSM RF Products, Philips Semiconductors

NZIF: An Innovative Architecture for Highly Integrated Multi-mode RF ICs

This presentation covers wireless multimedia applications and RF technology roadmaps. The NZIF architecture is described and a NZIF transceiver implementation is discussed. An RF and PA product roadmap for wireless applications is offered to pave the way to 3G.

Heikki Heliste, Nokia

EDGE Radio Performance

8-PSK modulation, Incremental Redundancy, Link Adaptation, Radio Link and Network Performance (based on simulations).

Wireless 6

Wednesday, 17 January, 15:00–15:45

Bluetooth and How to Go to the Bluetooth Qualification

Stefan Lof, Ericsson Microelectronics

What parts are necessary in a complete Bluetooth implementation? A single or multi-chip approach and the process technology to achieve it. Cost and performance aspects of a radio module vs. a discrete solution.

Michel Binaud, Rohde and Schwarz

Bluetooth Qualifications and Specifications

Qualification I, II and IV are described and Specification Status IV is covered.

[Continued on page 77]

Wireless 7

Wednesday, 17 January, 16:15–17:05

Frequency Allocations and Implications

To be announced.

Wireless 8

Thursday, 18, January, 8:30–9:20

Wireless LANs and System Level Simulation for Wireless Telephony

Wynne Davies, Cordless Consultants

Users have waited a long time for a decent wireless LAN. Although wireless LANs have been around for ten years, they have all, in the past and without exception, been high cost and low performance. However, all that changed in November 1999 when the IEEE in the US ratified a new high rate standard for wireless LANs. The industry is already planning the next generation of higher speed wireless LANs. In one case alone: HIPERLAN, a high performance radio LAN that offers more than 20 Mbps, the standard was formally completed, approved and ratified in 1997. Furthermore there are other developments afoot offering the potential to deliver 50 Mbps and above. This paper will chart the developemnt of wireless LANs, from the early days of high cost and low performance products through to today's high performance and low cost solutions. Developments within the Euroepan Telecommunications Standards Institute in relation to HIPERLAN 1 and HIPERLAN 2 will be considered, as well as the work of the IEEE with regard to the 802.11 suite of wireless LAN standards.

Heiki Rekonen,
Customer Service Director, Aplac

Using Circuit-level Simulation of RF Components in Combination with System Level Simulation in APLAC

The unique features of the APLAC RF Circuit Simulator's programming language interface are exploited. An amplifier is analyzed on a circuit level, and a model of it is constructed and used in a system level simulation. This work is from the world of wireless telephony but the principles can be applied to any circumstances.

Wireless 9

Thursday, 18 January, 9:30–10:20

Monitoring and Testing of Wireless Networks

Guenther Klenner,
Strategic Marketing Manager,
Dave Adams, Product Specialist Air Interface Test Systems, Acterna Wireless Network Division (Germany)

The transition from test and measurement to test and management. Test instruments are described that are good for network deployment and maintenance on-site. Fixed test systems that can audit a wireless network like a subscriber are discussed, and scalable test systems with fixed, mobile and automous probes for the future are described.

Benoit Deschamps, ANF

Optical 1

Tuesday, 16 January, 16:15–17:05

All Optical Networks – Defining and Partitioning the Hardware and Software Elements

Paul Liesenberg, Director Strategic Marketing, ZettaCom (US)

Optical Silicon

Some believe that the more optical networking advances, the more electronic switching fabrics and protocol processors are required. This presentation analyzes the requirements that the exploding Internet and optical layers put on the "intermediary" electronic components. How price-performance, market need and market acceptance come together, and why silicon is required to offer services with acceptable, deterministic QoS levels over an all-optical transport infrastructure.

Doug Arent, Director of Stretegic Marketing, Network Photonics (US)

Gigabit Level Services for the Metro Using Wavelength-routed All Optical Networks

This presentation discusses the opportunity for competitive data-oriented carriers to offer flexible gigabit level services built around third generation metro DWDM networks. This session shows the evolution of DWDM transport from "dumb" point-to-point systems to "intelligent" wavelength-routed systems offering high bandwidth, service flexibility, dynamic provisioning and reconfiguration. Solutions to the all-optical engineering challenges commonly posed are highlighted.

Optical 2

Wednesday, 17 January, 8:30–9:20

State-of-the-Art in Optical Devices

Gary Bjorklund, CTO,
Nanovation Technologies (US)

Smaller, more reliable and lower cost optical components are necessary for dense wavelength division multiplexed (DWDM) optical fiber communication to be fully deployed on the metro scale. Integrated optics technology is emerging as a strong contender for supplying such improved optical components. Using the silica-on-silicon materials system, integrated optical circuits that combine taps, splitters, wavelength mux/demuxers and switches can be fabricated on a single chip. Switches based on hybrid MEMS/silica technology have considerable promise in terms of latching capability, power consumption, high contrast and wide optical bandwidth. Although switching speeds are limited to the millisecond time scale, exciting components such as single chip optical add/drop multiplexers can be envisioned. Using the InP materials system, sub-nanosecond switching speeds can be achieved and active optical devices such as lasers, amplifiers and photodetectors can be included. Challenges for the practical implementation of silica-on-silicon and InP-based integrated optical components are discussed.

Dr. Adrian Janssen, Chief Technologist, Nortel Networks HPOC (UK)

In the last few years optical networks have been developing in response to ever-growing demands in transmission density. This is likely to continue in the foreseeable future with the accompanying evolution of optical devices to provide appropriate functionality. The ability to achieve a high degree of network flexibility, and sufficient optical precision to enable very high data transmission into the terabit regime is dependent on the evolution of a number of new technologies. Optical device solutions, which allow data to be routed by wavelength control or by optical switching, are now keenly sought. This presentation will give some perspective into the role of these technologies and point towards possibilities for future devices.

A number of strategies are being adopted to reduce costs of manufacture as the network expands closer to the end user. The advances in precision manufacturing using automation and the possibilities for integration and hybridization will be discussed.

Optical 3

Wednesday, 17 January, 10:30–11:20

Advances in Optical Switching and Cross Connects

Dr. Vivek Tandon, Business Development Director, Kymata (UK)

As the demand for bandwidth, fueled by the Internet, continues unabated, so the numbers of DWDM optical networking companies supposedly offering unique solutions to contend with this growth continue to expand. One of the main challenges for these companies is where and how to obtain the opto-electronic components in quantities necessary to build their DWDM systems.

The manufacturing of discrete components for the DWDM industry has been reasonably successful to date. However, the requirement for higher specifications (such as increased number of wavelengths and lower insertion losses), larger volumes of these building blocks and increased integration of functionality, dictate the need for new volume manufacturing techniques to be employed.

This presentation focuses on the use of planar manufacturing techniques to develop devices such as array waveguide grating, variable optical attenuators and thermo-optic switches. It will compare the advantages of AWG's with that of traditional thin film filters and fiber Bragg gratings. In addition, the different planar manufacturing techniques including flame hydrolysis deposition and plasma-enhanced chemical vapor deposition, and their relative advantages and disadvantages, are examined. The use of silica-on-silicon versus silicon-on-silicon is also discussed. Finally, the presentation explores the ability of developing a host of other vital DWDM components including variable optical attenuators and thermo-optic switches.

Dr. Narda Ben-Horin, Business Development Manager, Lynx Photonics (Israel)

Smart Photonic Switching for Intelligent Optical Network

Optical communications technology is the only solution for next generation unlimited bandwidth Internet-oriented carrier networks. However, where most long-haul communications transport is today conducted optically, most of the switching-routing is electronic, thus requiring optical-to-electrical switching and then electrical-to-optical signal conversion each time it has to be routed. This has become a major bottleneck in unleashing the full potential of DWDM enabled optical networks.

Multiple technologies are being adopted to develop optical switches, which will be capable of switching the optical signal without OEO conversion. Probably the most reliable method is based on integrated optics that is already widely deployed for other types of optical devices.

With the maturity of integrated optics technology, smart photonic switch modules are now being developed which take integrated optics to the next generation. These devices introduce novel features in multiple levels of the switch module and enable unique functionality's that are mandatory for cost-effective, efficient optical networks. Manufacturing of these devices is straightforward using established semi-conductor methodology and world-class contract manufacturers with large volume capacities.

Optical 4

Wednesday, 17 January, 15:00–15:45

Optical Signal Processing and Transmission

Steven Borley, Senior Photonics Engineer, Marconi Caswell (UK)

Tuneable Laser – a Key Enabling Technology for Advanced Optical Networks

This presentation offers a state-of-the-art review examining current and future tuneable laser devices, and characterization and control issues associated with the semiconductor tuneable laser are discussed. How the availability of widely tuneable lasers affect the way in which networks are designed is examined, and the likely deployment of widely tuneable lasers within access, LAN and trunk networks is evaluated.

Jung-Chih (J.C.) Chaio, Product Line Manager, Chorum Technologies (US)

Optical Signal Processors

To increase the network management and control flexibility in the next generation WDM optical networks, optical signal processors are essential to dynamically condition and regulate the WDM signals passing through cross connects or add/drop multiplexers. In the long haul, metro or access networks, optical signal processors, including optical switches, attenuators, power equalizers and dispersion compensators, are used to manage the photons in order to match the system requirements. In this presentation, several different technologies and devices for optical signal processing will be discussed.

Optical 5

Wednesday, 17 January, 17:10–-8:00

Theory and Techniques for Optical Networks

Dr. Jerry Bautista, Vice President Technology and CTO, Wavesplitter Technologies (US)

A review of current state-of-the-art optical devices based on planar lightwave circuits (PLC) and advanced fused fiber technology is offered. Planar lightwave circuits allow complex optical functions for high channel count DWDM systems to be integrated on a silicon

[Continued on page 80]

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Dissipation Factor @10GHz		0.002	0.004
Water Absorption	%	0.06	0.06
Tg	°C	>280	>280
CTE-Z Axis	ppm/°C	46	50
Dimensional Stability	mils/in.	<0.3	<0.5
Flexural Strength	KPSI	28	31
Flammability Rating		NA	94VO

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Rogers Corporation Microwave Materials Division • 100 S. Roosevelt Avenue, Chandler, AZ 85226 • Tel: 480-961-1382 FAX: 480-961-4533 platform. This platform allows for device flexibility without the typical increased manufacturing or development costs. Advanced fused fiber technology is critical for next generation optical amplifiers including Raman amplifiers, as well as dense interleaver products. Both of these applications are critical for enabling tomorrow's DWDM systems where higher bit rates and narrower channel spacing provide the required bandwidth. The range of devices that can be made from PLC and fused-fiber platform technologies include array waveguides, switches and optical add/drop multiplexers, dispersion compensators, high power pump combiners and channel interleavers.

Henry Yaffe, CTO, Yafo Networks (US)

Transmission Limitations Due to Optical Fiber Degradations

These degradations may be better understood and therefore managed if we examine the nature of these degradations and their corresponding effects. This presentation examines two major sources of optical degradations: polarization mode dispersion and chromatic dispersion. These effects and methods to manage them in order to achieve high speed, high quality transmission are discussed.

Optical 6

Thursday, 18 January, 8:30–9:20

Optical Network Monitoring, Restoration and Management

Ian Clark, Senior Systems Engineer, CIENA Europe (UK)

This presentation covers transparent transmission of ATM, IP and fractional gigabit Ethernet, and transmission distances from urban rings (metro) to long haul (2500 km+). Optical platforms for tomorrow's data rates (40 Gbits) are described, and optical services delivered from CIENA's Optical Services Platform CoreDirector are presented. Product families to fit all needs, managed under a services umbrella are discussed, along with optical dialtone, bandwidth on demand from automated IP routers, as well as network management from Web browser technologies.

Jean-Francois Rousselet, Daussault DA

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Broadband RF and Microwave

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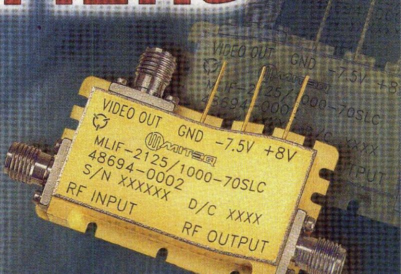

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MLS-550/500-70	300 to 800	-70 to 0	-73	±1.5	10	25	35
MLS-1000/500-70	750 to 1250	-67 to ±3	-70	±1.5	10	25	35
MLS-2000/1000-70	1500 to 2500	-67 to ±3	-70	±1.5	15	30	40
MLS-3000/2000-70	2000 to 4000	-65 to +5	-68	±2.0	10	25	35
MLS-5000/2000-70	4000 to 6000	-65 to +5	-68	±2.0	10	25	35

For additional information, please contact Boris Benger at (631) 439-9402, fax (631) 439-9540 or e-mail bbenger@miteq.com

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2000 • VOLUME 43

ANTENNAS

CAD/CAM

COMMERCIAL APPLICATIONS

COMPONENTS/SUBSYSTEMS

COVERS

DESIGN

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■ INSTRUMENTS/MEASUREMENTS

■ PRODUCT FEATURES

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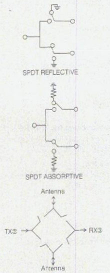

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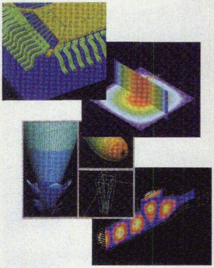

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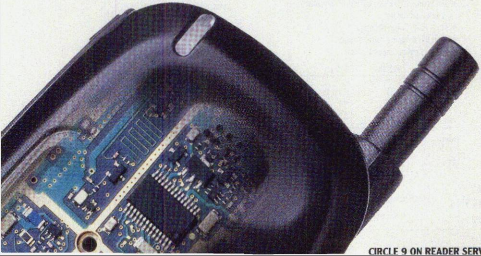

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Behavioral Modeling of High Power Amplifiers Based on Measured Two-tone Transfer Characteristics

Multi-stage high power amplifiers generally have a large memory effect and high nonlinearity. The usual AM-AM and AM-PM measurement data cannot describe the large distortion characteristics in the presence of the system's large memory. A more accurate amplifier behavioral modeling method based on two-tone transfer characteristics is presented and the measurement setup for these characteristics is described. The measured data are modeled using the conventional AM-AM and AM-PM model to fit the measured amplitudes and phases of the fundamental, third-order intermodulation (IM3) and fifth-order intermodulation (IM5) components. This is a quasi-memoryless model. However, it provides a better description of memory effects and an accurate presentation of highly nonlinear characteristics than the same quasi-memoryless model based on the single-tone transfer characteristics.

It is very useful to simulate the system level performance of power amplifiers using a simple behavioral or mathematical model. Class A power amplifiers have normally been treated with the assumption of a memoryless (representation of AM-AM characteristics only) or quasi-memoryless (complex representation of both AM-AM and AM-PM characteristics) system.[1–6] However, accurate characterization and modeling of very high power amplifiers with an output power of over a few hundred watts are very difficult because of their high nonlinearity and large memory effects. The single-tone transfer characteristics (measured AM-AM and AM-PM characteristics) cannot properly describe the nonlinearity of these high power amplifiers because they have no memory information. However, the two-tone nonlinear transfer characteristics including the amplitude and phase responses of the fundamental, IM3 and IM5 components contain the highly nonlinear properties and

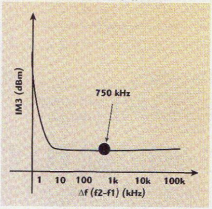
[Continued on page 92]

Youngoo Yang, Jaehyok Yi, Joongjin Nam and Bumman Kim
Department of Electronic and Electrical Engineering and Microwave Application Research Center
Pohang University of Science and Technology
Namku Pohang, Korea

are representative of the amplifier's large memory. Hence, the behavioral model based on two-tone transfer characteristics can reasonably predict the integrated average distortion for non-constant envelope signals (for example, π/4 QPSK and 16 QAM signals). For most high power amplifiers, the behavioral model based on single-tone transfer characteristics cannot even accurately predict the simple response of the amplitudes of the IM3 and IM5 in the two-tone test. W. Bosch, et al., reported on a case where a predistortion linearized amplifier with improved AM-AM and AM-PM characteristics did not provide any enhancement over two-tone intermodulation nonlinearity.[7] Therefore, a more accurate behavioral model based on two-tone characterization with phase information would be a better choice for modeling of multi-stage high power amplifiers.

This article presents an accurate measurement and modeling technique for determining the two-tone transfer characteristics of high power amplifiers. For the measurements, the amplifier output is down-converted to an intermediate frequency and the relative phase is measured by comparison with a reference signal. The relative phases of the harmonic terms of a very low frequency amplifier are 0° or 180°. A low power GaAs MESFET amplifier at 750 kHz is used for the reference intermodulation (IM) generator. The measured two-tone data have been fitted to the conventional model of AM-AM and AM-PM distortion characteristics. A 500 W class AB multi-stage power amplifier is used for measurement and modeling. The measurement set-up and sequence are described and the measured and modeled results are also shown.

Fig. 1 Conventional IM3 characteristics vs. tone spacing for a two-tone input case in the presence of a large memory effect.



WHY TWO-TONE CHARACTERIZATION?

The output signal having a memory effect is determined by both the real time input signal and the previous input signals, and it causes a drastic variation of the nonlinear behavior of power amplifiers. The effects of nonlinear behavior due to memory effect are an asymmetric IM spectra between lower (2f1-f2 for IM3) and upper (2f2-f1 for IM3) components and IMD characteristic variation for different tone spacings (Δf). The asymmetry of the IMD spectra is not discussed in this article because it can be avoided by proper stage matching (to avoid multiple reflection) and well-designed bias circuits (low frequency harmonic termination — resistive or short).

The IMD variation for different tone spacings due to large-time-constant memory effects is mainly caused by the thermal time constants of the high power amplifiers.[7,8] Generally, IM3 variation characteristics for various tone spacings are shown in ***Figure 1***, based on the results of Lu, et al.[8] From the graph, IM3 drastically decreases and settles down as the tone spacing (Δf) is increased. Hence, the single tone characteristics, which can be treated as asymptotically zero tone spacing, cannot represent the average distortion of a high power amplifier with a large memory. On the other hand, the two-tone characteristics with proper tone spacing (750 kHz in this experiment) better represent the nonlinear behavior of power amplifiers. Therefore, the behavioral model based on properly measured two-tone transfer characteristics will predict the integrated adjacent channel emission characteristics of the high power amplifier when it is applied to the modulated signals (for example, WCDMA, CDMA-2000).

MEASUREMENT OF THE TWO-TONE TRANSFER CHARACTERISTICS

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[Continued on page 94]

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S4W2	S4W5	N4W5	4	±0.40
S5W2	S5W5	N5W5	5	±0.40
S6W2	S6W5	N6W5	6	±0.40
S7W2	S7W5	N7W5	7	±0.60
S8W2	S8W5	N8W5	8	±0.60
S9W2	S9W5	N9W5	9	±0.60
S10W2	S10W5	N10W5	10	±0.60
S12W2	S12W5	N12W5	12	±0.60
S15W2	S15W5	N15W5	15	±0.60
S20W2	S20W5	N20W5	20	±0.60
S30W2	S30W5	N30W5	30	±0.85
S40W2	S40W5	N40W5	40	±0.85

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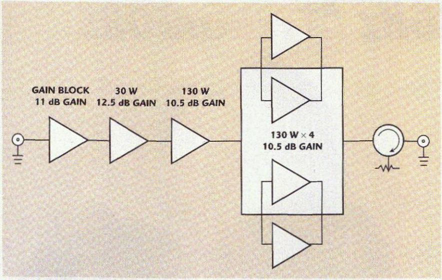

Fig. 2 Class AB high power amplifier module for measurement and modeling.

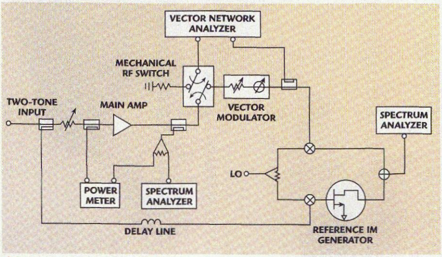

Fig. 3 Measurement setup for two-tone transfer characteristics.

band of 2.37 to 2.40 GHz. Its final stage consists of four balanced 130 W LDMOS FETs (Motorola's MRF-21120 RF LDMOS FET). It is a push-pull-type configuration with class AB operation. The other three stages are arranged to drive the final stage amplifier. The peak output power at the 1 dB gain compression point is approximately 500 W and the overall gain is 44.5 dB. The operational average output power is 45 W for a WCDMA signal with a chip rate of 8.192 Mcps. ***Figure 2*** shows a line-up diagram of the main amplifier used for measurement and modeling.

The measurement setup is shown in ***Figure 3***. This setup requires a two-tone signal generator, a vector network analyzer, a two-input power meter and two spectrum analyzers. The reference IM generator is Agilent's ATF21186 low power MESFET and operates at a center frequency of 750 kHz. At this low frequency the memory effect of the device can be ignored because its nonlinear capacitances are nearly open-circuited and the propagation delay is negligible. Hence, the device has no AM-PM characteristics and its fundamental, IM3 and IM5 components show no phase variations with input power level changes. This characteristic is verified with two-tone harmonic balance simulation using the large signal model of the device. ***Figure 4*** shows the results of this simulation. The phases of the fundamental, IM3 and IM5 signals are constant throughout input power level changes up to the 1dB gain compression point. The fundamental and IM5 signals have equal phase and IM3 is 180° out of phase because the third-order volterra series coefficient (gm3) has a negative sign.

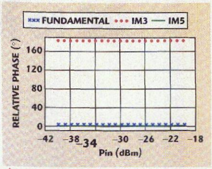

Fig. 4 Simulated relative phases of fundamental, IM3 and IM5 of reference IM generator vs. two-tone input power level at 750 kHz center frequency.

The two-tone input signal, which has a tone spacing of 100 kHz, is tapped to the reference path. The tone spacing is carefully chosen to consider the transient response of IMD with tone spacing in the two-tone signal and the integrated adjacent channel power (ACP) contributed by different delta-frequencies in the CDMA signal. The main path signal passes through the step attenuator for input power level control, and is then coupled to power meter A for monitoring the input power. The main amplifier output signal is attenuated and coupled to power meter B for monitoring the output power and to the spectrum analyzer for relative power measurements of IM3 and IM5. The vector modulator, which consists of a variable attenuator and variable phase shifter, is used to adjust the amplitude and phase of the fundamental, IM3 or IM5 components of the output signal in order to cancel the corresponding reference signal component at the adder.

Finally, the output signal and the reference signal are down-converted to approximately 750 kHz. The down-converted reference signal is amplified by the reference IM generator and the reference IM terms are generated. The output and reference signals are canceled using an analog adder circuit. This low frequency part may well be shielded to block out environmental noise. The vector network analyzer measures the required phase variation of the vector modulator for the cancellation by reading the phase of S_{21}. The mechanical RF switch connects and disconnects the loop without breaking calibration.

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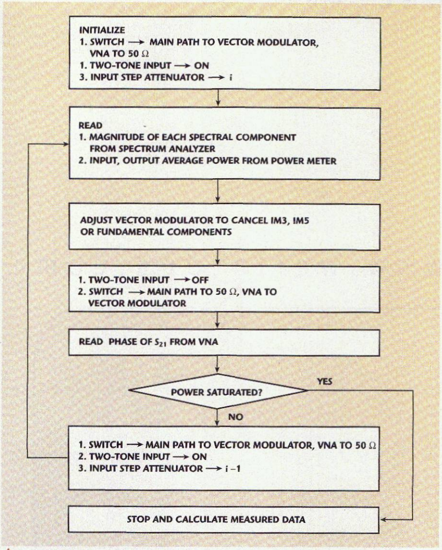

▲ *Fig. 5 Measurement sequence flow chart.*

The complete flow of the measurement sequence is shown in ***Figure 5***. For initialization, the vector network analyzer port 1 is connected to a 50 Ω load and the main path is connected to the vector modulator by a mechanical RF switch, the two-tone input is on and the input step attenuator is set to an appropriate starting power level. The input and output powers are read from the power meter and the relative amplitudes of the fundamental, IM3 and IM5 signals are acquired from the spectrum analyzer. Next, the vector modulator is adjusted to cancel the fundamental, IM3 or IM5 components. After the adjustment has been completed, the two-tone input is turned off at the signal generator and the RF switch changes the connection of vector network analyzer port 1 to the vector modulator and the main path to a 50 Ω load in order to measure the relative phase variation of the vector modulator. After reading the phase of S_{21} from the vector network analyzer, the RF switch connects the main path to the vector modulator, the two-tone input is switched on, and the input step attenuator is set to increase the input power level.

This sequence is repeated for the fundamental, IM3 and IM5 phase measurement until the output power of the main amplifier is saturated. The measured data provide the relative phase variations of the fundamental, IM3 and IM5 components of the main amplifier. The reference IM3 phase offset of 180° is de-embedded from the measured relative phase of IM3.

BEHAVIORAL MODELING USING AM-AM AND AM-PM FUNCTIONS

The measured two-tone characteristics are fitted to the general quadrature AM-AM and AM-PM nonlinearity model. The nonlinear transfer function of the power amplifier is formulated as

$$v_{out}(t) = A[v_{in}(t)] \bullet \exp\{j \bullet \Phi[v_{in}(t)]\} \quad (1)$$

where

$v_{in}(t)$ = input envelope signal of power amplifier
$v_{out}(t)$ = output envelope signal of power amplifier

In this experiment, the AM-AM distortion function is modeled using a modified sine series from the work of A. Leke and J.S. Kenney[5] and the AM-PM distortion function is a rational polynomial. AM-AM and AM-PM functions used in this experiment are represented as

$$A[v_{in}(t)] = a_0 \bullet v_{in}(t) + \sum_{n=1,2,3...} a_n \bullet \sin[(2n-1) \bullet \xi \bullet v_{in}(t)] \quad (2)$$

$$\Phi[v_{in}(t)] = \frac{\sum_{n=0,1,2...} b_n \bullet v_{in}(t)^n}{1 + c_0 \bullet v_{in}(t)^2 + c_1 \bullet v_{in}(t)^4} \quad (3)$$

where

ξ = input scaling factor
a_n = AM-AM expansion parameters
b_n, c_0 and c_1 = AM-PM expansion parameters

To extract the model parameters, all of the AM-AM and AM-PM coefficients are optimized to fit the measured amplitudes and phases of the fundamental, IM3 and IM5 simultaneously throughout the input power level range. As the nonlinearity and memory effect of the amplifier increase, more amplitude and phase modulation coefficients are required to fit the measured data. Twenty-seven parameters are used to represent amplitude modulation and 16-parameters, including c_0 and c_1, to represent phase modulation of the class AB 500 W high power amplifier.

The rather large number of parameters used in this experiment is essential for accurately predicting the substantial nonlinearity of the multistage class AB high power amplifier. It may require more parameters to fit

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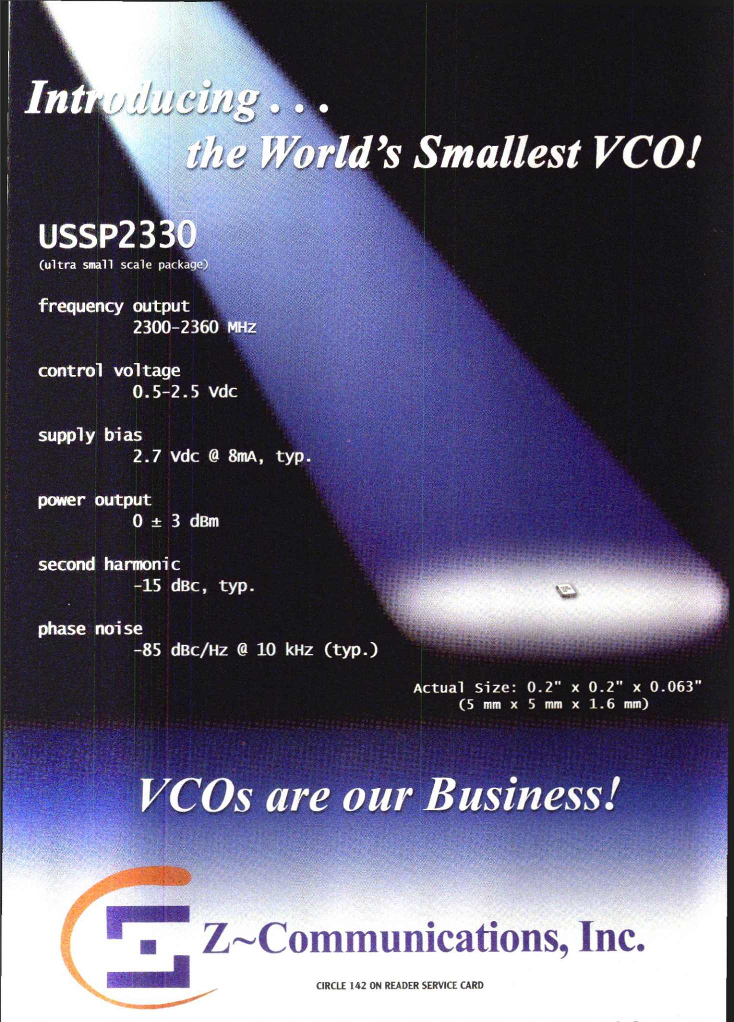
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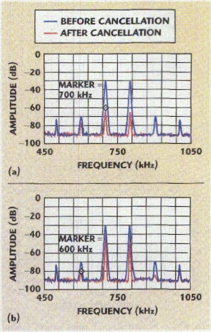
the rapidly changing data than that based on single-tone transfer characteristics. It means that the single-tone-based model cannot provide an accurate description of the highly nonlinear characteristics and the results may be very sensitive to the measurements, model functions and function parameters. The model parameters are optimized in Agilent's Advanced Design System (ADS) using the symbolic defined device (SDD) function.

MODELING RESULTS

Figure 6 shows the spectra of the output before and after cancellation by the vector modulator at an average output power of 50 dBm for fundamental and IM3 cancellation. To measure the relative phases, more than 30 dB cancellation has been achieved for the fundamental components. A 30 dB cancellation provides approximately a ±1.8° phase error range, if the amplitudes of the two branches are perfectly matched. However, for IM3 and IM5, the cancellation cannot reach as high as 30 dB at a low input power level due to the noise floor level of the spectrum analyzer. In the case of 15 dB cancellation, for example, the relative phase error range is increased to more than ±10° if the amplitudes of the main path and reference path are perfectly matched. But the relative phase error range can be drastically reduced (to ±1.5°) when the amplitude mismatch between the two branches is about 1.7 dB and a 15 dB cancellation is maintained. To obtain highly accurate measurement data of the relative phases of fundamental, IM3 and IM5 components, a proper amplitude mismatch condition should be applied.



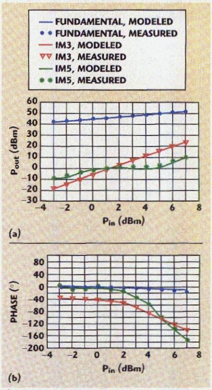
▲ *Fig. 6 Measured spectra of amplifier output before and after cancellation; (a) fundamental cancellation and (b) IM3 cancellation.*

Figure 7 shows the measured and modeled amplitude and phase characteristics of the high power amplifier under test. The two-tone average output powers of the fundamental, IM3 and IM5 signals are plotted in Figure 7(a). The measured and modeled relative phases are plotted in Figure 7(b). The first measurement point of fundamental is set to zero phase and the others are calculated to have relative values. As the power level approaches the saturation point, the phases of IM3 and IM5 vary greatly. The measured and modeled two-tone characteristics are in agreement.

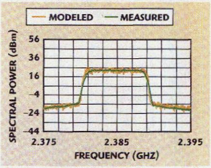
To verify this model, the measured and modeled adjacent channel power ratios (ACPR) of a WCDMA signal are compared. To accurately predict the ACPR of the high power amplifiers, an exact modeling of the amplitudes and phases of the fundamental, IM3 and IM5 components is inevitably required. A WCDMA signal with a chip rate of 8.192 Mcps and average output power of 45 W is used for the verification. The measured data are compared with the simulated data in the WCDMA co-simulation setup of the ADS using data flow and envelope simulations simultaneously. As shown in ***Figure 8***, the measured and modeled ACPRs have a very similar trend.

CONCLUSION

A new, accurate method for measuring and modeling two-tone transfer characteristics has been presented to take into account the memory effect of high power amplifiers. For phase measurement, a reference IM generator at a very low frequency was used. The two-tone harmonic balance simulation shows the accuracy of the relative phase of the reference IM generator. The complete measurement setup and sequence have been described. For the experiment, a multi-stage high power amplifier with 500 W peak envelope power and 44.5 dB gain was employed. The relative



▲ *Fig. 7 Measured and modeled two-tone transfer characteristics of high power amplifier; (a) amplitude and (b) phase.*



▲ *Fig. 8 Measured and modeled WCDMA responses with a chip rate of 8.192 Mcps and average output of 45 W.*

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phases of fundamental, IM3 and IM5 components were measured. The measured data of IM3 and IM5 are very smooth and continuous, and vary greatly as the power level approaches the saturation output power.

These measured two-tone amplitudes and phases have been modeled. The model accurately represents high nonlinearities and rapid phase variations of a high power class AB amplifier. A WCDMA measurement and simulation have been conducted for verification. The measured and modeled ACPRs are in agreement. This nonlinear behavioral model of a high power amplifier is very useful for the design of various predistortion linearizers and for the simulation of the amplifier systems incorporating various digital and analog control circuits. ■

References

1. K.G. Gard, H.M. Gutierrez and M.B. Steer, "Characterization of Spectral Regrowth in Microwave Amplifiers Based on the Nonlinear Transformation of a Complex Gaussian Process," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 47, No. 7, July 1999, pp. 1059–1069.
2. H.M. Gutierrez, K.G. Gard and M.B. Steer, "Spectral Regrowth in Microwave Amplifiers Using Transformation of Signal Statistics," *IEEE MTT-S International Microwave Symposium Digest*, June 1999, pp. 985–988.
3. Q. Wu, H. Xiao and F. Li, "Linear RF Power Amplifier Design for CDMA Signals: A Spectrum Analysis Approach," *Microwave Journal*, Vol. 41, No. 12, December 1998, pp. 22–40.
4. C.J. Clark, G. Chrisikos, M.S. Muha, A.A. Moulthrop and C.P. Silva, "Time-domain Envelope Measurement Technique with Application to Wideband Power Amplifier Modeling," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 46, No. 12, December 1998, pp. 2531–2540.
5. A. Leke and J.S. Kenny, "Behavioral Modeling of Narrowband Microwave Power Amplifiers with Applications in Simulating Spectral Regrowth," *IEEE MTT-S International Microwave Symposium Digest*, 1996, pp. 1385–1388.
6. S. Chen, W. Panton and R. Gilmore, "Effects of Nonlinear Distortion on CDMA Communication Systems," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 44, No. 12, December 1996, pp. 2743–2750.
7. W. Bosch and G. Gatti, "Measurement and Simulation of Memory Effects in Predistortion Linearizers," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 37, No. 12, December 1989, pp. 1885–1890.
8. K. Lu, P.M. McIntosh, C.M. Snowden and R.D. Pollard, "Low-frequency Dispersion and Its Influence on The Intermodulation Performance of AlGaAs/GaAs HBTs," *IEEE MTT-S International Microwave Symposium Digest*, 1996, pp. 1373–1376.

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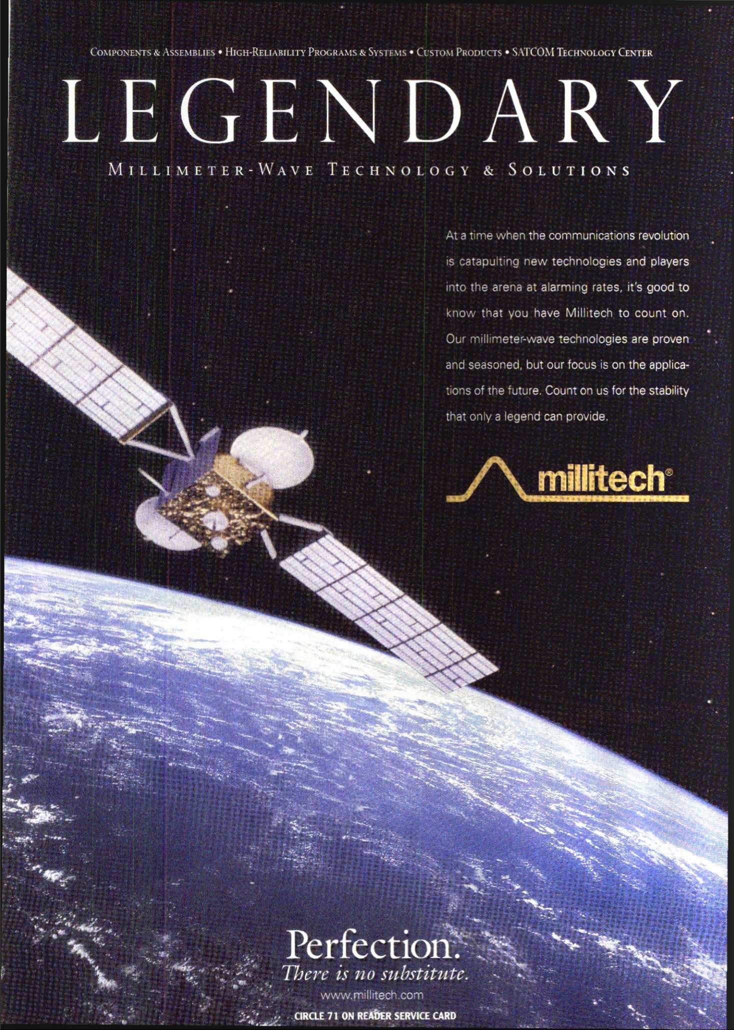

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3D FEM AND EM SIMULATIONS FOR DRFs

Three-dimensional (3D) fullwave analysis of a microwave dielectric resonator filter (DRF) in a rectangular metallic enclosure is presented. By using a 3D finite-element method (FEM) to perform numerical simulations, parameters and predictions that are difficult to measure but actually affect the performance of a microwave DRF can be accurately determined. In the process, a significant phenomenon was uncovered. The numerical results are in agreement with the experimental measurements.

Due to its desirable properties such as small size, low cost and good temperature stability, a DR not only acts as a frequency determination element but also offers high stability.[1,2] Analysis methods of the inner electromagnetic properties of applied DR devices such as the perfect magnetic conducting wall method,[3] the moment method based on the surface integral techniques[4,5] and general mode matching approaches[6,7] have been studied. Although the E-field and H-field attributes inside a microwave DRF are hard to observe, an accurate analysis of the overall inhomogeneous structure is inevitably required for practical design and application considerations.

With the advancement of computer hardware and software, numerical techniques enable us to perform more rigorous and complicated analysis on 3D structures. Two- and three-dimensional finite-element methods applied for microwave DRF simulation have been previously reported.[8,9] In those articles, DRFs coupled by coaxial probes were numerically simulated in the $TM_{01\delta}$ mode with a cylindrical DR placed along the central axis. In addition, a 3D FEM simulation of a DR coupled to microstrip lines in a DRF was studied by Chuang, et al.[10] for various dielectric constants.

This article deals with excitation in the $TE_{01\delta}$ mode, the highest Q value among all resonant modes of a cylindrical DR coupled to microstrip lines. The Ansoft® 3D FEM CAD tool of the high frequency structure simulator (HFSS) was used to compute the 3D structure of the DRF.

DRF DESIGN AND FABRICATION PROCEDURES

The coupling coefficient between DRs and the external coupling Q factor of a resonator to a microstrip line have been clearly described by Sun, et al. [2] The design and fabrication procedures of a DRF are briefly described as follows: First, the size of metal cavity and DRs are chosen from bandpass filter (BPF) specification requirements; next, the theoretical external Q and coupling coeffi-

[Continued on page 108]

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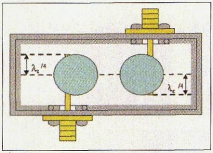
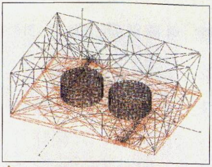


▲ *Fig. 1 The top view of a DRF in a metallic cavity.*



▲ *Fig. 2 FEM with 15292 meshes of the DRF structure.*

TABLE I

THE DRF PARAMETERS

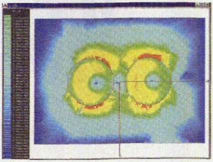
Number of DRs	2
DR ε_r	36
DR height (mm)	2.72
DR radius (mm)	3.43
Substrate ε_r	9.8
Substrate height (mm)	0.635
Inner dimensions (mm)	25.4 × 18.3 × 9.0
Microstrip line width (mm)	0.635

cients of the desired BPF are determined, along with the external Q values and coupling coefficients ($k_{j,j+1}$); finally, the DRF is assembled in the metallic cavity.

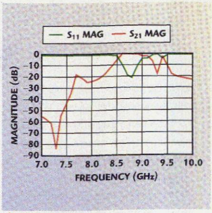
The top view of the DRF, shown in ***Figure 1***, indicates two DRs coupled to two straight microstrip lines in a rectangular metallic enclosure. The parameters of the designed DRF are listed in ***Table 1***. Element values of the designed DRF are $g_0 = 1.0000$, $g_1 = 1.0378$, $g_2 = 0.6745$ and $g_3 = 1.5386$ with coupling parameters of $Q_{e\ in} = 58.38$, $k_{12} = 0.02125$ and $Q_{e\ out} = 58.38$,[2] where $Q_{e\ in}$, $Q_{e\ out}$ and k_{12} are the external Q factors at the input and output ports and the coupling coefficient between two DRs, respectively.

DRF 3D FEM SIMULATIONS

Generally speaking, it is required to divide the structure into triangular two-dimensional (2D) or tetrahedron (3D) subdomains for EM analyses. FEM was applied to solve Maxwell's equations of the 3D-structured DRF. The FEM tool of Ansoft HFSS for 3D-structure computation was carried out on an HP-9000/735 with a PA-RISC7100 CPU and a 99 MHz clock rate. ***Figure 2*** shows the FEM with 15292 meshes that models the DRF 3D structure. ***Figure 3*** shows the E-field distribution parallel to the X-Y plane of the DRF with two straight microstrip couple lines. It is clear to see that the E-field distribution is not symmetrically centered on the circular plate of the DR dielectrics. Its simulated S_{11} and S_{21} results are shown in ***Figure 4***, which indicates the broaden area of rejection slope on the sideband.



▲ *Fig. 3 E-field distribution of DRF with two DRs coupled to two straight microstrip lines.*



▲ *Fig. 4 S_{11} and S_{21} of the DRF with two straight microstrip configuration.*

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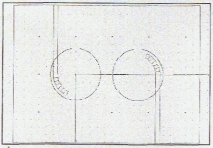
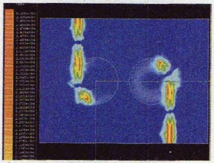
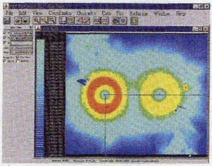


▲ *Fig. 5 Structure of DRF with the coupled microstrip in an arc shape.*

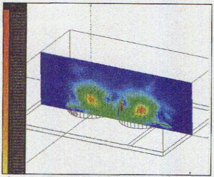


▲ *Fig. 6 Current distribution on surface of the substrate.*

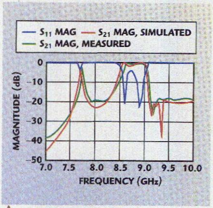


▲ *Fig. 7 E-field round symmetrical distribution of the DRF with the coupled microstrip configuration.*

After altering its coupling configuration as shown in ***Figure 5***, the filter's performance is greatly improved. Current distribution on the substrate surface of the DRF is shown in ***Figure 6***, and ***Figure 7*** illustrates the E-field distribution as being almost a symmetrical circle enclosed around the center of DR ceramics. This effective phenomena of the E-field and H-field distribution indicates that a coupled microstrip line with its arc-shaped open-end induces a better symmetrical E-field distribution than just a straight microstrip couple line. It improves the performance of the DRF by allowing most of the E-field energy to be symmetrically stored in the high Q dielectric resonator. ***Figure 8*** shows the H-field vector distribution seen from a cutaway surface



▲ *Fig. 8 H-field vector distribution of the arc-shaped microstrip of the DRF.*



▲ *Fig. 9 Comparison between the measured and simulated results of the DRF.*

parallel to y-axis of the DRF. It obviously demonstrates that the magnetic field vector distribution is the H-field coupling of the $TE_{01\delta}$ mode that operates like a magnetic dipole mode with magnetic coupling in between. ***Figure 9*** shows the simulated data which is better than the previous performance and in agreement with the measured results.

CONCLUSION

This article has presented a 3D full-wave analysis of a microwave DRF in a rectangular metallic enclosure. By using 3D FEM for numerical simulations, the device's field and current distribution can be visualized in a physical structure to abet the design process. The EM analysis permits accurate parameters and predictions to be determined that are difficult to measure and important for a microwave DRF designer to understand. The article also investigated the 3D electromagnetic and current distributions of the designed DRF with different couple configurations. It was discovered that the

[Continued on page 112]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performance of the DRF is improved by altering the microstrip coupling structure to an arc shape. The E-field distribution is mostly a symmetrical circle shape around the center of the DR. Obviously, most of the E-field energy is stored in the high Q dielectric resonator in this way. The numerical results of the microstrip DRF are in agreement with experimental performance. ■

References

1. D. Kajfez and P. Guillon, *Dielectric Resonators*, Artech House, 1986.
2. J.S. Sun and Y.L. Huang, "Design and Implementation of an X-Band DR Bandpass Filter," *Microwave Journal*, Vol. 42, No. 11, September 1999, pp. 92–103.
3. Okaya and Barash, "The Dielectric Microwave Resonator," *Proceedings of the IRE*, Vol. 50, October 1962, pp. 2081–2092.
4. A.W. Glisson, D. Kajfez and J. James, "Evaluation of Modes in Dielectric Resonators Using a Surface Integral Equation Formulation," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 31, December 1983, pp. 1023–1029.
5. A.W. Glisson and D.R. Wilton, "Simple and Efficient Numerical Methods for Problems of Electromagnetic Radiation and Scattering from Surfaces," *IEEE Trans. Antennas Propagat.*, Vol. 28, September 1980, pp. 593–603.
6. J. Van Bladel, "On the Resonances of a Dielectric Resonator of Very High Permittivity," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 23, February 1979, pp. 195–208.
7. M. Verplanken and J. Van Bladel, "The Electric Dipole Resonances of Ring Resonances of Very High Permittivity," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 24, February 1976, pp. 108–112.
8. J. Cousty, S. Verdeyme, M. Aubourg and P. Guillon, "Finite Elements for Microwave Device Simulation: Application to Microwave Dielectric Resonator Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-40, No. 5, May 1992, pp. 925–932.
9. D. Baillargent, S. Verdeyme, M. Aubourga and P. Guillon, "CAD Applying the Finite-element Method for Dielectric Resonator Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-46, No.1, January 1998, pp. 10–17.
10. H.R. Chuang, J.W. Huang, C.C. Wei and J.C. Chang, "3D DEM Simulation and Experimental Measurements of Microstrip Dielectric Resonator Filters," *Microwave and Optical Technology Letters*, Vol. 8, No. 4, March 1995, pp. 196–200.

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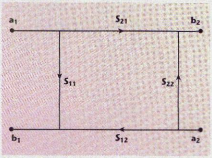
Measurement of Modulated Scattering Parameters using Modulated Vector Network Analysis

A new architecture for RF and microwave measurement has recently been introduced. The first instrument based on this architecture is called the modulated vector network analyzer (MVNA™). The MVNA shares some similarities with traditional vector network analyzers (VNA), which use sinusoidal stimuli to measure scattering parameters. The MVNA also has the ability to measure S-parameters, but can do so using modulated waveforms.

The concept of modulated S-parameters is new to the test and measurement world. The traditional VNA could not use real world signals, that is stimulus matching the end use of the device under test. Because of this drawback there has been some confusion about what modulated S-parameters mean. This article introduces the concept of modulated S-parameters. However, before discussing them, it is best to start with traditional (sinusoidal) S-parameters.

Fig. 1 S-parameters for a two port device.



SINUSOIDAL VECTOR NETWORK ANALYSIS

Figure 1 shows the four S-parameters for a two port device. The S-parameters are transfer functions which generally have different complex values at different frequencies. These functions of frequency describe how the device modifies input waveforms (a_1 and a_2) and produces output waveforms (b_1 and b_2).

Mathematically, the four S-parameters are defined as

$$S_{11} = \left.\frac{b_1}{a_1}\right|_{a_2=0} \qquad S_{12} = \left.\frac{b_1}{a_2}\right|_{a_1=0}$$

$$S_{21} = \left.\frac{b_2}{a_1}\right|_{a_2=0} \qquad S_{22} = \left.\frac{b_2}{a_2}\right|_{a_1=0}$$

Thus, S_{11} is the ratio of b_1 to a_1 when a_2 is zero, and similarly for the other S-parameters.

In order to account for the non-ideal properties of the measurement instrument and various cables and fixtures connecting the instrument to the device, a model accounting

[Continued on page 116]

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Attenuation Step (dB)	0.2	1
Nominal Impedance	50 ohm	
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Average Power Handling	1W @ 2GHz	
Temperature Range	-30°C ~ +80°C	
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Nominal Impedance	50 ohm		
I/O Port Connector	SMA(F) / SMA(F)		
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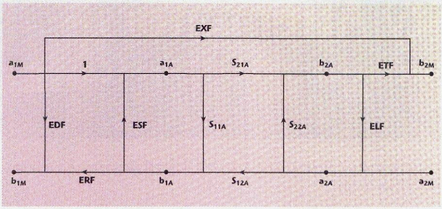
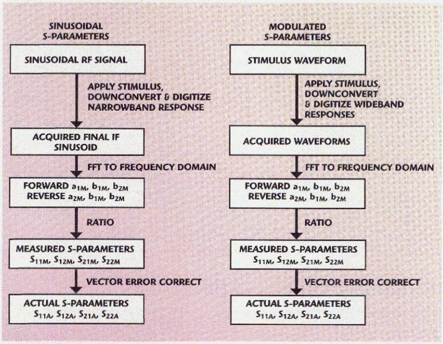


▲ *Fig. 2 Six-term forward error model.*



▲ *Fig. 3 The process of measuring and computing modulated and sinusoidal S-parameters.*

for these errors is introduced. ***Figure 2*** shows a six-term forward error model for a VNA. The reverse error model is similar, but with slightly different names for the error terms. In this model the measured waveforms have an M subscript, while the actual waveforms at the device have an A subscript. The S-parameters of the device are also denoted with an A subscript to distinguish them from the measured S-parameters. The terms beginning with an E are the error terms, which are used to model the non-ideal properties.

Through a process called calibration, the complex values of the error terms as functions of frequency are determined. The various terms in the error model are assumed not to vary over time or power level. They are assumed to model a system, which is linear. If the instrument, cables or fixtures are nonlinear then the error model will not be a good representation.

Figure 3 shows the flow of measuring and computing S-parameters. The arrows represent physical or mathematical operations while the boxes represent results.

The VNA applies a sinusoid of a known frequency at point a_{1M}. Measurements are made at points b_{1M} and b_{2M}. Measurements made in this manner are called forward measurements. A sinusoid of the same frequency is then applied at point a_{2M} and measurements made at b_{1M} and b_{2M}. Measurements made in this manner are called reverse measurements.

These forward and reverse measurements are then combined mathematically in a process called ratioing to produce measured S-parameters (for example, S_{11M}).

The effects of the various error terms in the six-term forward error model can then be removed by a process called vector error correction. The results of vector error correction are the actual S-parameters of the device (for example, S_{11A}).

Once the S-parameters have been determined for one frequency, the frequency can be changed and the measurement and mathematical process repeated. The end result of a VNA measurement of a two port device is the four S-parameters with the effects of the instrument and connections removed. These four transfer functions are complex functions of frequency.

MODULATED VECTOR NETWORK ANALYSIS

An MVNA operates similarly to a VNA in that it applies a stimulus at point a_{1M} in the forward error model. However, in this case the stimulus is not a sinusoid of a single frequency, but rather a modulated waveform with a continuum of energy spread around a carrier frequency. In order to produce this modulated signal, the sinusoidal source of the VNA is replaced by a modulated source. In the case of the MVNA, the source most frequently used is a synthesized RF signal generator with the I/Q modulator driven by two high speed arbitrary waveform generators; however, any modulated or unmodulated RF signal can be applied.

On the measurement side, wideband receivers replace the narrowband receivers of a VNA. Each receiver in the MVNA is a high speed transient digitizer with 15 MHz of usable bandwidth. Where the VNA must move from frequency to frequency making measurements at each, the MVNA can capture up to 15 MHz of frequency content at a time.

Thus, modulated S-parameters are computed very similarly to sinusoidal S-parameters. The primary difference being the MVNA's ability to compute S-parameters at multiple frequencies based on a single acquisition rather than repetitive, stepped frequency measurements.

[Continued on page 118]

THE USEFULNESS OF MODULATED S-PARAMETERS

The ability to measure S-parameters under modulated stimuli can be quite valuable, particularly for devices that behave differently under sinusoidal or modulated stimuli. Amplifiers operating near their compression point are a particularly good application of the MVNA because the gain S_{21} and input match S_{11} can be functions of the excitation type. One classic problem is to tune the input match and gain of an amplifier using a sinusoidal VNA, and then use the device to amplify a modulated signal. The careful tuning of the input matching accomplished using the sinusoid is invalidated because the match is different when using the modulated signal. By contrast, the MVNA allows tuning of the input match and gain of the amplifier using the waveform of interest.

For devices with signal characteristics varying with power or time, the MVNA offers a clean means of determining the S-parameters using the waveform of interest. Devices which do not benefit from measurements on an MVNA are passive devices or devices operating linearly. Thus, cables, connectors, filters and attenuators do not exhibit different S-parameters when measured with sinusoids or modulated waveforms. This fact is somewhat comforting, actually, for it shows that modulated S-parameters are the same as sinusoidal S-parameters in cases where the excitation source should not matter.

CONCLUSION

The ability to measure S-parameters under modulated stimuli can be quite valuable in analyzing the behavior of active devices, particularly those for which high linearity is a desirable performance characteristic. The MVNA allows accurate measurement of device characteristics under real world signal conditions. That is, the test stimulus matches the intended use of the device. The process of calculating modulated S-parameters is similar to the traditional method except for the data acquisition receiver bandwidth. ■

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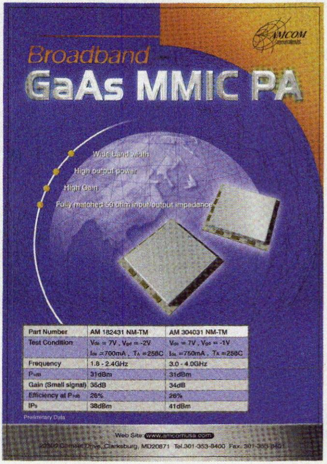
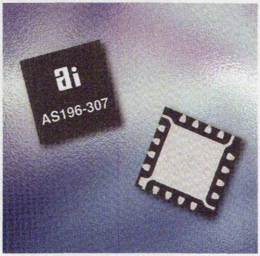


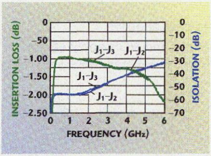


CONTROL PRODUCTS FOR WIRELESS AND BROADBAND APPLICATIONS

Switches, attenuators, directional detectors, phase shifters and other GaAs and silicon devices are shrinking dramatically as suppliers are challenged to develop new process and packaging techniques. Customers are demanding that new devices operate with a higher degree of linearity and maintain performance at low battery voltages, while still driving integration up and costs down.

Alpha Industries is responding to these market demands. As a leading manufacturer of GaAs ICs and silicon discretes used in current wireless, broadband and third-generation (3G) designs, the company is integrating multiple functions into components that cost less and take up less space on a PCB. For example, the new 25 mm^2 model AA107-310 digital attenuator replaces two separate components previously requiring over 100 mm^2 of board space. This represents a four-to-one reduction in real estate.

Fig. 1 AS196-307 insertion loss and isolation vs. frequency.



This article describes some of the innovations resulting from combining the company's core competencies in circuit design, silicon and GaAs semiconductor manufacturing, process integration and packaging. It also touches on products under development to demonstrate the company's ability to provide the technology needed to support the next generation of wireless and broadband applications.

BASE STATION INNOVATIONS

RF GaAs IC Switches

Significant package size reduction has been achieved on many RF GaAs IC switches. The model AS196-307 high isolation GaAs SPDT switch with integrated silicon ASIC 1:2 decoder (shown in the photo above) is packaged in a 4 × 4 mm leadless plastic chip carrier (LPCC-16) exposed-pad package. Very high isolation is achieved by soldering the exposed paddle directly to the PCB ground. Lead inductance is reduced from 2 nH (1 nH/lead) to approximately 0.4 nH (0.2 nH/lead).

The AS196-307 requires only a positive supply voltage (V_{CC} = 3 to 5 V) and one CMOS-compatible control line (V_{CTL} = 0 to 3/5 V). A logic 0 is equal to 0 to 0.5 V while a logic 1 is equal to 3.5 to 5 V with V_{CC} = 5 V. Insertion loss is approximately 1 dB, I/O SWR < 1.4 and isolation 55 dB up to 2 GHz, 40 dB at 4 GHz and 30 dB at 6 GHz, as shown in ***Figure 1***.

[Continued on page 122]

ALPHA INDUSTRIES INC.
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These characteristics make the AS196-307 switch ideal for applications requiring high isolation such as in 2G, 3G, base station LO switching, U-NII time division duplex transceivers and WLL radios.

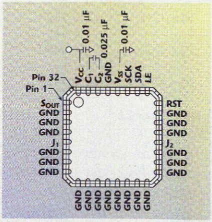
Digital Attenuators

New packaging is also reducing the size of voltage variable digital attenuators. For example, a silicon ASIC serial-to-parallel converter has been integrated with a GaAs attenuator IC in a single micro lead frame 5 × 5 × 1 mm exposed-pad package (MLF-32). ***Figure 2*** shows the attenuator's pinout diagram. The model AA107-310 attenuator takes up just 25 mm^2 on a PCB. Older designs required two separate packages taking up over 100 mm^2.

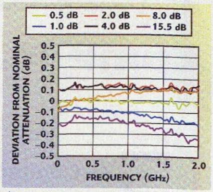
The AA107-310 attenuator is a 5-bit device with 0.5 dB steps to 15.5 dB total attenuation with low insertion loss and high bit accuracy, as shown in ***Figure 3***. It is designed for use as a gain control element in the IF sections (< 500 MHz) of base station radios and is to be used with a reverse path amplifier in broadband systems. Insertion loss is 1 dB, bit accuracy is < ±0.3 dB and SWR is < 1.4 below 500 MHz.

The silicon ASIC performs serial-to-parallel data conversion eliminating the need for individual bit control. Only three inputs are required: serial clock and data, and latch enable. The reset pin can be tied high for truth table control or low for master reset to the insertion loss state. A single positive supply voltage (V_{CC} = 5 V) and three external capacitors are required, one for V_{CC} bypassing, one for a charge pump (C_1, C_2) and one for negative voltage holding. An on-chip negative voltage generator (f = 600 kHz) allows direct control of a standard GaAs attenuator IC eliminating the need to float ground connections.

The model AA109-310 is another new digital attenuator that integrates a silicon ASIC serial-to-parallel convert-



▲ *Fig. 2 AA107-310 pinout diagram.*



▲ *Fig. 3 AA107-310 attenuation accuracy vs. frequency at 25°C.*

[Continued on page 124]

TABLE I

AV111-12 ELECTRICAL SPECIFICATIONS AT 25°C

	Min.	Typ.	Max.
Frequency (GHz)	0.80		1.0
Insertion loss (0 mA control current) (dB)		1.0	1.5
Attenuation at 1.2 mA control current (900 MHz) (dB)	17.5		21.5
SWR all ports		1.5	1.8
Input third-order intercept (dBm)	+37	+40	
Relative phase shift up to 20 dB attenuation* (°)		7	10
Group delay (ns)		0.4	0.9

*When built with external components.

er with a GaAs attenuator IC. It is a 5-bit device with 1 dB steps to 31 dB total with low insertion loss and high bit accuracy. It is designed for use as a gain control element in the RF sections (> 500 MHz) of base station radios. Insertion loss is 2 dB, bit accuracy is < ±0.5 dB and SWR is < 1.8.

The silicon ASIC performs the same function for this device without the negative voltage generator. The GaAs IC is floated on-chip eliminating the need for a negative voltage. The package is the same as the AA107-310 device.

High Dynamic Range Voltage Variable Attenuators

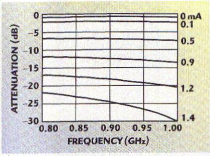
A family of GaAs FET-based low cost, low current, high dynamic range voltage variable attenuators (VVA) has also been developed. Applications are as gain control elements in low power, wireless and broadband systems. They are controlled with a single positive voltage (3 to 5 V) with linear attenuation vs. voltage. Dynamic range is greater than 35 dB. Models AV105-12, AV109-73 and AV110-73 are typical of these devices.

Low Distortion Voltage Variable Attenuators

The distortion performance of the traditional GaAs FET-based VVA is a primary limitation in large signal handling at base stations. The company's solution is based on its GaAs passive IC quadrature hybrid structure technology, low distortion silicon PIN diode design and the small footprint SOIC-8 package. The new HIP3™ attenuator product line comprised of models AV101-12 and AV111-12 (0.8 to 1.0 GHz), AV102-12 and AV112-12 (1.7 to 2.0 GHz), and AV113-12 (2.1 to 2.3 GHz) covers the wireless bands.

For example, the AV111-12 VVA operates at between 0.8 to 1.0 GHz, integrates two silicon PIN diodes and a quadrature hybrid, and operates with an IP3 guaranteed better than 37 dBm. This performance is approximately a 20 dB improvement over a GaAs MMIC-based VVA. Other performance specifications are equally impressive, with an attenuation range higher than 20 dB and a 1.5 dB insertion loss. The AV111-12 is actually a current-controlled attenuator, but it achieves its specified dynamic range with no more than 1.2 mA. *Table 1* lists the AV111-12

[Continued on page 126]



▲ *Fig. 4 AV101-12 typical attenuation vs. current, and attenuation vs. frequency.*

TABLE II

PERFORMANCE TRADE-OFFS

Part No.	Insertion Loss at 900 MHz (dB)	Isolation at 900 MHz (dB)	H_2, H_3 at 900 MHz V_{CTL} = 2.7 V (dBc)
AS190-73	0.37	18	70 to 75
AS191-73	0.45	28	65
AS193-73	0.35	26	67 to 70
P_{IN} = 34.5 dBm			

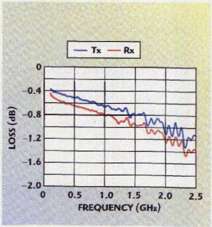
VVA's electrical specifications. ***Figure 4*** shows the AV102-12 VVA's typical attenuation vs. frequency characteristics.

HANDSET INNOVATIONS

RF GaAs IC Switches

Device integration and packaging are critical in handset switches. The AS190-73, AS191-73 and AS193-73 family of PHEMT SPDT switches provide extremely high linearity at low control voltages for handset applications. ***Table 2*** lists the performance trade-offs for each part. These parts all have the same package, pinout and truth table.

The model AS198-306 is a new high power PHEMT SP4T switch with integrated silicon 3:5 decoder in a MLF-16 4 × 4 mm exposed-pad package. The switch has excellent linearity performance at low voltages. Typical second- and third-order harmonics are 65 dBc at 900 MHz and 3 V. Designed for dual-band handset applications, the AS198-306 has low TX path insertion loss (0.6 dB at 900 MHz) and good RX isolation (25 dB at 900 MHz), as shown in ***Figures 5***



▲ *Fig. 5 AS198-306 insertion loss vs. frequency.*

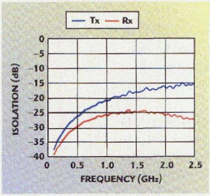
[Continued on page 128]

and **6**, respectively. The integrated silicon decoder reduces the number of positive control lines to three. If used in the 2:4 configurations two control lines can be used.

Directional Detectors

Another innovation combines passive circuit design and semiconductor technology in a monolithic structure that integrates a GaAs directional coupler with GaAs Schottky diodes for use as a broadband detector used as an automatic gain control element. The model DD01-92 directional detector is packaged in a single miniature SC-88 (six lead SC-70) plastic package and operates from 650 MHz to 2.4 GHz. The DD01-92 may be conveniently temperature compensated due to the closely matched pair of Schottky diodes. The monolithic construction of the detector consists of two Schottky diodes and a terminated directional coupler. This product features both small size and low cost, making it appropriate for high volume handset applications.

Figure 7 shows the detector's circuit configuration, and ***Figures 8*** and ***9*** show the device's differential detected voltage, and insertion and return losses vs. frequency, respectively.



▲ *Fig. 6 AS198-306 isolation vs. frequency.*

IN DEVELOPMENT

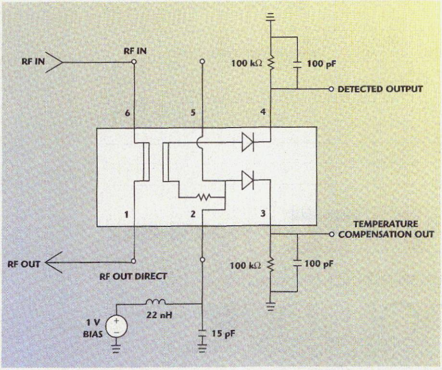
A variety of new control products are currently in development to meet market demands for smaller, more reliable devices. These new products include RF diodes in chip-scale packaging, vector modulators, amplitude phase shifters and low distortion digital attenuators.

Chip-scale Packaging of RF Diodes and GaAs RF ICs

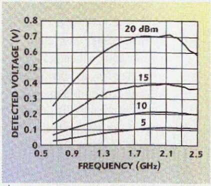
To meet the market demand for smaller components, the company is developing the technologies to produce virtually package-less devices that will be compatible with current pick-and-place insertion techniques. Using cost-efficient, batch-scale processing, which eliminates the need for wire bonding, chip-scale technology creates surface-mountable diodes with dimensions of less than 30 mils (0.7 mm) per side and smaller than 15 mils (< 0.4 mm) in height. This marks a significant height reduction compared to the widely-used 0.7 mm height of the SC-79 package.

Because of its low parasitics, chip-scale PIN diodes in switch and attenuator circuits show a significant improvement in frequency performance in comparison with plastic-packaged parts. A primary limitation to the performance of a broadband control circuit working above 5 GHz has been the parasitic package inductance of the plastic-packaged PIN diodes. The inductance of the chip-scale PIN diode is expected to approach 0.1 nH compared to 0.7 nH for the SC-79 package shown in ***Figure 10***.

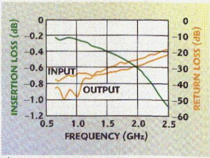
The company's smallest present GaAs RF IC switch package is the 2.2 × 2.0 mm footprint of the SC-70. The chip-scale version reduces this area to 1.5 × 1.0 mm. This package is leadless with backside land grid contacts. The lower package inductance yields



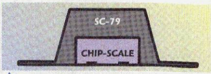
▲ *Fig. 7 DD01-92 circuit configuration.*



▲ *Fig. 8 DD01-92 differential detected voltage vs. frequency.*



▲ *Fig. 9 DD01-92 insertion loss and return loss.*



▲ *Fig. 10 Chip-scale package diagram.*

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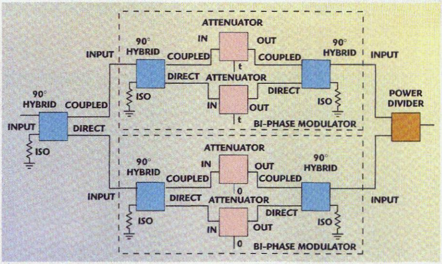

Fig. 11 *Vector modulator block diagram.*

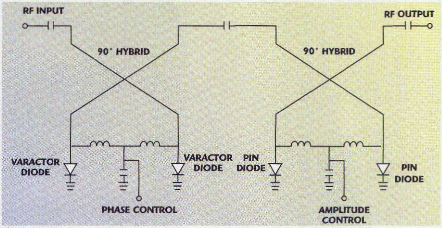

Fig. 12 *Amplitude and phase shifter circuit diagram.*

higher switch isolation and frequency response. Future chip-scale plans also include Schottky and varactor diodes, as well as integrating multiple semiconductors — including amplifiers, switches and driver circuits — on a discrete chip.

VECTOR MODULATOR

A series of vector modulators are in development to cover the wireless bands. These devices utilize existing monolithic quadrature hybrids, power dividers, FETs and PIN diode chips to create devices designed to adjust the phase and amplitude of an RF signal. This results in a very small (1 cm^2) BGA module. Vector modulators are similar to I & Q modulators, but unlike some basic monolithic I & Q modulators, they provide a linear path for the RF signal. With a vector modulator, the RF signal is not amplitude-limited because the output RF power is always proportional to the input RF power. This feature is widely used in feedforward or feedback loops of multi-channel power amplifiers to cancel distortion. The new vector modulator design has approximately 15 dB loss and an accuracy of better than 4° over a control range of 10 dB. ***Figure 11*** shows the vector modulator's block diagram.

Amplitude and Phase Shifter

An amplitude and phase shifter (APS), shown in ***Figure 12***, is also in development. This small (1 cm^2) ball grid array module will accomplish the same task as a vector modulator, but is less complex and operates with less loss (9 dB). Amplitude variation is 1 dB over 360° of phase shift. The APS is controlled by separate phase and amplitude signals whereas the vector modulator is controlled by separate in-phase and quadrature control signals.

Low Distortion Digital Attenuator

Six-bit attenuators for both the wireless infrastructure and broadband markets are under development as well. They feature a least significant bit of 0.5 dB with a total attenuation of 31.5 dB. This broadband, high linearity device is designed to achieve greater than 60 dBc second harmonic performance at a 5 MHz fundamental frequency.

CONCLUSION

Due to manufacturers looking for a differentiating advantage in a growing, complex market, the current generation of wireless and broadband devices will probably be obsolete in a year or two. One mobile telephone company is even promising new subscribers a replacement phone every two years. Handset product features are blurring as multimedia devices take on the roll of handsets and handsets incorporate features of multimedia devices.

The next generation of handsets — already under development — may contain three or four radios operating in the cellular, PCS and 3G spectrum, while incorporating Bluetooth functionality. Building components for products like these leverages the company's strengths in advanced semiconductor and hybrid process technology, innovative circuit design and modeling, and state-of-the-art packaging.

Alpha's capabilities go beyond manufacturing highly reliable RF GaAs ICs, discrete semiconductor devices and passive components. Working with leading handset and base station equipment manufacturers, the company is creating the innovative solutions needed to implement a new generation of wireless devices and has demonstrated its ability to integrate multiple components and functions in ever-smaller packages. With its proven high volume, low cost production capabilities, innovative products to meet the growing demand for ultra-high speed, high capacity, data and voice wireless communications are being developed. For additional information, visit the company's Web site at www.alphaind.com.

Alpha Industries Inc.,
Woburn, MA
(781) 935-5150.

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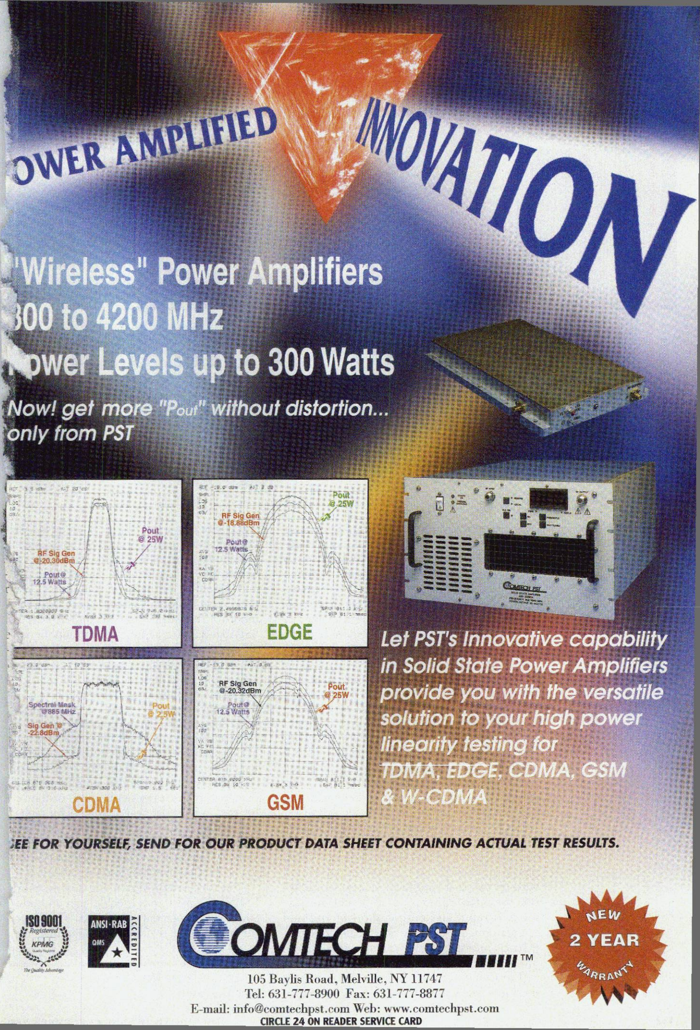
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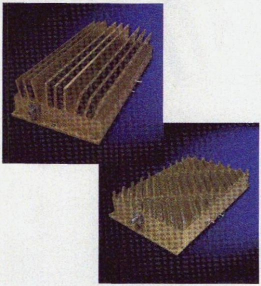


BROADBAND POWER AMPLIFIERS FOR 600 MHz TO 4.5 GHz SYSTEM APPLICATIONS

A new line of medium and high power broadband amplifiers has been introduced that covers the 600 MHz to 4.5 GHz frequency bands. All of the power amplifiers (PA) offer medium to high gain with excellent linearity and moderate noise figures. These units are designed to be used in any commercial or military system where high reliability and excellent performance are required. In addition, the amplifiers are ideal for laboratory testing. The lowest output power amplifier, model SSPA-0.8-4.5-5.0, has useable gain and power from 800 MHz to 4.5 GHz, making it one of the only compact broadband amplifiers on the market that offers this type of performance. There are five amplifiers in the series and they vary in output power from 1 W to greater than 100 W. The smallest bandwidth covered is 500 MHz with a typical output power of greater than 100 W.

All of the amplifiers are packaged in very rugged and compact housings. The medium and high power units operate from 12 V DC power supplies. These units can be configured with an external shutdown as a separate option. Standard options on all models include internal input and output short circuit and open circuit protection, reverse polarity protection, internal over-current protection and SMA female connectors.

Proprietary circuit design techniques are used to achieve the amplifier's broadband gain and power responses. The design methodolo[g] utilized in the power amplifiers enables co[m]pact housing sizes that fit conveniently on [a] bench top or in a system's shelter. One com[]pact amplifier can now be used for all lowe[r] microwave frequency testing needs. The thre[e] model SSPA0.8-4.5-5, SSPA0.6-2.0-20 an[d] SSPA0.8-3.2-10 medium power amplifiers ar[e] all multi-octave amplifiers that standout be[-] cause of their pricing, bandwidth and compac[t] size. The two model SSPA1722-80 an[d] SSPA2227-80 high power amplifiers cover th[e] frequency ranges of 1.7 to 2.7 GHz in 5[00] MHz increments. These units are unique b[e-] cause of their high power and broadband ga[in] in such a compact unit. What further sets the[se] amplifiers apart from other PAs is the fact th[at] they can be used as linear amplifiers for d[e-] manding multi-carrier applications or they c[an] be used as pulsed power amplifiers for high e[f-] ficiency data transmission. Their mechanic[al] enclosures utilize heat sinks that are integ[ral] with the housings to ensure excellent heat fl[ow] that in turn ensures long-term reliability.

The first amplifier in the series, mo[del] SSPA-0.8-4.5-5.0, has useable gain and pow[er] across an 82 percent bandwidth. This PA h[as] the broadest bandwidth of any amplifier in th[e]

[Continued on page 13

AETHERCOMM INC.
San Marcos, CA

TABLE I

SSPA-0.8-4.5-5.0
TYPICAL PERFORMANCE
FROM 1.0 TO 4.5 GHz AT 25°C

	Min	Typ	Max
Small-signal gain (dB)	20	22	26
Saturated output power (W)	1.35	3	5
Input SWR (1.4 to 4.5 GHz)	1.15	1.5	2.0
Input SWR (0.8 to 1.4 GHz)	1.5	2.0	3.0
Output SWR (1.4 to 4.5 GHz)	1.15	1.5	2.0
Output SWR (0.8 to 1.4 GHz)	1.5	2.0	3.0
Supply voltage (VDC)	10	12	13.5
Quiescent current (A)	2.0	2.2	2.5
OIP3 at 2.5 GHz with a 1 MHz, two-tone spacing (dBm)	45	46	48

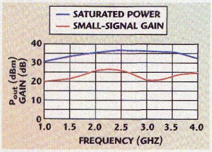


Fig. 1 SSPA-0.8-4.5-5 small-signal gain and saturated output power vs. frequency at 25°C.

series. The amplifier is ideal for bench top testing because it covers many of the popular military and commercial bands. It can be used as a linear or saturated amplifier in most medium power applications. It is competitively priced and meets virtually all medium power testing needs. This amplifier is unique because of the very wide bandwidth it achieves at a very competitive price. The amplifier delivers a minimum output power of 1 W from 1 to 4.5 GHz with a maximum output power of 5 W. Typical gain is greater than 20 dB. The output third-order intercept (OIP3) at 2.5 GHz with a 1 MHz two-tone spacing is 46 dBm at 25°C. Input/output SWRs are typically less than 2.0 from 1.5 to 4.5 GHz. This unit is offered in a housing that is 4" × 6" × 2", including the heat sink with four through holes in the bottom cover for mounting. ***Table 1*** lists the amplifier's typical performance and ***Figure 1*** shows the unit's small-signal gain and saturated output power vs. frequency at 25°C.

TABLE II

SSPA-0.6-2.0-20
TYPICAL PERFORMANCE
FROM 1.0 TO 2.0 GHz AT 25°C

	Min	Typ	Max
Small-signal gain (dB)	48	50	52
Saturated output power (W)	8	20	26
Input SWR	1.10	1.25	1.5
Output SWR	1.10	1.25	1.5
Supply voltage (VDC)	10	12	13.5
Quiescent current (A)	6.5	7.0	7.3
OIP3 at 1.5 GHz with a 1 MHz, spacing at P_{out} SCL = 39 dBm (dBm)	50	52	54
Noise figure (dB)	4	5	6

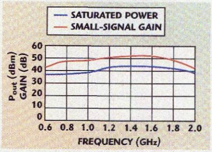


Fig. 2 SSPA-0.6-2.0-20 small-signal gain and saturated output power vs. frequency at 25°C.

The second amplifier in the series, model SSPA-0.6-2.0-20, has useable gain and power across a 70 percent bandwidth. This model delivers a minimum output power of 8 W from 1 to 2 GHz and was designed to be a laboratory amplifier for all testing requirements between 600 MHz and 2 GHz that require high gain and medium output power. The amplifier functions very well in high linearity applications where a high compression point is required. The amplifier is ideal for varying envelope modulation types and is also well suited for constant envelope modulation where saturated power is desired. Maximum output power is 26 W across the band with a typical gain greater than 45 dB. The OIP3 at 1.5 GHz with a 1 MHz two-tone spacing at a 39 dBm single carrier level (SCL) is 52 dBm at 25°C. Input/output SWRs are less than 1.5 from 1 to 2 GHz. The unit is offered in a housing that is 4.00" × 8.25" × 2.00", including the heat sink with six through holes in the bottom cover for mounting. ***Table 2*** lists the amplifier's typical performance and ***Figure 2*** shows the small-signal gain and saturated output power vs. frequency at 25°C.

TABLE III

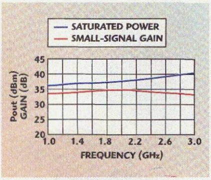
SSPA-0.8-3.2-10
TYPICAL PERFORMANCE
FROM 1.0 TO 3.2 GHz AT 25°C

	Min	Typ	Max
Small-signal gain (dB)	28	32	35
Saturated output power (W)	5	9	12
Input SWR	1.10	1.20	2.0
Output SWR	1.10	1.20	2.0
Supply voltage (VDC)	10	12	13.5
Quiescent current (A)	6.5	6.7	7.0
OIP3 at 1.5 GHz with a 1 MHz, spacing at P_{out} SCL = 39 dBm (dBm)	45	46	48
Noise figure (dB)	4	5	6

Model SSPA-0.8-3.2-10 has useable gain and power across a 75 percent bandwidth. This amplifier was designed as a bridging amplifier between models SSPA0.8-4.5-5 and SSPA0.6-2.0-20. This amplifier is used when more power than the broadest band model and more bandwidth than the 20-W unit is required. Similar to the other units, this model works very well with constant or varying envelope modulation schemes. The amplifier stands out from other PAs because of its price and broad bandwidth. The PA is ideal as a laboratory amplifier for all medium power testing requirements between 1 and 3.2 GHz, and is well suited for many commercial and military systems. The amplifier delivers a minimum output power of 5 W from 1 to 3.2 GHz and a maximum output power of 12 W across the band. Typical gain is greater than 28 dB. The OIP3 at 2.45 GHz with a 1 MHz two-tone spacing at a 35 dBm SCL is 46 dBm at 25°C. Input/output SWRs are less than 2.0 from 1.0 to 3.2 GHz. This unit is offered in a 4.00" × 8.25" × 2.00" housing, including the heat sink. ***Table 3***

[Continued on page 136]

PRODUCT FEATURE



▲ *Fig. 3 SSPA-0.8-3.2-10 small-signal gain and saturated output power vs. frequency at 25°C.*

lists its typical performance and ***Figure 3*** shows the small-signal gain and saturated output power vs. frequency at 25°C.

Model SSPA-2227-80 is a high power, S band solid-state power amplifier (SSPA) with 500 MHz of bandwidth. This PA delivers a minimum output power of 100 W from 2.3 to 2.7 GHz and has a small-signal gain of 30 dB minimum across the full band. The OIP3 at 2.5 GHz with a 1 MHz two-tone spacing at a 47 dBm SCL is 58 dBm at 25°C. Input/output SWRs are less than 2.0 from 2.2 to 2.7 GHz. What makes this PA unique is that it can be operated as a pulsed amplifier or CW amplifier. In the pulsed mode, the amplifier has a typical efficiency of 35 percent. In the CW mode, the amplifier has outstanding linearity that makes it ideal for multi-carrier systems or demanding complex modulation schemes. An added feature of this amplifier is that all of the power and bandwidth is available in a very compact size. Versions of this amplifier are flying on NATO and US fighter aircraft utilizing its excellent pulsed characteristics. Other versions of this amplifier are being used in multi-carrier ISM2400 systems. This unit is offered in a housing that is 4.00" × 8.25" × 2.50", including the heat sink. The amplifier's typical performance is listed in ***Table 4*** and its small-signal gain and saturated output power vs. frequency is shown in ***Figure 4***.

The last amplifier in the series is model SSPA-1722-80, a high power PA with 500 MHz of bandwidth. Again, this amplifier stands out because of its ability to operate either CW or pulsed. In the CW mode, this PA is an extremely linear amplifier with an OIP3 of 60 dBm typical. In the pulsed mode, this model functions as a high efficiency amplifier. An extra bonus is that all of this bandwidth and power comes in a very compact assembly. The amplifier delivers a minimum output power of 80 W from 1.7 to 2.2 GHz. Typical output power from 1.8 to 2.1 GHz is greater than 110 W, and its small-signal gain is 30 dB minimum across the full band. The OIP3 at 2.0 GHz with a 1 MHz two-tone spacing at a 47 dBm SCL is 60 dBm at 25°C. Input/output SWRs are less than 2.0 from 1.7 to 2.2 GHz. This unit is offered in a housing that is 4.00" × 8.25" × 2.50", including the heat sink. ***Figure 5*** shows small-signal gain and saturated output power vs. frequency at 25°C and ***Table 5*** lists its typical performance.

The new line of broadband, medium and high power amplifiers offers users a one-PA solution for their entire laboratory or system test needs. Amplifier users can now buy one unit to cover multiple bands, while enjoying medium to high power with very good gain. The two 100 W units can be used as linear or high efficiency PAs in applications from 1.7 to 2.7 GHz. The solid-state power amplifiers cover all of the lower microwave frequency bands used by commercial and military systems. All of the models are manufactured with the highest quality to ensure long-term reliability and come with a one-year warranty. Data sheets for the SSPAs can be easily downloaded at the company's Web site at www.aethercomm.com.

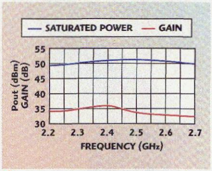
Aethercomm Inc.,
San Marcos, CA (760) 598-4340.

Circle No. 301

TABLE IV

SSPA2227-80 TYPICAL PERFORMANCE FROM 2.2 TO 2.7 GHz AT 25°C

	Min	Typ	Max
Small-signal gain (dB)	32	34	36
Saturated output power (W)	70	100	140
Input SWR	1.25	1.5	2.0
Output SWR	1.25	1.5	2.0
Supply voltage (VDC)	12	12.0	13.5
Quiescent current (A)	9.0	11.0	12.0
OIP3 at 1.5 GHz with a 1 MHz, spacing at P_{out} SCL = 39 dBm (dBm)	56	58	60
Noise figure (dB)	3.5	4.5	5.0
Efficiency (%)	30	35	45

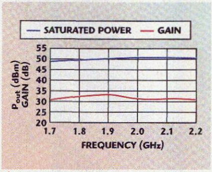


▲ *Fig. 4 SSPA2227-80 small-signal gain and saturated output power vs. frequency at 25°C.*

TABLE V

SSPA1722-80 TYPICAL PERFORMANCE FROM 1.7 TO 2.2 GHz AT 25°C

	Min	Typ	Max
Small-signal gain (dB)	30	32	35
Saturated output power (W)	70	100	150
Input SWR	1.25	1.5	2.0
Output SWR	1.25	1.5	2.0
Supply voltage (VDC)	12	12.5	13.5
Quiescent current (A)	9.0	11.0	12.0
OIP3 at 1.5 GHz with a 1 MHz, spacing at P_{out} SCL = 39 dBm (dBm)	57	60	62
Noise figure (dB)	3.5	4.5	5.0
Efficiency (%)	30	35	45



▲ *Fig. 5 SSPA1722-80 small-signal gain and saturated output power vs. frequency at 25°C.*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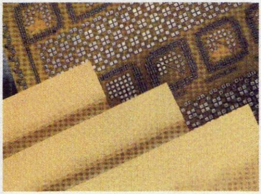
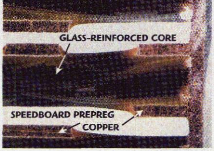


A Low Loss Dielectric for High Frequency HDI Substrates and PCBs

The wireless telecommunications market continues to require denser circuitry and higher I/O count chip packages to meet ever growing performance requirements. These new requirements can only be satisfied with multilayer PCBs incorporating RF and microwave, as well as digital signal processing circuitry on the same high density interconnect (HDI) multilayer circuit board. These multilayer PCBs are used in applications from Bluetooth modules to base stations and consist of thin dielectric layers interconnected with microvias. The dielectric layers are sequentially laminated on FR-4 or other conventional cores to make up the mixed signal multilayer PCB. One dielectric that has been proven in the industry as a high speed prepreg is now seeing significant growth in HDI applications. Speedboard® C prepreg is being used as a low loss HDI dielectric that improves the performance of these controlled impedance, high speed digital, RF and microwave PCBs by making them thinner, lighter and faster. The product is comprised of expanded polytetrafluoroethylene (ePTFE) that has been impregnated with a modified BT resin. The air space inside the ePTFE is replaced with resin and the ePTFE membrane becomes the carrier or delivery system for the resin. The conformable ePTFE toughens the dielectric, improving reliability and enabling excellent surface planarization for high density fine lines and spaces.

Fig. 1 Speedboard C prepreg with FR-4 core.



Speedboard C prepreg has traditionally been used as a bonding sheet to bond together the inner layer core material in multilayer PCBs. Ultimately, the resin flows, fills and bonds during the lamination process the same as a conventional glass-based thermoset prepreg. Speedboard C is also an excellent choice to replace thermoplastic fluoropolymer bondfilms and fusion bonding processes in PTFE microwave PCBs.

MATERIAL PROPERTIES

Speedboard C material features a low dielectric constant of 2.6 and a low loss tangent of 0.0036 that is stable over frequency and temperature. It utilizes standard thermoset processing as opposed to fusion processing. The material forms thin bonding layers and features a controlled flow and fill, as shown in **Figure 1**.

Multiple plies of prepreg can be used to obtain a wide range of dielectric thickness for

[Continued on page 145]

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MBA-15L	+4	1.2-2.4	6.95	MBA-25LH	+10	2.2-3.6	6.95
MBA-18L	+4	1.6-3.2	6.95	MBA-35LH	+10	3.0-4.0	6.95
MBA-25L	+4	2.0-3.0	6.95	MBA-9MH	+13	0.8-1.0	7.95
MBA-35L	+4	3.0-4.0	6.95	MBA-12MH	+13	0.8-2.5	7.95
MBA-9	+7	0.8-1.0	5.95	MBA-15MH	+13	1.4-2.4	7.95
MBA-12	+7	0.8-2.5	5.95	MBA-18MH	+13	1.6-3.2	7.95
MBA-26	+7	2.2-2.7	5.95	MBA-25MH	+13	2.0-3.0	7.95
MBA-591	+7	2.8-5.9	6.95	MBA-35MH	+13	3.0-4.0	7.95
MBA-671	+7	2.4-6.7	8.95	MBA-9H	+17	0.8-1.0	9.95
				MBA-12H	+17	0.8-2.5	9.95

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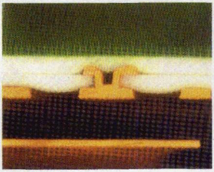
TABLE I SPEEDBOARD C PROPERTIES	
Dielectric constant* (1 MHz to 10 GHz)	2.6
Loss tangent* (1 MHz to 10 GHz)	0.0036
Dielectric strength (V/mil)	> 1000
Glass transition temperature (°C)	220
CTE (X, Y, Z) (–55 to 125°C) (ppm/°C)	58
Thermal conductivity (W/m°C)	0.29
Flammability	UL V0
Outgassing	NASA approved
Pressed thickness (µm)	38, 56, 86
Resin content (%)	70
*Stable over temperature range 20° to 200°C	

controlled impedance layers. In addition, the material is fully compatible with all laminates and affords very fast laser drilling speeds. ***Table 1*** lists Speedboard C prepreg properties.

THE LAMINATION PROCESS

The standard hydraulic lamination recommended for cyanate resin systems is used for normal lamination using Speedboard C prepreg. Two high throughput temperature cycles have been used for the prepreg, depending on the glass transition temperature of the inner layer core materials or other process considerations. Vacuum lamination is recommended and cooling under pressure is preferred.



▲ *Fig. 2 Speedboard C (shown white) with a 2 mil laser drilled blind via.*

Speedboard prepregs are excellent materials for via processing in HDI-type PCBs, as shown in ***Figure 2***. Reliable laser microvias as small as 25 µm (1 mil) have been drilled using harmonic YAG, CO_2 and excimer lasers. The thin, uniform, all organic nature of the prepreg allows for rapid and clean lasing of vias. No plasma treatment of the via is necessary prior to copper metallization. However, if mechanical holes are drilled, plasma or sodium etching is recommended for those holes.

[Continued on page 146]

PERFORMANCE BENEFITS

Several distinct performance benefits are derived from the use of Speedboard C prepregs. Its low dielectric constant reduces signal delay and offers a designer increased electrical line lengths for FR-4 construction. The reduced effective dielectric constant also yields a thickness reduction for FR-4 boards, thus allowing greater overall layer density, thinner board construction and reduced weight.

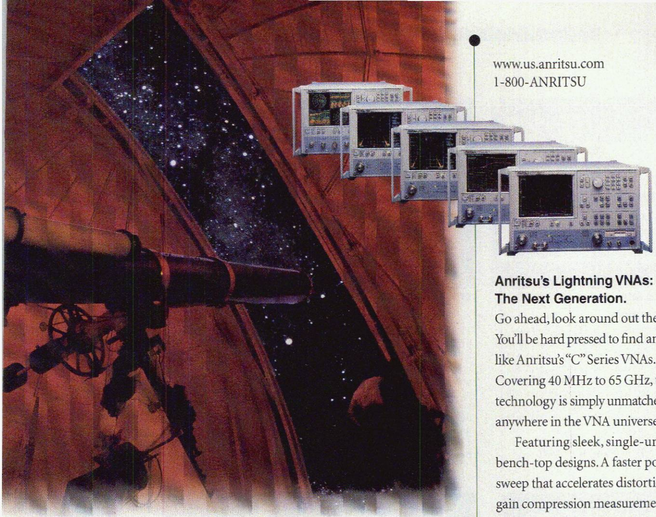
The lower dielectric constant allows the velocity of propagation to increase significantly over an all FR-4 solution, and Speedboard C prepreg can be combined with all types of laminates to lower the effective dielectric constant of the PCB. The material's lower loss tangent results in significant reductions in signal attenuation, and the lower dielectric constant permits wider line widths for a given transmission impedance, thus maximizing tract cross-sectional area and reducing skin effect. In general, Speedboard C combines the electrical benefits of PTFE with the processability of thermoset resins.

CONCLUSION

Mixed dielectrics are becoming popular in today's microwave and high speed digital PCBs. The use of Speedboard C prepreg, whether as a prepreg or an outerlayer HDI dielectric, for critical signal routing while using low cost FR-4 for non-critical layers in multilayer PCBs provides a good solution for these applications. Additional information may be obtained from the company's Web site at www.gore.com.

W.L. Gore & Associates Inc., Newark, DE (800) 445-4673.

Circle No. 302



WEB UPDATE

RF and Microwave Components

This Web site offers a broad range of categories from which to browse: Employment Opportunities, Block Diagrams and Associated Productions, Parametric Search Capability, New Information, Application Notes, Product Data Sheets and View by Market. The site will be continually updated, adding technical market data and application notes during the next phase of site construction.

Alpha Industries Inc.,
20 Sylvan Rd., Woburn, MA 01801

www.alphaind.com

Antenna Products and Services

This Web site contains information on EMC products, digital communications, RF and antenna systems, HF products, GSA products and antenna accessories. In addition, new press releases, literature requests, product inquiries/specifications, tradeshow information and employment opportunities are featured.

Antenna Research Associates (ARA),
11317 Frederick Ave.,
Beltsville, MD 20705

www.ara-inc.com

Digital Broadband Test

This Web site specializes in test and measurement equipment offering state-of-the-art broadband, deep memory signal generation and analysis. Instrumentation is provided to the wireless, space and defense markets.

Celerity Systems,
an L-3 Communications company
10411 Bubb Rd., Cupertino, CA 95014

www.csidaq.com

3-D EM Simulation Software

This Web site details software products for the simulation of 3-D EM fields in the time domain. The company's simulators use the proprietary PBA and FI methods and specialize in accurate simulation of high frequency problems on a PC in a Windows-based environment.

CST of America Inc.,
123 Mount Auburn St., Suite 200N,
Cambridge, MA 02138

www.cst-america.com

Cost-effective RF and Microwave Products

Visit this Web site to learn more about this leader in the design and manufacture of cost-effective RF and microwave cable assemblies, delay lines and harnesses for the wireless, commercial communications and military defense markets. Get information on the company's state-of-the-art manufacturing facilities, product reliability and customer satisfaction.

Dynawave Inc.,
135 Ward Hill, Haverhill, MA 01835

www.dynawave.com

Electrical Test Products and Services

This Web site features electrical test products and services, including semiconductor test products, bare-board automatic test systems, Pogo® spring contacts, and bare and loaded PCB test fixtures. Corporate manufacturing, service and support facilities are ISO registered with locations worldwide.

Everett Charles Technologies,
700 East Harrison Avenue,
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Application Profile

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Inexpensive??
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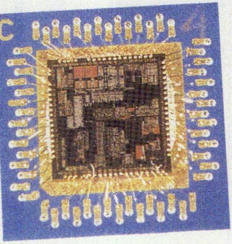

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National: Doing what we do best — prototype turns in 7 days; state-of-the-art technology; and low-cost/high-volume QS9000 manufacturing.

For more information, call National at (949) 380-2054 or visit the National LTCC website at http://www.national.com/ltcc.

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WEB UPDATE

RF to Millimeter-wave Integrated Circuits

This Web site includes the full line of standard product data sheets in .pdf format, S-parameters of selected products, a mixer spur chart calculator, as well as application notes and other topics of interest. Over 100 MMIC die, ceramic packaged die and plastic packaged die products are featured covering DC to 40 GHz.

Hittite Microwave Corp.,
12 Elizabeth Dr., Chelmsford, MA 01824

www.hittite.com

DDS and Communication Subsystems Products

This redesigned Web site features information on a new, innovative synthesizer that has been added to the company's growing line of DDS and Communication subsystems products. The MS-2000 is a high performance, dual channel synthesizer designed for the wireless market. This Ku-band exciter features low phase noise and spurious, and is ideal for LMDS systems.

ITT Microwave Systems,
59 Technology Dr., Lowell, MA 01851

www.ittmicrowave.com

Precision Microwave Instruments and Components

This Web site showcases a product line of over 4000 microwave instruments and components, including the Maury/PAF Active Load Pull System, Automated Tuner Systems (ATS) and Windows-compatible system software. Product information and technical data is found throughout the site. A large library of downloadable (.pdf) application notes and frequently asked questions (FAQs) are among the most popular site areas.

Maury Microwave Corp.,
2900 Inland Empire Blvd.,
Ontario, CA 91764

www.maurymw.com

Waveguide Components and Subassemblies

Visit this Web site to discover how the company became the largest independent producer of waveguide components and subassemblies in the microwave industry. In addition, learn more about waveguide bends and twists, directional couplers and monopulse comparators, rotary joints, microwave filters, rotary switches, and waveguide shutters and waveguide pressure windows.

MDL Inc.,
135 Crescent Road,
Needham Heights, MA 02494

www.micro-dev-labs.com

Sampling Phase Detectors

This new Web site was launched to complement the company's main Web site. The site allows designers to review data, outline drawings and electrical specs on sampling phase detectors, a series of resin encapsulated products ideal for phase lock VCO and DRO designs.

MicroMetrics Inc.,
136 Harvey Rd., Building C,
Londonderry, NH 03053

www.phasedetectors.com

Custom Microwave Components

This Web site includes information on the company's waveguide products and capabilities, including filters, diplexers, circulators, Gunn oscillators, double-ridge components and comparators, as well as custom applications and standard product information. Descriptions and photographs are displayed for manufacturing processes, design capabilities and test facilities.

Microwave Development Company Inc. (MDC),
41 Northwestern Dr., Salem, NH 03079

www.mdc-inc.net

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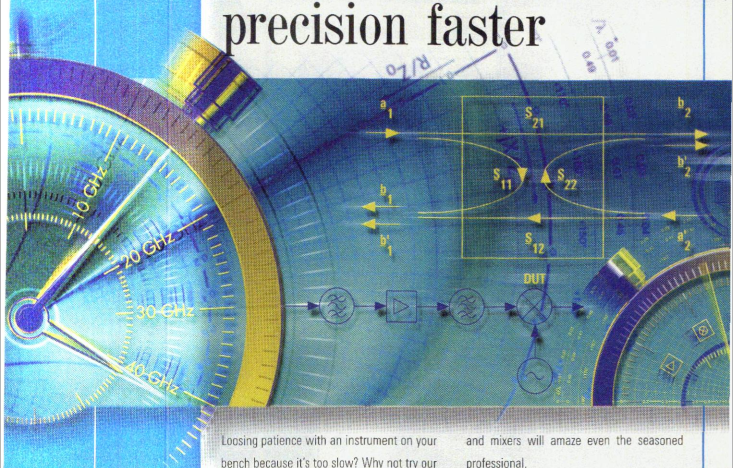

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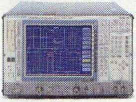

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Electronically Scanning Antennas

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Paratek Microwave Inc.,
6935N Oakland Mills Rd.,
Columbia, MD 21045

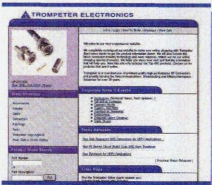
www.paratek.com

High Frequency Laminates

This Web site provides information about high frequency laminates for RF and microwave applications such as cellular and PCS basestations, power amplifiers, low noise blocks for direct broadcast systems, patch antennas and high performance, high speed digital circuits.

Rogers Corp.,
Microwave Materials Division,
100 S. Roosevelt Ave.,
Chandler, AZ 85226

www.rogers-corp.com/mwu/index.htm



High Reliability Coaxial BNC Connectors

This Web site features the company's line of RF coaxial, triaxial and twinaxial interconnect products, cross-connects, patch panels, cable assemblies and related tools. It offers electronic commerce capabilities such as on-line quotations and direct order placement, as well as product line drawings, specifications and pricing.

Trompeter Electronics,
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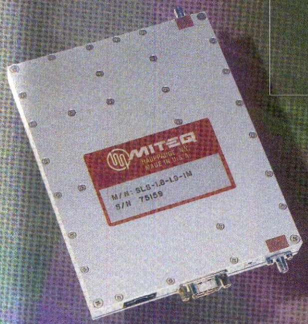

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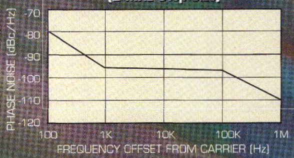

SPECIFICATIONS

MODEL	SLS SERIES
Frequency	1–15 GHz
Frequency step size	200 kHz to 10 MHz
Tuning range	Up to half octave
Switching speed	500 µs*
Output power	10 dBm min.
Output power variation	±2 dB min.
In band spurs	70 dBc min.
Harmonics	20 dBc
Phase noise	See graph
Reference	Internal or external
External reference Frequency Input power	 5/10 MHz 3 dBm ±3 dB
Frequency control	BCD or binary
DC power requirement	+15 or +12 volts, 200 mA 5.2 volts, 500 mA
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* Acquire time depends on step size (low as 25 µs).

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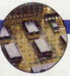


NEW PRODUCTS

COMPONENTS

■ Surface-mount Voltage Variable Attenuator

The model AV850M2-A2 18 to 40 GHz broadband millimeter-wave voltage variable attenuator (VVA) offers 33 dB attenuation range and low insertion loss. It is designed for use in millimeter-wave communications and sensor systems as a variable attenuation

stage in the receiver or transmitter chain when wide dynamic range and high linearity are required. In addition, the attenuator is ideal for high volume millimeter-wave applications such as point-to-point and point-to-multipoint wireless communications systems. The rugged, robust packaging provides excellent electrical performance and a high degree of environmental protection for long-term reliability. Price: $14.13 (10,000).

Alpha Industries Inc.,
Woburn, MA (781) 935-5150.

Circle No. 216

■ Solid State Transfer Switch

The model SWN-218-TRA Options 160M, LVT10MV, PAM solid state transfer switch works from DC to 3 GHz (usable to 4 GHz) with insertion loss of < 0.8 dB at 40 MHz and < 1.5 dB at 3 GHz. Switching speed is < 10 ns ON and < 10 ns OFF. Video transient is

≤ 37 mV peak to peak at 300 MHz and ≤ 5 mV peak to peak at 20 MHz. Isolation is ≥ 70 dB at 40 MHz and ≥ 40 dB at 3 GHz. Phase and amplitude are matched to within ±0.1 dB and ±4°, respectively, between port to port from 40 MHz to 3 GHz. SWR is 1.6 (typ), power supply is –5 V DC at 2.6 mA, with other supply voltages available. Weight: 2.5 oz. Size: 1.50" × 1.50" × 0.75".

American Microwave Corp.,
Frederick, MD (301) 662-4700.

Circle No. 217

■ Low Loss Porcelain RF/Microwave Capacitors

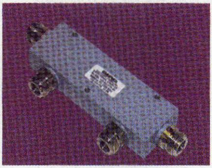
The AQ series of low loss porcelain capacitors is designed for RF/microwave applications ranging from 10 MHz to 4.2 GHz, and includes an 0603 size chip for space-constrained applications. These capacitors

are characterized by a fine grain, high density, high purity dielectric material, which is impervious to moisture and features internal palladium electrodes. The AQ series is ideal for applications in the microwave range requiring high current carrying capabilities, low ESR, high series resonance and stability under the stress of changing voltage, frequency and temperature. They feature capacitance values from 0.1 to 5100 pF, rated voltage is from 50 to 500 V DC, with a temperature coefficient of 90 ±20 ppm/°C or 0 ±30 ppm/°C. Operating temperature is –55° to +125°C.

AVX Corp.,
Myrtle Beach, SC (843) 946-0414.

Circle No. 218

■ High Power Coupler



The model 100-AC-FFN-20 100 W coupler features a frequency range of 800 to 2500 MHz, coupling at 20 dB and 20 dB (min) directivity making it ideal for cellular and PCS applications. Insertion loss of 0.25 dB (excluding power coupler) and 0.3 dB thruline. SWR is 1.15 (max) for the primary and secondary line, while frequency sensitivity is ±1.0 dB (max), and reflected power depends on the external load used. The operating temperature is up to 105°C. Weight: approximately 8 oz. Price: $175 (1 to 10). Delivery: four weeks (ARO).

Bird Components Products (BCP),
Largo, FL (727) 547-8826.

Circle No. 219

■ Six-way Broadband Wilkinson Power Divider/Combiner

The model P6W-10-1 six-way broadband Wilkinson power divider/combiner was specifically developed to meet industry demands for greater performance in the company's integrated assemblies. The device offers a multi-octave bandwidth and high reliability to meet stringent requirements

for test equipment. It is designed to cover present and future wireless frequency ranges, offers excellent RF performance and has very low IM properties (–100 dBc). It operates over a 0.8 to 4.0 GHz frequency range, with insertion loss of 1.45 dB (max), isolation of 18 dB (typ) and amplitude balance of 0.5 dB (max).

Dow-Key Microwave Corp.,
Ventura, CA (805) 650-0260.

Circle No. 221

■ High Responsivity 10 Gbps Optical Receiver

The model R402HR low noise PIN+TIA optical receiver has a conversion gain of 475 V/W (at 1550 nm). This fiber-optic pigtailed component serves the standard OC-192/STM-64 telecommunications market with sensitivity of –20 dBm and bandwidth of 30 kHz to 8 GHz. Featuring low ripple, low group delay and low electrical return loss, the device provides designers of telecommunications systems with the signal level needed for driving filter, AGC or limiting amplifier stages. With a circuit board footprint of 13 × 18 mm, it saves considerable space over discrete photodiode and amplifier models.

Discovery Semiconductors Inc.,
Princeton Junction, NJ (609) 275-0011.

Circle No. 220

■ High Performance Coaxial Cable

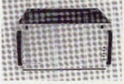
The model RG393 IMAX high performance coaxial cable has a stranded silver-plated copper center conductor, solid PTFE dielectric, two silver plated copper braids and an FEP jacket. The cable is manufactured with great consideration given to performance over the intermediate frequencies from 400 MHz to 3 GHz. It is swept for SWR with improved performance and attenuation is lower than maximum levels allowed in the MIL-C-17 specification.

Harbour Industries,
Shelburne, VT (802) 985-3311.

Circle No. 222

■ Wire Matrix

The model 10046 wire matrix operates over the DC to 5 MHz frequency range and routes multiwire buses such as RS-232C. Poles are switched in groups of 25 with bi-directional control programming and remote



control programming. It has solid state contacts and features RS-232C and IEEE-468 interfaces. Typical switching applications include RS-232C serial data lines, IEEE-4888 parallel data lines, modem to computer data lines, twisted pair for Kelvin measurements in ATE, audio intercom switching and computer to peripheral switching. Size: 8.75" × 19.00" × 17.00".

Matrix Systems Corp.,
Calabasas, CA (818) 222-2301.

Circle No. 224

■ Unequal Power Splitter

The model DG-54FN unequal way power splitter is designed to split a signal between two outputs in a 4:1 ratio, covering all frequencies from 800 to 2200 MHz. In addition, unlike directional couplers and capacitively coupled devices, it also provides DC continuity to both outputs. This allows the powering of remote amplifiers

[Continued on page 156]

without additional wiring and systems using antennas and Leaky-Line, where low loss and complete reliability are essential. An input SWR of less than 1.25, passive intermodulation below –140 dBc and insertion loss below 0.1 dB will appeal to system designers trying to meet tough performance criteria. When compared to most conventional power dividers, the DG-54FN is more ruggedly constructed, has no resistors to burn out and reflects less power back to the transmitter. The shape allows simple attachment to pole or wall using the clip provided, and the hex-style N connectors allow consistent tightening to a specified torque.

Microlab/FXR,
Livingston, NJ (973) 992-7700.

Circle No. 267

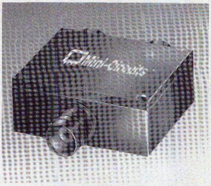
Low Cost Termination

The model 50T-19 covers a frequency range of DC to 2000 MHz and has a SWR of 1.2 (min). This unit will handle 1 W (average) power at 25°C and 1000 W peak. The operating temperature range is –20° to +100°C. It is available with BNC male RF connectors.

JFW Industries Inc.,
Indianapolis, Indiana (877) 887-4539 or (317) 887-1340.

Circle No. 223

High Power Two-way Splitter

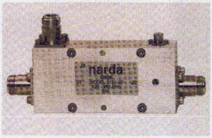


The model ZAPD-20 10 W power splitter is designed to split a signal two ways with 0° in the 700 to 2000 MHz frequency range. Band wide, insertion loss is very low, 0.3 dB (typ, above 3 dB) and isolation is excellent at 30 dB (typ), while maximum amplitude and phase unbalance is 0.4 dB and 3°, respectively. This 50 Ω coaxial unit is housed in a tough metal case equipped with SMA-female connectors. Price: $59.95 (1 to 9).

Mini-Circuits,
Brooklyn, NY (718) 934-4500.

Circle No. 225

Low Cost, Type-N Directional Coupler



The model 3151 low cost, type-N directional coupler for PCS and cellular applications offers high directivity and extremely low intermodulation. It is available in 10, 20 and 30 dB coupling values and offers exceptionally low insertion loss. Price: $89. Delivery: stock.

Narda,
an L-3 Communications company,
Hauppauge, NY, (631) 231-1700.

Circle No. 226

Adaptive Differential Pulse Code Modulation Codec

The model ML7029 single-rail adaptive differential pulse code modulation (ADPCM) codec is designed to serve high volume, cordless phone and wireless local loop handset applications. It is a good fit for this market segment as it allows design engineers to partition for optimal cost without sacrificing value-added functionality while maximizing battery life. The ML7029 operates from a 3 V power supply, complies with ITU-T G.711 and G. 726 with parametrically specified enhanced frequency sampling rates of 16 and 21 kHz. The codec is available in a 30-pin plastic SSOP with tight 0.65 mm pin pitch. Price: $2.80 (100,000).

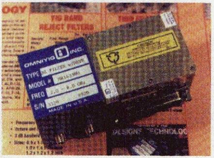
Oki Semiconductor,
Sunnyvale, CA (408) 737-6347.

Circle No. 227

[Continued on page 158]

NEW PRODUCTS

Band Reject Filter



The model MR143DD multi-octave band reject filter consists of eight stages covering the frequency range of 2 to 8 GHz. At 2 GHz, the 30 dB rejection bandwidth is 9 MHz, at 5 GHz the 50 dB rejection bandwidth is 20 MHz and at 8 GHz the 60 dB rejection bandwidth is 30 MHz. The out of band insertion loss is 1.5 dB (typ) and the tuning sensitivity is 24 MHz/mA (typ). The unit is integrated with a 12 bit digital driver to tune the full frequency range. The operating temperature is –54° to +85°C and the filter is built to MIL-E-5400 specifications. Size: 1.7" × 1.7" × 1.7".

Omniyig Inc.,
Santa Clara, CA (408) 988-0843.

Circle No. 228

Specialized Interface Adapters and Connectors

This line of specialized interface adapters and connectors were developed in response to requirements of FCC Part 15.203 and comply in three ways: reverse polarity, or gender; reverse, or left-handed threads; and the use of metric rather than Unified Standard threads. The RT-1227, TNC Male to TNC Female right-angle adapter, is one of these compliant parts. It features left-hand, or reversed, threads at both ends; nickel-plated body; gold-plated contact and pin; and Teflon industries.

RF Connectors, a division of RF Industries,
San Diego, CA (800) 233-1728
or (858) 549-6340.

Circle No. 229

Surface-mount Toroidal-core Compensated Chokes

These surface-mount toroidal-core transformers come in a pick-and-placeable liquid crystal polymer plastic housing, are suitable for reflow and vapor phase soldering, and are supplied on carrier-and-reel. The series is characterized as current compensated chokes with inductance values from 11 to 4700 μH, but RF or pulse transformer models can be provided. The chokes operate from –40° to 125°C, and are well suited for applications such as EMI isolation in switching power supplies and other filtering requirements. Price: $1.43 (5000, for models with inductance values up to 470 μH), $1.53 (5000, for higher inductance values). Delivery: 10 to 12 weeks.

Sprague-Goodman Electronics Inc.,
Westbury, NY (516) 334-8700.

Circle No. 230

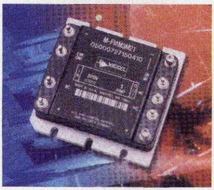
Directional Coupler

The model CPL/17BE-08S7 directional coupler can be used to monitor or match power, establish branch signals, feedback or signal sampling. The device has good phase inversion with respect to input and low insertion loss at 1.0 dB (max). In addition, the coupler has directivity of 12 dB (min) at 4 to 740 MHz and 8 dB at 750 to 1000 MHz, return loss of 16 dB (min), impedance of 75 Ω, and a coupling flatness above 8.2 dB. Size: 0.30" × 0.31".

TRAK Microwave Corp.,
Tampa, FL (813) 901-7200.

Circle No. 231

Military Filter and Input Attenuator Module



The military filter and input attenuator module (M-FIAM) is a modular, DC input front-end providing transient protection, inrush current limiting and EMI filtering in a single, miniature package. The M-FIAM enables designers to meet the conducted emissions requirements of MIL-STD-461E, the transient requirements of MIL-STD-704E and the environmental test requirements of MIL-STD-810. It also protects system hardware from potentially damaging effects of inrush current. The M-FIAM accepts an input voltage of 180 to 375 V DC, and delivers output current up to 3 A. Size: 2.28" × 2.20" × 0.54". Price: $105 (100).

Vicor Corp., Andover, MA (800) 735-6200.

Circle No. 232

Miniature Diplexer

The model W2446D miniature IMD free diplexer has two standard +43 dBm input test signals and produces < –100 dBm of IMD signals. It offers 60 MHz DCS/UMT bandwidth and insertion loss is 1 dB. Return loss is better than –17 dB and Tx-to-Rx isolation is > 65 dB. Type-N connectors are standard, but SMA connectors are optional for low power applications. The operating temperature is from –40° to +70°C. Size: 1.0" × 2.0" × 5.0".

Wireless Technologies Corp.,
Springdale, AR (501) 750-1046.

Circle No. 233

AMPLIFIERS

IP Telephony Reverse Path Amplifier

The model ARA3000 reverse path amplifier is targeted specifically for residential gateway and IP telephony applications, and compensates for noisy reverse paths that can plague typical cable systems and allows cable operators to remotely diagnose and isolate noise ingress problems. It is also capable of amplifying signal levels from the house insuring highly reliable upstream data transmission, even over a lossy cable system. Price: $7.75 (1000).

ANADIGICS Inc.,
Warren, NJ (908) 668-5000.

Circle No. 234

Driver Amplifier

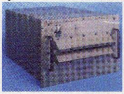
The model CMM3020-BD increased data rate, 30 GHz, driver amplifier is designed for external fiber-optic modulators targeting higher bandwidth applications and data rates greater than 13 Gbps. It gives fiber-optic system designers a unique combination of wideband frequency coverage along with an improved eye diagram, flat response and very low internal jitter. It is a precision PHEMT GaAs MMIC, medium power, +23 dBm amplifier and operates from 30 kHz to 30 GHz with a linear 10 dB gain response. Low internal jitter makes it especially well suited for high speed digital data applications. Output voltage is 7.5 V (typ) peak-to-peak.

Celeritek Inc.,
Santa Clara, CA (408) 986-5060.

Circle No. 235

500 W VHF Radio Booster

The model BHE27157-500 VHF radio booster operates over the 20 to 150 MHz frequency range with 500 W (min) of output power. This ruggedized power amplifier is powered from vehicular 22 to 32 V DC power and can operate over the –20° to +55°C temperature range with 100 percent condensing humidity. Output power is measured and controlled remotely, as are the AM and FM automatic level controls. Weight: 150 lb. Size: 12.25" × 19.00" × 26.00".



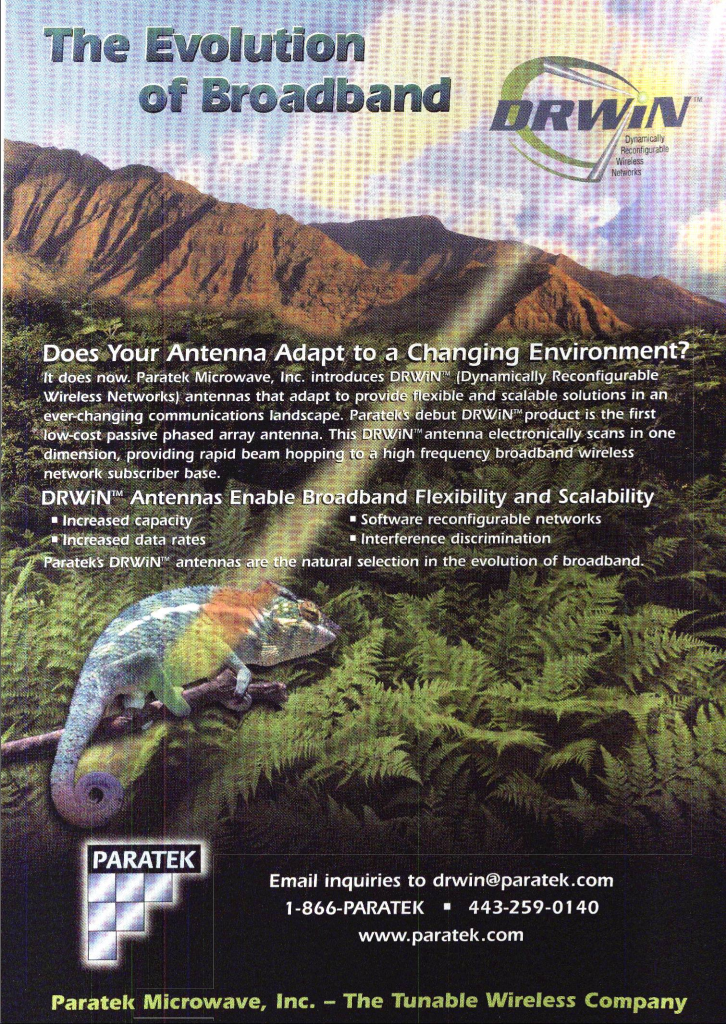
Comtech PST,
Melville, NY (631) 777-8877.

Circle No. 236

Tri-band Power Amplifiers

This family of global standard for mobile communications (GSM) power amplifiers (PA) are designed to enable mobile phones that can be used around the world. They operate in the 900, 1800 and 1900 MHz bands, providing a singular solution for all networks using GSM. Also, the PAs process twice as much information as traditional GSM PAs to support emerging data services, such as Internet browsing, online shopping, video messaging and other in-

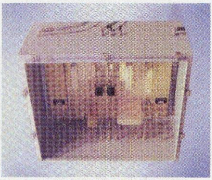
[Continued on page 160]


The Evolution
of Broadband
DRWiN™
Dynamically
Reconfigurable
Wireless
Networks
Does Your Antenna Adapt to a Changing Environment?
It does now. Paratek Microwave, Inc. introduces DRWiN™ (Dynamically Reconfigurable Wireless Networks) antennas that adapt to provide flexible and scalable solutions in an ever-changing communications landscape. Paratek's debut DRWiN™ product is the first low-cost passive phased array antenna. This DRWiN™ antenna electronically scans in one dimension, providing rapid beam hopping to a high frequency broadband wireless network subscriber base.
DRWiN™ Antennas Enable Broadband Flexibility and Scalability
▪ Increased capacity
▪ Increased data rates
▪ Software reconfigurable networks
▪ Interference discrimination
Parateks DRWiN™ antennas are the natural selection in the evolution of broadband.
PARATEK
Email inquiries to drwin@paratek.com
1-866-PARATEK ▪ 443-259-0140
www.paratek.com
Paratek Microwave, Inc. – The Tunable Wireless Company

teractive high bandwidth applications. Size: 9" × 11". Price: $4.85 (10,000).
Conexant Systems Inc.,
Newport Beach, CA (800) 854-8099.
Circle No. 237

ANTENNAS

Distribution Antenna Interface



The model 50289-DAI distribution antenna interface is designed for frequency bands from FM broadcast (88 to 108 MHz) to PCS (1800 to 2000 MHz). This new interface enables multiple communication devices for radiating systems. The DAI is 100 percent passive, has transmission line filters and type-N connector ports. This advanced interface unit offers the user the capability of providing multiple services including all municipal operations on a single antenna system with the ability to add bands as their system grows. The DAI features a maintenance friendly modular construction in a rugged, field proven NEMA-4 environmental enclosure, requires no AC power and supports power levels up to 50 W per band. The operating temperature is –30° to 60°C. Weight: 120 lb. Size: 36" × 30" × 12".
Aerocomm,
Englewood Cliffs, NJ (201) 227-0066.
Circle No. 238

Dynamically Reconfigurable Wireless Networks Family of Antennas

The DRWiN™ family of antennas for the wireless communications markets includes the first commercially available electronically scanning antenna. This unique antenna, with the ability to be reconfigured from a very broad 120° beam to a narrow 2° beam that can be scanned across the full sector, enables dramatic increases in network capacity, reliability and noise discrimination. The DRWiN antennas focus all of their power into a smaller volume directed at the selected subscriber to provide higher data rates, greater throughput or longer range. This beam can then be refocused on each subscriber requiring service in any random sequence. It can alternately revert back to broad coverage to acquire subscribers requesting new service. Another benefit of the family is that multiple beams may be operated independently at the same frequency within the same sector.
Paratek Microwave Inc.,
Columbia, MD (443) 259-0140.
Circle No. 239

DEVICE

GaAs PHEMT

The model MRFG35010 unmatched, 3.5 GHz, 10 W, 12 V, GaAs discrete transistor is designed for broadband wireless access infrastructure applications in the S-band frequency range. It is available in a bolt-down, non-hermetic package suitable for use as a driver stage in a broadband wireless local loop basestation amplifier. Non-hermetic packaging is utilized for cost savings, and the use of a non-hermetic package has been validated by performing a highly accelerated stress and temperature test on bare GaAs die under normal operating voltages. Price: $75.
Motorola SPS Inc.,
Tempe, AZ (480) 413-5383.
Circle No. 240

INTEGRATED CIRCUITS

3GPP Solution

The model MS8608A is a single instrument that combines a transmitter tester, power meter and spectrum analyzer for the analysis of 3GPP WCDMA signals. With the ability to perform modulation analysis, and measure code domain power, transmit power, adjacent channel power, occupied bandwidth and spurious emissions, the unit is designed for measuring basestations and mobile and basestation amplifiers at both the research and development and production stages. The MS8608A's transmitter tester covers the 9 kHz to 7.8 GHz frequency band and features an analysis bandwidth of 20 MHz and measures transmit power to an accuracy ±0.4 dB. Adjacent channel power is –68 dBc at 5 MHz offset and –75 dBc at 10 MHz offset. The built-in power meter measures a frequency range of 10 MHz to 3 GHz, and power levels of +40 to –20 dBm. Amplitude measurements can be made down to –60 dBm at ±0.6 dB accuracy. Frequency/modulation measurements are made with 1 percent (typ) modulation accuracy and origin offset accuracy of ±0.5 dB. Code domain analysis is conducted with power measurement accuracy of ±0.1 dB and error measurement accuracy ±0.5 dB. A transmitter power control measurement function allows relative power per slot and Go/No Go evaluation to be made.
Anritsu Co.,
Richardson, TX (800) 267-4878
or (972) 644-1777.
Circle No. 242

Quadrature Digital Upconverter

The model AD9857 highly integrated 200 Msps 14-bit quadrature digital upconverter (QDUC) features breakthrough functionality and superior dynamic performance for broadband communications and wireless infrastructure applications. The single-chip, mixed-signal QDUC integrates a high speed direct digital synthesizer, 14-bit DAC, digital filter, clock multiplier circuitry and user programmability in an 80-lead LQFP. It accepts complex I/Q input data, upsamples the data, quadrature-modulates the data onto a carrier and outputs a frequency-agile modulated carrier in the analog domain. Superior dynamic performance makes the unit ideal for broadband/cable modem return path modulation and cellular basestations. Generating a DC to 80 MHz digital output from a single 3.3 V supply, its 80 dB narrowband spurious free dynamic range provides the spectral performance needed to upconvert GMSK, CDMA, spread spectrum, OFDM, 256-QAM and any other complex modulation formats. The AD9857 operates over the –40° to +85°C. Price: $15.40 (10,000).

Analog Devices Inc.,
Wilmington, MA (800) 262-5643.
Circle No. 241

WLAN Chipset

The model AR5000 fast, low powered chipset delivers true radio-on-a-chip (RoC) capabilities and provides the first two-chip, all-CMOS end-to-end solution for next-generation 5 GHz wireless LANs. Operating at speeds up to 72 Mbps, the chipset enables ubiquitous, economical connections in the home and office between devices such as personal computers, printers and access points. It is compliant with the IEEE's new 802.11a 5 GHz wireless LAN

[Continued on page 162]

NEW PRODUCTS

standard, and includes an enhanced turbo mode. Price: $35.
Aetheros Communications Inc., Sunnyvale, CA (408) 773-5200.
Circle No. 243

Low Current Downconverter

The model MD59-0049 low cost, highly linear integrated circuit downconverter is designed for use in PCS band RF systems. It integrates an on-board LNA, mixer, LO buffer, RF amplifier and output buffer in a miniature 4 mm MLF package. The unit meets stringent linearity and low current requirements of PCS-band CDMA handsets, as well as the IS-98 CDMA linearity requirements for the US and Korean PCS bands. The MD59-0049 offers continuous control of current and gain by application of a control voltage, which enables the unit to operate over a wide range of input signal power and further minimize current draw and maximize battery life using real time gain control. It operates with an RF output frequency between 1.8 and 2.0 GHz and has a low noise figure of 2.3 dB, very low current draw (20 mA in high gain mode) and an input IP3 of –8 dBm (typ). The device requires an LO signal of only –10 dBm.
M/A-COM, Lowell, MA (800) 366-2266.
Circle No. 244

High Power Amplifier MMICs

The model TGA1135B and model TGA1172 millimeter-wave, high power amplifier MMIC

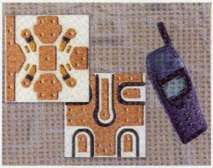
products cover the 18 to 32 GHz frequency band. Through the use of advanced 0.25-micron gate length PHEMT GaAs production process technology, these devices both provide the smallest available physical size per watt output power and lowest costs per watt of output power in this frequency range. These units provide equipment designers with an efficient, one-watt source of millimeter-wave power for use in wireless communication products such as point-to-point or point-to-multipoint radios, satellite communication earth stations and spacecraft payloads. Frequency bands include the 18, 23 and 26 GHz microwave bands and 24, 28 and 31 GHz LMDS bands, as well as the 18 and 30 GHz Ka-band satellite communications bands. Price: $49 TGA1135B (1000); $50 TGA1172 (1000). Delivery: 12 weeks (ARO).
TriQuint Semiconductor Inc., Hillsboro, OR (503) 615-9000.
Circle No. 245

77 GHz FS Radar Chipset

The chipset includes two multifunction MMICs: a 19 GHz VCO including a 18 to 38 GHz frequency multiplier and a 13 dBm 77 GHz power amplifier including a 38 to 76 GHz frequency multiplier. The devices have been developed taking into account the industrial and environmental constraints of Automated ACC radar manufacturers. They provide internal self-biasing with only two voltages to apply, +4.5 V and –4.5 V, and are designed for automatic pick and place and wire bonding equipment, thus are less sensible to assembly dispersion. The MMICs operate over –40° to +100°C and are optimized to work together and be an overall cost-effective solution.
United Monolithic Semiconductors (UMS), Orsay, France 33 1 69 33 02 11.
Circle No. 246

MATERIALS

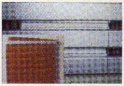
Thermal Vias



The refined PowerPlug™ technology consists of solid, copper plated via fills used in the fabrication of metallized ceramic substrates, chip carriers and packages. This development allows circuit and package designers to significantly improve the thermal and electrical parameters of microelectronic packages. Thermal resistance as low as 2°C/W can be achieved, expanding maximum operating temperature and power limits. The solid via plugs have high thermal conductivity (200W/CxM) as well as an electrical resistance as low as 0.38 mΩ.
Remtec Inc., Norwood, MA (781) 762-9191.
Circle No. 247

Silicone Press Pads

BISCO™ Silicone press pads are designed to be used in the lamination of multilayer printed



circuit boards, flexible circuits and liquid crystal display (LCD) modules. These pads offer 25 to 100 times longer life than traditional pads and save time at the press. They consist of a reinforcement layer made of fiberglass cloth that is encased between two layers of calendared silicone rubber. Standard thickness is 1/16" and the material is supplied in widths up to 36". The pads are offered in two grades: BISCO HT-1500 Solid Silicone and BISCO HT-1510 Solid Silicone. The former is a general purpose material that can be used at temperatures of 300° to 350°F and pressures of 250 to 400 psi, while the latter is a high performance material designed for temperatures up to 550°F and pressures of 250 to 400 psi.
Rogers Corp., Rogers, CT, (800) 237-2068.
Circle No. 248

High Frequency Circuit Material

The ComClad™ HF high frequency circuit material consists of Noryl® plastic material as the base dielectric and has excellent electrical performance for use in microwave and RF applications. It has a dielectric constant of 2.6, a dissipation factor of .0025 and is rated at a continuous operating temperature of –40° to +85°C. The material uses a common plastic as the base dielectric, designers and fabricators can form, mold, bend and even insert-mold it in a plastic injection process. The flexible manufacturing also allows for custom designs of panel size, thickness and copper clad. It is available in standard circuit board panel sizes of 12" × 18" and 18" × 24".
Sheldahl Inc., Northfield, MN (507) 663-8477.
Circle No. 249

SOFTWARE

Design and Simulation Tool

APLAC Version 7.6 design and simulation tool includes a fast RFIC module, which is useful when the designer has to deal with hundreds of active components, along with few passive components. A variety of new and improved semiconductor and passive component models are included as well. In addition, a Simulation Definition Wizard has been added in order to simplify the creation of analysis definitions. Nonlinear simulations can be specified even without any knowledge of APLAC language syntax.
APLAC Solutions Oy, Helsinki, Finland +358 9 5404 5010.
Circle No. 250

EM Simulation Software

CST MICROWAVE STUDIO™ Version 2.1 includes over 250 new features, options and improvements which have been implemented over the past six months. The palette of solver modules has also been extended to include a frequency domain solver available as a beta test version. Among the new features are adaptive mesh refinement, SAR calculation, improved import options, extended healing capability, extended dynamic SPIC extraction, surface impedance, plane waves, 2D profile editor, multi-pin port modes, human data set interface, anisotropic materials, RCS calculation and many new VBA functions and commands.
Computer Simulation Technology (CST), Darmstadt, Germany +49 (0) 6151 7303 0.
Circle No. 251

Microwave Design Software

Concerto Version 2 combines the universally accepted Finite Difference Time Domain method with a unique conforming mesh technique, and has already proven to be a success converting increasing numbers of customers from the older, slower packages. Version 2 includes a number of new features to increase this package's capabilities in EMC and radar cross sections. In addition, enhancements to its already impressive capabilities in microwave component and antenna design have been incorporated. The new version includes plane wave excitation, enabling the user to define a plane wave and study the reflections and diffractions due to complex objects in its path. The main advantage of this new feature is in EMC simulation, where a plane wave can be directed at a structure from a distance to determine the radiation reaching sensitive pares of the device.
Vector Fields Ltd., Kidlington, Oxford, UK +44 (0) 1865 370151.
Circle No. 252

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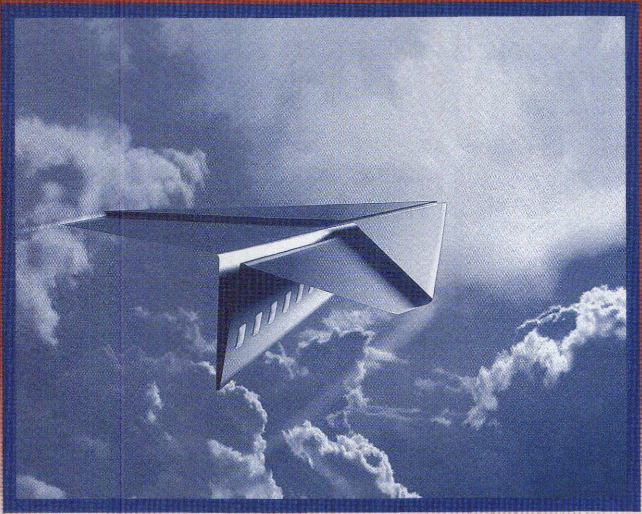


Imagine the possibilities.

Introducing our newest NGA InGaP HBT amplifier family with low thermal resistance for higher reliability and improved linearity with broader bandwidth.

Stanford Microdevices introduces the NGA-100 through 600 Series InGaP HBT amplifiers designed for today's and tomorrow's advanced communication infrastructure equipment. Design and fabricated with state-of-the-art InGaP/GaAsHBT technology for higher reliability, these devices are ideal for use as driver stages for higher power applications. Available in small-form factor plastic packages, the NGA series are biased with a single voltage and provide wide bandwidth, high gain and exceptional linearity.

For more information on these new InGaP amplifiers, visit our website today. Imagine the possibilities with RF innovation from Stanford Microdevices.

NGA - InGaP MMIC 50 Ohm Gain Block Amplifiers

Model	Freq Range (GHz)	Vd (V)	Id (mA)	Gain (dB)	PldB (dBm)	IP_3 (dBm)	Thermal Resistance (°C/W)
NGA-186	0.1-6.0	4.1	50.0	12.5	14.6	32.9	120
NGA-286	0.1-6.0	4.0	50.0	15.5	15.2	32.0	120
NGA-386	0.1-5.0	4.0	35.0	20.8	14.5	25.8	144
NGA-486	0.1-6.0	5.0	80.0	14.8	18.3	39.5	118
NGA-586	0.1-6.0	5.0	80.0	19.9	18.9	39.6	121
NGA-686	0.1-6.0	5.9	80.0	11.8	19.5	37.5	121

Data at 1 GHz and is typical of device performance.

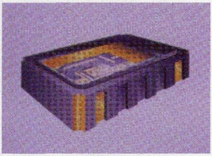
STANFORD MICRODEVICES

www.stanfordmicro.com • 800-764-6642

NEW PRODUCTS

SOURCES

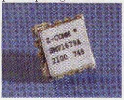
■ SMD Voltage-controlled Crystal Oscillator



The EV series of ceramic surface-mount VCXOs is ideal for applications such as digital subscriber line (DSL), cable modems and ATM/SONET/SDH. It is available for 3.3 or 5 V operation with a frequency range from 1.024 to 52.000 MHz. Features include absolute pull range up to 100 ppm, tri-state function, commercial or industrial temperature range and linearity up to 10 percent. Tube or tape and reel packaging is available. Size: 5.00 × 7.50 × 1.95 mm. Delivery: stock to 12 weeks.
Ecliptek Corp.,
Costa Mesa, CA (800) 325-4783.
Circle No. 253

■ Voltage-controlled Oscillator

The model SMV1679A surface-mount, low profile package VCO is designed for demanding wireless locating systems. This compact packaged device has been specially engineered to provide quick integration into



PLLs. It will generate frequencies between 1678 and 1680 MHz within a control voltage range of 0 to 3 V DC allowing the error voltage to be taken directly from the ICs charge pump circuitry. Drawing only 6 mA of current from a 2. 7 V DC supply, the unit saves valuable PCB space through its subminiature size. It exhibits spectral purity of –87 dBc/Hz (typ), at 10 kHz from the carrier and is specified to operate over the extended commercial temperature range of –30° to +85°C. Furthermore, this device provides the end user –5 ±2 dBm of output power into a 50 Ω load and suppresses the second harmonic to better than –9 dBc. Size: 0.3" × 0.3" × 0.8". Price: $15.95.
Z-Communications Inc.,
San Diego, CA (858) 621-2700.
Circle No. 254

SUBSYSTEMS

■ Co-channel FM Demodulator

The Platinum III demodulator is a new concept to FM communications whereby two co-channel transmissions can be demodulated simultaneously and separated from each other without distortion, crosstalk or beating. The receiver operates with dual carrier inputs from 20 to 500 MHz and produces the choice of four outputs, the dominant signal, the subdominant signal, the linear addition of the two modulations and the standard FM output. Multipath and quasi-synchronous signals simply add up and improve the reception. Separation starts when one carrier is ±1.0 dB (typ) different from the other. The sub-dominant carrier can be recovered down to –20 dB below the stronger carrier. Power supplies are ±6 V DC at 160 mA. Size: 160 × 100 × 10 mm.
Ampsys Electronics Ltd.,
Paisley, Scotland +44 (0) 141 848 3444.
Circle No. 255

■ I/Q Vector Modulators

The 73/74 Series of I/Q vector modulators are designed for today's more demanding system applications. The modulators feature 60 dB dynamic range of attenuation and 360° phase control in three broadbands, covering the 2 to 24 GHz frequency range. The 73-Series offers 12-bit I and Q digital control for high resolution and the 74-Series units offer analog control with comparable RF performance. All models incorporate multiple bi-phase attenuator sections to provide in excess of 60 dB attenuation range at any frequency. They are capable of the full 360° phase range at any attenuation level. The units operate over the –54° to 100°C range. Weight: < 12 oz. Size: 4" × 3" × 1".
General Microwave,
a Herley Industries Inc. company,
Farmingdale, NY (631) 630-2000.
Circle No. 256

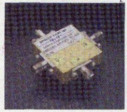
■ AC-DC Switching Power Supplies

The low profile SC150 series of AC-DC switching power supplies is a reliable source of power for computer peripherals, telecommunications, point-of-sale and test and measurement equipment in a package that fa-

cilitates multiple sourcing. In addition, thousands of other models are easily configured delivering up to four output voltages of 1.8 to 48 V. Additional flexibility is provided through the low profile height of the unit that enables the SC150 to easily fit in 1U racking applications. The series meets UL1950, CSA950 and EN60950 regulations, and accepts DC inputs from 130 to 360 V. Price: $129 (100).
Lambda, an Invensys company,
San Diego, VA (800) 526-2324.
Circle No. 257

■ MMIC LMDS Receiver

The model MM25-6LNA integrated receiver consists of a low noise amplifier, mixer and LO doupler-amp. The RF frequency range is 20 to 30 GHz, the LO frequency range is 10 to 15 GHz at –4 to 0 dBm and the IF range is DC to 5 GHz.



SSB noise figure is 3.0 dB (typ), 3.5 dB (max). RF to IF gain is 20 dB (typ), DC bias is +8 to +12 V at 200 mA (max). This receiver can be used for narrowband LMDS or full-band multi-channel radiometer applications.
Spacek Labs Inc.,
Santa Barbara, CA (805) 564-4404.
Circle No. 258

SYSTEM

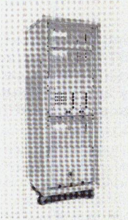
■ Wireless LAN LMDS Solution

The model PPC-10/37000-L basestation for wireless point-to-multipoint LAN connectivity is a 40 GHz wireless building-to-building link for multiple Ethernet LAN connectivity. It is a transparent, software-free wireless transceiver, designed to connect two or more Ethernet LANs. Used in conjunction with the model PPC-10/37000-B LAN-to-LAN bridges, the system provides a true LMDS wireless solution for wide area Ethernet network connectivity. The network will pass all Ethernet-type protocols, including IP, IPX and AppleTalk with full duplex throughput at standard Ethernet 10 Mbps in each direction. The network is much more cost-effective than using equivalent multiple point-to-point links, and easily resolves last mile issues such as prohibitively-priced optical cable installation or bandwidth limitations of copper pairs. The wireless system can be quickly deployed to cost-effectively deliver any kind of traffic, such as data, Internet, voice, video or multimedia services.
ELVA-1 Millimeter-wave Division,
St. Petersburg, Russia
+7 812 325 58 58 ext. 282.
Circle No. 259

TEST EQUIPMENT

■ Bellcore SmartRack

The Bellcore SmartRack is a 19" rack that houses the transient generators used to test to Bellcore GR-1089-CORE that permits multiple-phenomena testing with the press of single button. Software and a coupling/decoupling matrix allow series' of tests to be sequenced and executed without engaging and disengaging the EUT. Other options include configuring the system for ESD



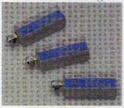
testing for Section 2, Section 9 frame, surge and EFT tests. It can be operated from a front panel or remotely from a Windows-based computer. The software operates on Windows 95, 98, 2000 or NT and it generates complete reports.
Amplifier Research (AR),
Souderton, PA (215) 723-8181.
Circle No. 261

[Continued on page 166]

NEW PRODUCTS

Noise Figure Analysis Tool

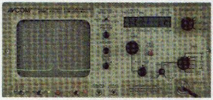
The models N8974A and 8975A additions to the NFA series noise figure analyzers simplify measurement set up and improve accuracy. They offer a flexible, intuitive user interface that makes it easy to characterize amplifiers and frequency converting devices. Measuring 6.7 to 36.5 GHz in a single instrument eliminates the need for a separate downconverter, and accurate and repeatable results allow tighter specification of device performance. The N8974A operates over the 10.0 MHz to 6.7 GHz range with noise figure uncertainty of ≤ 0.15 dB, while the N8975A operates from 10 MHz to 26.5 GHz with ≤ 0.15 dB noise figure uncertainty.



Agilent Technologies Ltd., Amstelveen, The Netherlands 020 547 7225.

Circle No. 260

Wireless and Satellite Spectrum Analyzer



The model PSA-86A wireless spectrum analyzer includes the company's proven microprocessor frequency control technology, attractive multi-function backlit LCD and automatic digital frequency lock (DFL). It covers a frequency range between 5 and 7 GHz in spans of 1000MHz (typ), in accordance with option selected and customer specification. The spectrum analyzer with option 001 covers the 5.5 to 6.5 GHz frequency range for economical analysis of satellite uplink band. The model with option 002 covers the 5.1 to 6.1 GHz band for wireless communications. The choice of frequency coverage, amplitude and frequency accuracy, and high sensitivity (–95 dBm) of the PSA-86A combined with its low cost make these analyzers an ideal choice where portability and economy are required. Price: $2975. Delivery: stock to 2 weeks.

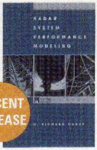
AVCOM of Virginia Inc., Richmond, VA (804) 794-2500.

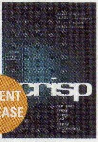
Circle No. 262

Test Set for Wireless Amplifier and Digital Radio Test

The model CS2010W virtual test instrument for power amplifier, software-defined digital radio and digital signal encoder applications has memory of 4000 MB, resolution via 14-bit D/As and an excellent dynamic range. It essentially offers three products in one with various functions, which may include multi-carrier, multi-standard signal generation through VSS software, digital IF and IQ transmit and receive with interface

[Continued on page 168]

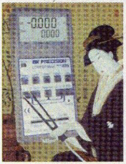




capabilities to proprietary back planes. The 2010W is an off-the-shelf solution that offers multi-domain generation and analysis at different levels of functionality to meet different budget and performance requirements.
Celerity Digital Broadband Test, a division of L-3 Communications, Cupertino, CA (888) 274-5604.
Circle No. 264

Synthesized In-circuit LCR/ESR Meter

The model 885 lightweight, battery powered, handheld, synthesized in-circuit LCR/ESR meter can be used to test components at frequencies up to 10 kHz. It offers a large variety of measurement parameters such as Z, L, C, DCR, ESR, D, Q and ϕ and a wide range of test conditions including 100 and 120 Hz, 1 and 10 kHz, 1 Vrms, 0.25 Vrms and 0.05 Vrms. It features DC resistance measurement, rechargeable battery/AC power, 0.5 percent basic accuracy, a large, easy-to-read dual LCD display, fully auto/manual selection and very quick response. The model 885 comes complete with instruction manual, battery, SMD surface-mount probe and carry case. Price: $549.



BK Precision Corp., Placentia, CA (714) 237-9220.
Circle No. 263

Transponder Test Set

The model IFF-701Ti transponder test set responds to the military's need for greater flight safety, and is aimed at flight line and bench testing of transponders and interrogators, and can test both identification friend or foe (IFF) transponders and IFF interegators. It is also capable of testing enhanced traffic alert collision avoidance systems (ETCAS). The IFF-701Ti allows user control of pass/fail parameters using RS-232 communications port and provides capability for storing IFF Mode 4 codes for use during transponder testing. Price: $19,995. Delivery: 4 weeks.

IFR Systems Inc., Wichita, KS (800) 835-2352 or (316) 522-4981.
Circle No. 278

Protocol Analysis Solution

The model K1297-G20 is one of the first tools to support the Universal Mobile Telecommunication System (UMTS) and already supports test-

[Continued on page 170]

ing and monitoring of diverse second generation equipment. UMTS supports the combination of voice, video and data in next-generation mobile communication infrastructures. Adding the UMTS standard to its K1297-G20 protocol analyzer allows telecommunications equipment designers to develop and test, and network operators to deploy features such as global roaming and Internet access. This feature puts this analyzer in the mainstream of 3G development and deployment. The instrument delivers full support of the UMTS Iu interface signaling protocols towards the circuit-switched and packet-switched domain. Among other duties, it can simulate the Radio Network Controller via the Iu interface while verifying the functions of the UMTS mobile switching center (and vice versa), allowing independent development of the two elements. Price: $188,000, including hardware and software for the simulation, emulation and monitoring packages; $123,000 for the monitoring package option.

Tektronix Inc., Beaverton, OR (503) 627-2001.

Circle No. 265

TUBE

■ Miniature Traveling-wave Tube

The model TH 3968 traveling-wave tube (TWT) for modern electronic countermeasure systems offers a very wide bandwidth, meeting all requirements for equipment operating in the 6 to 18 GHz frequency range at an average power of 100 W. The TWT uses a helix delay line, the only technology capable of providing the necessary bandwidth. The signal is modulated by a dedicated Wehnelt beam-forming electrode and it uses a single-stage collector. The TH 3968 is conduction-cooled, and satisfies the demanding requirements of the harsh countermeasures environment, in particular for temperature and vibrations.

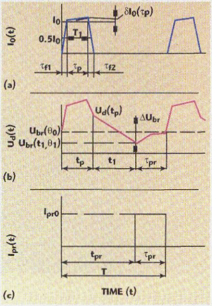
Thomson Tubes Electroniques, Cedex, France +33 (0) 1 30 70 35 00.

Circle No. 266

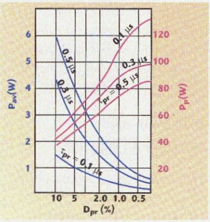

Wireless

ERRATUM

In "Stabilization of RF Parameters of Injection-locked Pulsed IMPATT Oscillators," a technical feature by L.V. Kasatkin and N.F. Karushkin that appeared in the September issue of *Microwave Journal*, there were several typographical errors. The text describing ***Figure 1*** should have read: For a diode temperature θ = 500 K the bias current density is J_0 = 16 kA/cm^2 and current compensation in the described temperature interval is achieved by decreasing the current density in the limits of $12 \leq J_0 \leq 16$ kA/cm^2; the different colors in the data plot correspond to fixed voltage amplitudes at the diode terminals of U_m = 10, 15 and 20. Also, the correct ***Figures 2*** and ***4*** appear below:



▲ *Fig. 2 Time dependencies of the diode's (a) pulse bias current $I_0(t)$, (b) diode voltage $U_d(t)$ and (c) pulse perheating current $I_{pr}(t)$ defined for constant bias current pulse width and pulse period.*



▲ *Fig. 4 The required additional average power P_{av} and pulse power P_p for diode preheating as a function of preheating pulse width τ_{pr} and pulse bias current duty factor $D_1 = \tau_1/T$.*

NEW LITERATURE

PRODUCT BROCHURE

This six-page brochure describes integrated assemblies, converter assemblies, log IFs, filter banks and switch filter banks. Product photographs are provided. Descriptions of the company's manufacturing and engineering processes are included, as well as a company mission statement.

AKON, San Jose, CA (408) 432-8039.

Circle No. 200

CELLULAR/PCS CATALOG

This 48-page catalog, *CEL-6006*, details vehicular, fixed station and low power in-building repeater kits. It features many new products for dual-band/PCS and dual-system cellular/GPS applications, as well as the recently released EAC-50™ in-building repeater kit. Mobile antenna additions include the "On-Glass"® cellular/PCS 3 dBd/unity gain antenna.

Antenna Specialists,
an Allen Telecom company,
Cleveland, OH (440) 349-8400.

Circle No. 201

RF FEEDTHROUGH BROCHURE

This four-page brochure features the company's full line of RF feedthroughs, both single and dual conductor. The feedthrough ratings are classified by frequency and amperage in order to meet all of the various parameters for different applications.

Ceramaseal,
New Lebanon, NY (800) 752-7325.

Circle No. 202

PRODUCT DATASHEET

This data sheet features the model 6150 laser trimming system, which offers small spot size, flexible configuration and easy use, along with the speed and precision needed for linear devices, mixed signal devices and sensors. The data sheet includes a photograph and product description, as well as a specifications summary.

Electro Scientific Industries Inc., (ESI),
Portland, OR (503) 641-4141.

Circle No. 203

MASTER SOURCEBOOK CATALOG

This 300-page catalog features thousands of products from leading manufacturers, including many items that are new to the industry. It features an extensive selection of tool kits, cases and carts, test equipment, hand, power and specialty tools, wire and cable, soldering equipment, computer and LAN products.

Jensen Tools Inc.,
Phoenix, AZ (800) 426-1194
or (602) 453-3169.

Circle No. 204

PC-BASED MEASUREMENT AND CONTROL SOLUTION BROCHURE

This six-page brochure details manufacturing test and measurement, OEM, and factory automation and machine control solutions. Product descriptions, photographs and applications are provided, along with a chart comparing each product's price, general functions, electrical measurements and physical measurements.

Keithley Instruments Inc.,
Cleveland, OH (888) 534-8453.

Circle No. 205

FLEXIBLE MICROWAVE CABLE ASSEMBLIES CATALOG

This 21-page catalog features UTiFLEX® miniature low loss, low loss, ultra low loss and ultralight cable assemblies. Product descriptions, photographs, performance graphs, mechanical characteristics, electrical characteristics and environmental characteristics are included.

MICRO-COAX,
Pottstown, PA (610) 495-0110.

Circle No. 206

PRODUCT CATALOG

This 16-page catalog, Analytical Test Stations and Accessories, provides product photos and short summaries of the company's more popular products. The 300 mm probe station, the 9000 Series, 8000 Series, 6000 Series, 4000 Series and RF/Microwave systems are featured.

The Micromanipulator Co.,
Carson City, NV (800) 967-4358.

Circle No. 207

PRODUCT LINE CATALOG

This 96-page product line catalog featuring test and measurement products can be downloaded from the firm's Web site, www.bkprecision.com, or is available by contacting an authorized distributor. It features over 50 new and best selling products, and is an ideal source document for use by electrical and electronic field service, depot service and engineering/R&D personnel.

BK Precision Corp.,
Placentia, CA (714) 237-9220.

Circle No. 208

PRODUCT DATA SHEET

This data sheet details the 28 dBi gain DRWiN™ electronically scanning antenna. The antenna features adaptive beam patterns, rapid beam hopping, software control and low power consumption. The data sheet provides a photograph, product features, benefits, applications and specifications, as well as performance graphs.

Paratek Microwave Inc.,
Columbia, MD (443) 259-0140.

Circle No. 209

EMC COMPONENTS CATALOG

This 256-page EMC components catalog provides detailed technical data on a broad range of filters, chokes and feedthrough components. Product information includes current ratings, IEC compliance, differential and common mode attenuation, optional versions and installation instructions. Insertion loss diagrams and mechanical schematics are also provided.

Schaffner EMC Inc.,
Edison, NJ (732) 225-9533.

Circle No. 210

PRODUCT BROCHURE

This 15-page brochure deals with applications of the ANT-20 advanced network tester in SONET networks up to the OC-192 hierarchy level. It provides product descriptions, photographs, sample test sequences and results, and screenshots, as well as some solutions to typical test problems using the ANT-20.

Wavetek Wandel Goltermann
Eningen GmbH and Co.,
Eningen, Germany +49 7121 86-1616.

Circle No. 211

THE BOOK END

Electromagnetic Simulation Using the FDTD Method

Dennis M. Sullivan

IEEE Press
165 pages; $89.95
ISBN: 0-7803-4747-1

This book is not a theoretical explanation of finite-difference-time-domain (FDTD) simulation. Instead its main purpose is to enable the reader to learn how to do three-dimensional electromagnetic simulation using the FDTD method. It is aimed at those engineers and students that would like to learn to do FDTF simulation in a reasonable amount of time.

> ***"...how to do three-dimensional electromagnetic simulation using the FDTD method."***

The book is structured as a tutorial where every chapter addresses an additional level of complexity. That is, the text starts with one-dimensional simulation and progresses to two- and three-dimensional examples. Also, the analysis starts with free space, then progresses to dielectric material, lossy dielectric material and, finally, frequency-dependent material.

The first chapter covers one-dimensional simulation in free-space. A step-by-step introduction to the FDTD method is provided with appropriate example problems to be solved. Chapter 2 presents some advanced concepts within the one-dimensional simulation framework. The use of flux density in the simulation is described, providing advantages for later simulations involving frequency-dependent materials. Chapter 3 introduces two-dimensional simulation, beginning with a simple point source for an example. Then absorbing boundaries are described, along with their implementation into the FDTD program.

Chapter 4 covers three-dimensional simulation. Here, the simulation becomes considerably more difficult. Chapter 5 provides two examples to illustrate the use of FDTD, the characterization of a stripline antenna and the calculation of the far field of an aperture antenna using a time domain transformation. The final chapter describes using FDTD for other types of simulation (other than electromagnetics). Examples are provided for acoustic simulation, and simulation of the Schroedinger equation, the heart of quantum mechanics. Appendix A describes the use of the Z transform when dealing with digital signals.

The book is written as a tutorial for either course work or self study. Each chapter contains a concise explanation of an essential concept and instruction on its implementation into computer code.

To order this book, contact: (The Institute of Electrical Engineers) Inspec Dept., IEEE Operation Center, P.O. Box 1331, Piscataway, NJ 08855-1331 (908) 562-5553.

Microwave Materials and Fabrication Techniques

Thomas S. Laverghetta

Artech House Inc.
287 pages; $83, £57
ISBN: 1-58053-064-8

This third edition of the book provides much needed updates with regard to microwave materials, computer-aided fabrication tools, plating processes and other areas driven by the recent boom in commercial wireless microwave applications and the advances in materials and processes resulting from that effort. The intention remains the same: to educate the microwave circuit designer in material and fabrication techniques, so as to avoid problems in converting theoretical designs to practical hardware.

Following a brief introductory chapter, Chapter 2 describes the latest laminate and substrate materials and their properties. This area has seen some of the most dramatic changes with the development of new materials to meet the commercial demands of the wireless market. Chapter 3 discusses metals used in fabrication and remains largely as before.

Significant changes have been made to update the chapter on microwave artwork. Here the methods used to generate the artwork have improved significantly and Chapter 4 describes the latest computer-aided methods to go from circuit design to board fabrication automatically. Chapter 5 covers etching and plating, and contains new material on plated-through-hole fabrication techniques with regard to the newer materials. Chapter 6 on bonding techniques has remained largely unchanged except for the addition of some newer solders and epoxies in use today. The final chapter on microwave packaging primarily deals with stripline, microstrip and suspended substrate circuit configurations, and describes the techniques used to implement effective external packaging of those circuits.

> ***"...a good reference text for designers involved in the development of practical microwave circuit products."***

The many appendices have also been updated where appropriate, and provide useful reference data for designers including selected data sheets for some of the circuit material referred to in the text. In general, the book is a good reference text for designers involved in the development of practical microwave circuit products.

To order this book, contact: Artech House Inc., 685 Canton St., Norwood, MA 02062 (781) 769-9750, ext. 4002; or 46 Gillingham St., London SW1V 1HH, UK +44 (0)20 7596-8750.

Frank Bashore

Frank Bashore is a member of the Microwave Journal *staff.*

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3	Alpha Industries	35	781-935-5150	781-935-2359	www.alphaind.com
4	Amcom Communications Inc.	118	301-353-8400	301-353-8401	www.amcomusa.com
5	American Technical Ceramics	65	631-622-4700	631-622-4748	www.atceramics.com
6	Amplifier Research	69	215-723-8181	215-723-5688	www.amplifiers.com/@/mj-shep
7	Anritsu Company	147	800-ANRITSU	972-671-1877	www.us.anritsu.com
8,9,10	Ansoft Corporation	25,87,123	412-261-3200	412-471-9427	www.ansoft.com
11	Antenna Research Associates	58	301-937-8888	301-937-2796	www.ara-inc.com
12	Aplac	74	972-719-2562		www.aplac.com
13	Applied Wave Research	140	310-726-3000	310-726-3005	www.mwoffice.com
14,15,16,17	Artech House	152,167	800-225-9977	781-769-6334	www.artechhouse.com
18,19	Astrolab	43,152	732-560-3800	732-560-9570	www.astrolab.com
20	Bird Component Products	119	727-547-8826	727-547-0806	www.birdfla.com
21,22	Cascade Microtech	COV 4	503-601-1000	503-601-1002	www.cascademicrotech.com
23	Coilcraft	47	800-322-2645	847-639-1469	www.coilcraft.com
	Communication Solutions Inc.	168	410-344-9000	410-344-1790	www.comsol-inc.com
24	Comtech PST	131	631-777-8900	631-777-8877	www.comtechpst.com
25	Condor Systems Inc.	145	408-879-2236	408-377-6892	www.condorsys.com
26	CST of America	61	617-576-5857	617-576-5702	www.cst-america.com
27	CTT Inc.	84	408-988-2999	408-986-9097	www.cttinc.com
28	Daico Industries	COV 3	310-507-3242	310-507-5701	www.daico.com
29	Dielectric Laboratories	54	315-655-8710	315-655-8179	www.dilabs.com
30	Dupont	149	800-284-3382	919-248-5770	www.dupont.com/mcm/
31	Dynawave	127	978-469-0555	978-521-4589	www.dynawave.com
32,33	Eagleware Corporation	20–21,129	678-291-0995	678-291-0971	www.eagleware.com
	Edith Roman Associates	146	914-620-9000	914-620-9035	www.edithroman.com
34	Florida RF Labs	15	800-544-5594	888-544-5594	www.rflabs.com
35	Focus Microwaves Inc.	155	514-335-6227	514-335-6287	www.focus-microwaves.com
36	FSY Microwave Inc.	101	410-381-5700	410-381-0140	www.fsymicrowave.com
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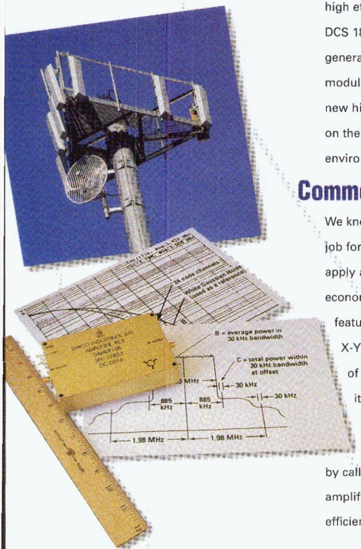

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