

**MMDS—bringing wireless services home**

**Performance requirements of base station oscillators**

**Design receivers using digital signal processing**

wireless internet  
multimedia  
telephony  
tv/radio

IBM  
ALAN VICTOR DIR WIRELESS TECH  
#00795047# 0000 A RFDG 1067  
#BXNHCHY \*\*\*\*\* ALL FOR ADC 270  
RALEIGH NC 27613  
9609 ROSS CRT

# Do You Have The Tools To Test...



- C/N • Eb/No • SATCOM • CATV • DOCSIS
- Jamming • Noise Power Ratio • Fibre Channel
- Wireless • Military Applications
- Noise Figure Measurement • Automated Test Equipment

## We Do!



NC 346 Series



UXF 7000 Series



UXF-NPR Series

*Ask us how our products  
can meet your testing needs.*

E. 64 Midland Avenue, Paramus, NJ 07652  
Phone: (201) 261-8797 Fax: (201) 261-8339  
Email: [info@noise.com](mailto:info@noise.com)  
Web Site: <http://www.noise.com>

INFOCARD 1

# NOISE/COM



**NATIONAL'S LMX23XXL  
PRODUCTS ARE UP TO 60% LOWER  
POWER AT A MERE 2.5mA FOR 1GHz**

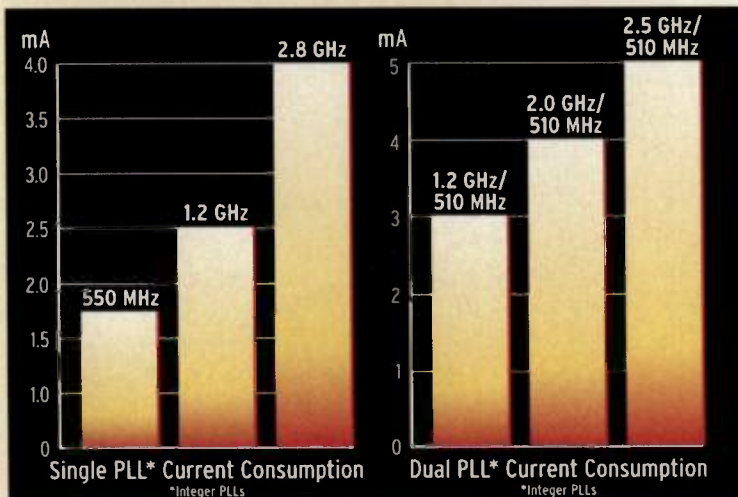
- SUPPLY VOLTAGE VERSATILITY (2.3-5.5V FOR SINGLES AND 2.7-5.5V FOR DUALS)
- OPERATING CHOICE OF FREQUENCY FROM 10MHz TO 2.8GHz
- INDUSTRY LEADING LOW LEAKAGE AND BALANCED CHARGE PUMP PERFORMANCE
- PROVIDES SUPERIOR COMBINATION OF LOW PHASE NOISE, LOCKTIME AND POWER CONSUMPTION
- Bi-CMOS PROCESS
- LOWEST PHASE NOISE FLOORS AVAILABLE (-167dBc/Hz FOR SINGLES, -169dBc/Hz FOR DUALS)
- CSP (CHIP SCALE PACKAGE) AVAILABLE

IDEAL FOR WIRELESS APPLICATIONS SUCH AS PORTABLE WIRELESS DEVICES, WLANS, CABLE TV TUNERS, PAGERS AND OTHER WIRELESS SYSTEMS

**FOR MORE INFORMATION:**  
[www.national.com/see/PLL](http://www.national.com/see/PLL)  
**1-800-272-9959**

Part Number	RF Input (Main & Aux PLLs)	Active $I_{CC}$ (typ @ 3V)	$V_{CC}$ Range	Package
<b>Single PLLs</b>				
LMX2306	550MHz	1.7mA	2.3 to 5.5V	TSSOP16*
LMX2316	1.2GHz	2.5mA	2.3 to 5.5V	TSSOP16*
LMX2326	2.8GHz	4.0mA	2.3 to 5.5V	TSSOP16*
<b>Dual PLLs</b>				
LMX2330L	2.5GHz & 510MHz	5.0mA	2.7 to 5.5V	TSSOP20*
LMX2331L	2.0GHz & 510MHz	4.0mA	2.7 to 5.5V	TSSOP20*
LMX2332L	1.2GHz & 510MHz	3.0mA	2.7 to 5.5V	TSSOP20*
LMX2335L	1.1GHz & 1.1GHz	4.0mA	2.7 to 5.5V	TSSOP16/SO16*
LMX2336L	2.0GHz & 1.1GHz	5.0mA	2.7 to 5.5V	TSSOP20*
LMX1600	2.0GHz & 500MHz	5.0mA	2.7 to 3.6V	TSSOP16*
<b>Frac-N Dual PLLs</b>				
LMX2350	2.5GHz/550MHz	7mA	2.7 to 5.5V	TSSOP24*
LMX2352	1.2GHz/500MHz	5.5mA	2.7 to 5.5V	TSSOP24*

\*CSP package option also available.



©1998 National Semiconductor and are registered trademarks and PLLatinum is a trademark of National Semiconductor Corporation. All rights reserved.

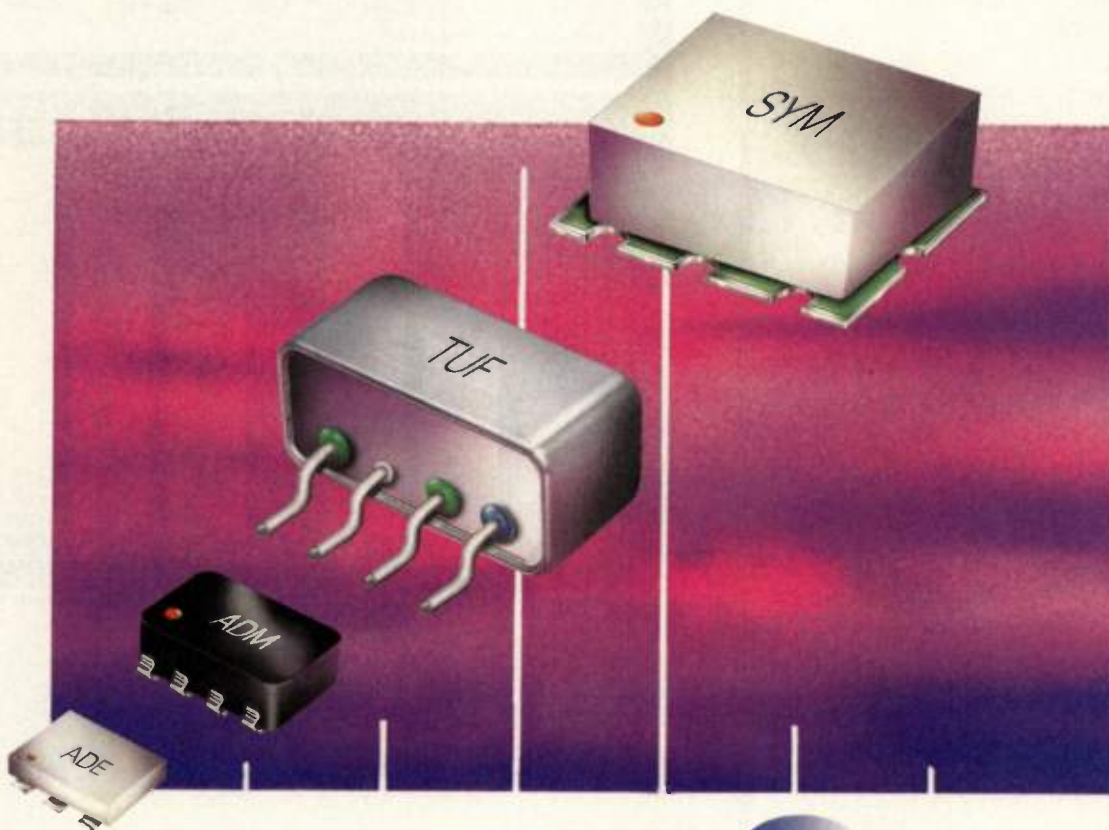
# ULTRA LOW POWER & DUAL PLLATINUM™ PLLS



National Semiconductor

# HIGH IP3 MIXERS

**suppress noisy intermods**



**+30dBm IP3** 5 to 2200MHz **\$7<sup>95</sup>** (10-49 qty)

**WOW!**

The popularity of wireless communication services is soaring, but when signal overcrowding creates intermodulation distortion... Mini-Circuits has the solution! Our full range of low distortion high IP3 mixers provide the muscle it takes to **suppress noisy intermods** and clear the air of unwanted signals. At the same time, these affordable surface mount and plug-in solutions achieve low conversion loss and excellent L-R, L-I isolation. Developed for both analog and digital use, applications include airphone, cellular and cordless phones, radar, satellite, FM Broadcast, ISM, PCS, and PCN. Achieve the high performance your customers expect. Specify low loss, high IP3 mixers from Mini-Circuits. It's the *clear* choice!

**Mini-Circuits...we're redefining what VALUE is all about!**

TYPICAL SPECIFICATIONS (LO=+17dBm), Surface Mount

Model	Freq. (MHz)	IP3 Midband (dBm)	Isol. Bandwidth L-R L-I (dB)	Conv.Loss Midband (dB)	Price \$ea. Qty. 1-9
*ADE-10H	400-1000	30	39 25	7.0	7.95**
*ADE-12H	500-1200	28	34 28	6.7	8.95**
SYM-18H	5-1800	30	45 40	5.75	17.95
SYM-10DH	800-1000	31	45 29	7.6	18.95
SYM-22H	1500-2200	30	33 38	5.6	19.95
•TUF-18DHSM	100-1800	27	41 33	7.3	21.95
*ADM-10DH	800-1000	30	35 37	6.0	15.95

**IT** Innovative Technology  
(Patent Pending)

\*\*Quantity 10 to 49

•Plug-in version available, specify TUF-18DH  
Available in tape and reel.

**Mini-Circuits®**

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718)332-4661 INTERNET <http://www.minicircuits.com>

For detailed specs on all Mini-Circuits products refer to • 760- pg. HANDBOOK • INTERNET • THOMAS REGISTER • MICROWAVE PRODUCT DATA DIRECTORY • EEM

**ISO 9001 CERTIFIED**

US 83 INTL 84

CIRCLE READER SERVICE CARD

F 270 Rev A





Only **\$36<sup>95</sup>** ea.(qty. 1-49)

## 2W SMA DC to 18GHz ATTENUATORS

How can you buy attenuators that combine world renowned engineering expertise with high quality stainless steel construction, low cost, and off-the-shelf availability? Specify Mini-Circuits fixed attenuators! Built tough to handle 2 watts average with 125 watts peak power, this attenuator series supplies precision accurate 1dB to 40dB attenuation values with high temperature stability and excellent phase linearity in the wide DC to 18GHz band. Call Mini-Circuits and capture this next generation of value for your system integration today!



*Mini-Circuits...we're redefining what VALUE is all about!*

### Special Designer's Kits

Kit No.	No. of units in kit	Attenuation Values	Price \$ per kit
K-BW1	6	2 of each: 3, 6, 10	150
K-BW2	6	1 of each: 3, 6, 10, 20, 30, 40	150
K-BW3	10	1 of each: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	200

Model	Attenuation (dB)		Length (Inches)
	Nominal	Accuracy*	
BW-S1W2	1	±0.40	.85
BW-S2W2	2	±0.40	.85
BW-S3W2	3	±0.40	.85
BW-S4W2	4	±0.40	.85
BW-S5W2	5	±0.40	.85
BW-S6W2	6	±0.40	.85
BW-S7W2	7	±0.60	.85
BW-S8W2	8	±0.60	.85
BW-S9W2	9	±0.60	.85
BW-S10W2	10	±0.60	.85
BW-S12W2	12	±0.60	.85
BW-S15W2	15	±0.60	.99
BW-S20W2	20	±0.60	.99
BW-S30W2	30	±0.85	.99
BW-S40W2	40	±0.85	.99

Equipped with SMA male and female connectors. .312" across hex flats.

\*At 25°C includes power and frequency variations up to 12.4GHz. Above 12.4GHz add 0.5dB typ. to accuracy.

**ALL VALUES IN STOCK**

**Mini-Circuits®**

US 27 INT'L 28  
CIRCLE READER SERVICE CARD

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 INTERNET <http://www.minicircuits.com>  
For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

**ISO 9001 CERTIFIED**

F 276 Rev C

ROS  
50MHz to 1600MHz



## MINIATURE SURFACE MOUNT VCO's from \$12.95

The big news is Mini-Circuits miniature family of **50 to 1600MHz** ROS voltage controlled oscillators! Each unit is housed in a shielded 0.5"x0.5"x0.18" non-hermetic industry standard package for highly efficient wash-thru capability, reliability, and cost effectiveness. Models with "PV" suffix typically operate from a 5 volt power supply and require 5V tuning voltage to cover the frequency range. This makes them ideal for integration with monolithic PLL chips and commercial synthesizers working within the 245 to 1600MHz band. The series also features wide band 12V models optimized for 50 to 1410MHz linear tuning, up to one octave band widths, and low phase noise. Support your customers demands for smaller size and better performance, switch to ROS VCO's today!



ACTUAL SIZE

Mini-Circuits...we're redefining what **VALUE** is all about!

### ROS SPECIFICATIONS:

Model	Freq. Range (MHz)	V <sub>tune</sub> (V) Max.	Phase Noise* Typ.	Harmonics** (dBc) Typ.	Voltage V	Current (mA) Max.	Price \$ea. (5-49)
ROS-285PV	245-285	5	-100	-20	5	20	17.95
ROS-900PV	810-900	5	-102	-25	4.5	12	19.95
ROS-960PV	890-960	5	-102	-27	5	12	19.95
ROS-1000PV	900-1000	5	-104	-33	5	22	19.95
ROS-1600PV	1520-1600	5	-100	-26	5	25	18.95
ROS-100	50-100	17	-105	-30	12	20	12.95
ROS-150	75-150	18	-103	-23	12	20	12.95
ROS-200	100-200	17	-105	-30	12	20	12.95
ROS-300	150-280	16	-102	-28	12	20	14.95
ROS-400	200-380	17	-100	-24	12	20	14.95
ROS-535	300-525	17	-98	-20	12	20	14.95
ROS-765	485-765	16	-95	-27	12	22	15.95
ROS-1410	850-1410	11	-99	-8	12	25	19.95

\*Phase Noise: SSB at 10kHz offset, dBc/Hz. \*\*Specified to fourth.

 **Mini-Circuits®**

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 **INTERNET** <http://www.minicircuits.com>

For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

**ISO 9001 CERTIFIED**

US **30** INT'L **31**  
CIRCLE READER SERVICE CARD

F 295 Rev 0rg



# in this issue

M A Y 1 9 9 9



## DEPARTMENTS

Editorial	8
Editorial Forum	10
Calendar	12
Courses	16
News	18
Company Index	66
Product Focus	71
Products	74
Software	84
Literature	85
Marketplace	87



GET LINKED — RF Design Online now has three ways to link to companies mentioned in this issue: *advertiser links*, *product directory* and *editorial links*. See page 66 for more information.

**22** — *Featured technology: Semiconductors*  
**Advantages of SiGe for RF front-ends** — Components manufactured using a SiGe bipolar process exhibit lower noise, better linearity and lower current consumption than their pure, bipolar-only process counterparts.  
*—Richard Lodge*

**28** — *Featured technology: Time & Frequency*  
**Performance requirements of communication base station time standards** — Modern communication systems demand high reliability time standards. Understanding the environmental conditions will help in selecting the right oscillator.  
*—John A. Kusters and Charles A. Adams*

**40** — *Cover story: Broadcasting*  
**Advances in broadcast technology—MMDS's rocky past and promising future** — MMDS, aka wireless cable, has been around for several years now. Recent advances in both distribution technology and infrastructure will open new avenues of opportunities for the RF industry.  
*—Ernest Worthman, Contributing Editor*

**50** — *Tutorial: Testing*  
**Automated RF path characterization in mobile phone test systems** — An automated application can make the process of RF path characterization easier and more accurate.  
*—Dennis Thiers*

**56** — **An (almost) all-digital HF communications receiver** — CMOS monolithic digital downconverters permit the construction of low-cost receivers using digital signal processing.  
*— Peter Traneus Anderson*

**94** — **RF...in Ernest**  
 Each month Ernest Worthman offers his insights on the technologies, issues and events impacting the RF design community. This month, he looks at platform integration.



# Ultra-Broad Band AMPLIFIERS



## ULTRA BROAD BAND

Model	Freq. Range GHz	Gain dB min	NF dB max	Gain Flat +/- dB	1 dB Comp. pt. dBm min	3rd Order ICP typ
JCA018-200	0.5-18.0	24	3.8	2.5	0	10
JCA018-203	0.5-18.0	20	5.0	2.5	7	17
JCA018-204	0.5-18.0	25	4.0	2.5	10	20
JCA018-300	0.5-18.0	30	3.8	2.5	0	10
JCA018-303	0.5-18.0	27	5.0	2.5	7	17
JCA018-400	0.5-18.0	37	3.8	2.5	0	10
JCA018-403	0.5-18.0	35	5.0	2.5	7	17
JCA018-504	0.5-18.0	40	5.0	2.5	10	20
JCA218-200	2.0-18.0	15	5.0	2.5	10	20
JCA218-206	2.0-18.0	17	5.0	2.5	15	25
JCA218-300	2.0-18.0	23	5.0	2.5	10	20
JCA218-306	2.0-18.0	22	5.0	2.5	15	25
JCA218-307	2.0-18.0	20	5.0	2.5	21	31
JCA218-400	2.0-18.0	29	5.0	2.5	10	20
JCA218-406	2.0-18.0	30	5.0	2.5	15	25
JCA218-407	2.0-18.0	30	5.0	2.5	21	31
JCA218-506	2.0-18.0	35	5.0	2.5	15	25
JCA218-507	2.0-18.0	35	5.0	2.5	18	28

### Features/Options:

- Removable SMA Connectors
- Competitive Pricing
- Compact Size
- Quick Delivery
- Alternate Gain/Noise/Power/VSWR levels if required

**JCA**  
TECHNOLOGY

**DELIVERY IN 2-4 WEEKS ARO**

4000 Via Pescador, Camarillo, CA 93012  
(805) 445-9888 Fax: (805) 987-6990  
email: [jca@jcatech.com](mailto:jca@jcatech.com)  
[www.jcatech.com](http://www.jcatech.com)

INFOCARD 19

## RF editorial

# High-tech manufacturing. Who said it was easy?

By Don Bishop  
Editorial Director



Our friends from Sunnyvale, CA-based Spectrian came by the office to talk about engineering power amplifiers (PAs) for base stations.

First, the statistics. Easy now. Just a few.

Did you know that 4.2% of the cost of a base station is for the power amplifier? And that a third of the market for the amplifiers, \$1 billion worth, is not "captive"?—meaning, for that portion, the original equipment manufacturers (OEMs) of the base station transmitters do not make their own power amplifiers. And that the PA is the most expensive single component?

"The key is cost, cost, cost," said Peter R. McIntyre from corporate communications.

Engineering and manufacturing for minimum cost to meet a standard defines many commercial projects. But wait. What if the standard hasn't yet been issued? Actually, a PA supplier can't wait, as McIntyre explained. Because the OEM can't wait.

Spectrian has to engineer a design and offer prototypes to OEMs well before a standard is set. If not, OEMs do the same to make sure they can be among the first to market with base stations for carriers.

"We have to break the make/buy decisions," McIntyre said.

Early engineering, a delivery track record and financial strength combine to convince OEMs not to make their own PAs but to buy them from suppliers.

John Pelose, vice president and general manager of the company's Multi-carrier Business Unit added that third- and fourth-generation PAs are approaching commodity status. They are moving from small, high-tech manufacturing to high-volume production where manufacturing techniques make big cost differences and where off-shore production is indicated to

meet performance and yield gates.

"PAs are the No. 1 user of DC power at base stations," Pelose said. "They generate the most heat, and they are among the largest components."

These characteristics raise network operating costs. Improved PA efficiency that reduces power consumption, heat generation and size gives a supplier a selling advantage. Upgrading a site with such amplifiers boosts network capacity without changing operating costs. Some sales turn on this factor. One reason for Spectrian's visit was to give us information to pass to you about products with such improvements.

By Spectrian's count, four or five companies compete to supply PAs to OEMs. Some specialize in commercial applications, others in military. And in Spectrian's opinion, the market has to have competitors because OEMs won't risk sole-source vendor relationships. Without competition, OEMs now using suppliers might return to making their own PAs. Only two companies are large competitors for the OEM base station PA business.

There's a dilemma. If Spectrian somehow were to achieve market domination, that achievement could undermine itself. Someone once said, "Competition is good, but market domination is better." Might have been someone in my own organization, come to think of it. Anyway, maybe it wouldn't be better for a PA supplier.

Joe Veni, executive vice president and general manager of the company's Single Carrier Business Unit explained the market fluctuations that lifted and plunged Spectrian and other wireless equipment makers in 1997. That's a story for another time.

Our thanks to Spectrian for the visit, and to Jane Bryant of McQuarterm Group for the arrangements.

RF



# THE NEW CROP FROM KALMUS



## Low-Band Series

### 10kHz-100MHz

A new range of high-performance, single-band power amplifiers primarily designed for use in HF transmission, EMC and scientific applications. Robust and efficient with less than 1dB compression at rated power—ideal alternatives to distributed tube amplifiers.

LA300L	300 Watts
LA500L	500 Watts
LA1000L	1000 Watts
LA4000L	4000 Watts



## KM Series—Microwave Power Amplifiers

### 1-8GHz, Up to 1000W

A comprehensive line of high-quality Class A, high-power amplifiers with outstanding reliability. Designed for wide-band EMC and similar RF test applications but equally suited to operational use, particularly as solid-state (GaAsFET) octave-band replacements for TWT amplifiers.

Your choice of rugged, high-reliability amplifiers just got wider. Three fresh new varieties of Kalmus amplifiers covering 10kHz to 8GHz are now ready for market. Pick from low frequency RF (10kHz-100MHz), high-frequency RF (80-1000MHz) or microwave (1-8GHz) ranges.

Today, we offer over a hundred different amplifiers with output powers from 2 to 4000 watts and beyond in simple modular packages, as fully-featured bench top versions, or rack-mounted with others as a system. We're committed to supplying amplifiers designed to meet your needs.

Kalmus builds quality products that are fully supported worldwide. For more information on the new products or to review the entire range, contact your local representative, call Kalmus direct or visit our Web site ([www.kalmus.com](http://www.kalmus.com)). And if no standard product meets your

precise requirements, let's talk about our extensive custom capabilities.



## 7000 SERIES

### 80-1000MHz

Four new wideband, load tolerant, highly linear amplifiers with the industry's best 1dB compression figures and very low harmonics. The perfect choice for radiated RF immunity and comparable broadband test applications.

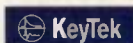
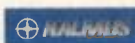
7050LC	50 Watts
7200LC	200 Watts
7500LC	500 Watts
7000LC	1000 Watts



## The RF Amplifier Company

11807 North Creek Parkway South, Suite 109, Bothell, WA 98011 • Phone: (800) 344-3341 • (425) 485-9000 • Fax: (425) 486-9657 • E-mail: [kalmus@kalmus.com](mailto:kalmus@kalmus.com) • Web: [www.kalmus.com](http://www.kalmus.com)  
Kalmus is a division of Thermo Voltek, a Thermo Electron Company

**Thermo Voltek**  
CORPORATION





## Editorial Forum



*By Emily Reid,  
Associate Editor*

### Three cheers for paper

In recent months, *RF Design* has made several improvements to its Web site ([www.rfdesign.com](http://www.rfdesign.com)), with more to come. You can now find links to advertisers and editorial as well as a product directory. Does that mean that you can just forget about your hands-on paper copy of the magazine? I don't think so.

In this age of constantly evolving technology, people are talking about paper publications becoming obsolete. Personally, I'm not worried. First of all, reading on a computer screen is difficult. Researchers have performed studies on reader's speed and comprehension reading from a computer screen as compared to printed copy. So far, the results favor the old standby. I don't know how many times I've found something interesting on the net and still had to print it to be able to read it.

Beyond eye strain, paper is more portable. Is anyone going to drag their laptop out to the beach to read the latest bestselling novel off of "www.booksthatveryonereads.com" (which by the way, will charge you an access fee) while they hang out by the ocean? I doubt it. What about the Sunday paper? You can't exactly kick back on the couch with any ease, to read the "computer" paper.

When it comes to trade publications, while having articles posted on a Web site for future reference is a value added (which, by the way, *RF Design* will be offering in the near future), having that printed copy offers you the ability to look at back issues for that one product manufacturer or advertiser you may need to contact. You'll find most companies have a Web address listed and now it's time to get on the computer.

I think it's safe to say that paper is here to stay. The Internet is a great tool, but use it as a supplement to the great (paper) publications that are out there. You can relax knowing that your paper copy of *RF Design* will be around for the long haul.

**RF**

# RF design.

Engineering RF & Wireless Products ... DC to Light

Established 1978

#### Editorial offices

5680 Greenwood Plaza Blvd., Suite 100  
Englewood, CO 80111  
720-489-3100; Fax 720-489-3253;  
e-mail [rfdesign@intertec.com](mailto:rfdesign@intertec.com)  
Web site [www.rfdesign.com](http://www.rfdesign.com)

#### Editor

*Technical Editor*  
*Senior Associate Editor*  
*Editorial Assistant*  
*Contributing Editor*  
*Art Director*  
*Editorial Director*

Roger Lesser  
Gregg V. Miller  
Nikki Chandler  
Emily Reid  
Ernest Worthman  
Valerie J. Hermanson  
Don Bishop, 913-967-1741

#### Group Publisher

*Marketing Director*  
*Marketing Services Supervisor*  
*Sr. Classified Ad Coord.*  
*Ad Production Coord.*  
*Senior Circulation Manager*

Mercy Contreras  
Patricia Zahner  
Karen Clark  
Annette Hulsey, 913-967-1746  
Janet Luckner, 720-489-3278  
Julie Neely

#### Director of Production

Barbara B. VanSickle  
*Desktop Publishing Coordinator*  
*Electronic Publishing Technician*  
*Electronic Publishing Technician*  
*Directories Issues Manager*  
*Reprints Manager*  
*List Rental Manager*

Shawn Warren  
Maurice Lydick  
Bonnie Long  
Deborah Dickson  
Jenny Eisele, 913-967-1966  
Lori Christie, 913-967-1875

#### Customer Service

800-441-0294

#### Subscription inquiries

P.O. Box 12907, Overland Park, KS 66282-2907  
800-441-0294; Fax 913-967-1903

#### Editorial Review Board

Andy Przedpelski, *Chairman*  
Madjid A. Belkaid, Ph.D.  
Alex Burwasser  
Robert Feeney, Ph.D.  
Joe Gorin  
Dave Krautheimer  
Ed Oxner  
Raymond Sicotte  
Robert J. Zavrel, Jr.

The Shedd Group  
Univ. of Central Florida  
RF Products  
Georgia Tech University  
Hewlett-Packard  
MITEQ  
InterFET  
American Microwave  
IBM

#### Intertec Publishing, A PRIMEDIA Company

9800 Metcalf Ave.  
Overland Park, KS 66212-2215  
913-341-1300; Fax 913-967-1898

#### Chairman of the Board President/CEO

Raymond E. Malon  
Cameron Bishop

#### Vice President -

*Communications Division*  
*Vice President - Production*  
*Vice President - Circulation*  
*Senior Managing Editor*  
*Director Advertising Services*  
*Corporate Creative Director*  
*Corporate Circulation Director*  
*Division Director of Marketing*

Larry Lannan  
Jack Morris  
Nick Cavin  
Tom Cooper  
Nancy Hujar  
Doug Coonr  
Sheri Gro  
Stephanie Hanaw

#### PRIMEDIA Information Group

*President/CEO*  
Curtis Thompson

#### PRIMEDIA Inc.

*Chairman/CEO*  
*President*  
*Vice Chairman*

William F. Reil  
Charles McCur  
Beverly C. Ch

Copies of most issues printed within the past two years are available for \$10 postpaid from Intertec Publishing Corporation, a PRIMEDIA company customer service, 800-441-0294; Fax 913-967-1899. Photocopies are unavailable from the publisher.

Photocopies in paper and electronic formats are available from Information Express, 3221 Porter Drive, Palo Alto, CA 94304-1225, Tel: 650-494-8787. Web site [www.express.com](http://www.express.com). Photocopies are also available via microform and/or electronic databases from UMI, a Bell & Howell Company, 300 North Zeeb Rd., P.O. Box 1346, Ann Arbor, MI 48106-1346; Tel. 800-521-0600 (+1 734-761-4700 outside North America) or check [www.umi.com](http://www.umi.com) for additional information on format availability.



## advertising sales staff

**MTT-S**  
**Anaheim, CA**  
**June 12-19**

**VTC**  
**Houston, TX**  
**May 16-20**



**Phil Cook**  
*Marketing Manager-West*  
16795 Von Karman Ave.  
Suite 110  
Irvine, CA 92714  
Tel. 949-838-2165  
Fax: 949-252-0556  
e-mail: [phil\\_cook@intertec.com](mailto:phil_cook@intertec.com)



**David Jeans**  
*Marketing Manager-East*  
5680 Greenwood Plaza Blvd.  
Suite 100  
Englewood, CO 80111  
Tel. 720-489-3201  
Fax: 720-489-3253  
e-mail: [david\\_jeans@intertec.com](mailto:david_jeans@intertec.com)

**Europe: David Jeans**  
5680 Greenwood Plaza Blvd. Suite 100  
Englewood, CO 80111  
Tel. 720-489-3201; Fax: 720-489-3253  
e-mail: [david\\_jeans@intertec.com](mailto:david_jeans@intertec.com)

**Israel: Asa Talbar**  
Talbar Media  
Tel. +972.3.523.5394, 522.3621;  
Fax +972.3.524.2177  
e-mail: [talbar@inter.net.il](mailto:talbar@inter.net.il)

**Classifieds: Jody Schrader**  
5680 Greenwood Plaza Blvd. Suite 100  
Englewood, CO 80111  
Tel. 720-489-3290; Fax: 720-489-3253  
e-mail: [jody\\_schrader@intertec.com](mailto:jody_schrader@intertec.com)



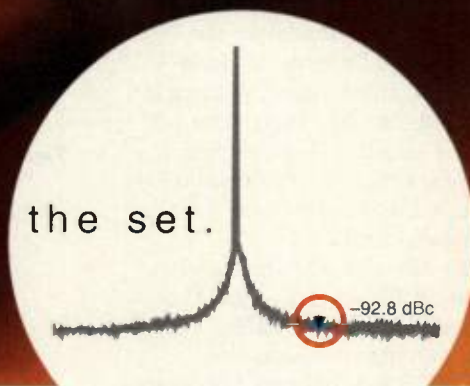
ASICs

1394

Networking

Infotainment

Quiet on the set.



Spurious Noise

### SL Series PLL Frequency Synthesizers

#### Single PLLs

Part Number	f <sub>in</sub> Max	I <sub>cc</sub> (mA)	V <sub>cc</sub> (V)
MB15E03SL	1.2 GHz	2	2.7
MB15E05SL	2.0 GHz	3	2.7
MB15E07SL	2.5 GHz	3.5	2.7

#### Dual PLLs

Part Number	f <sub>in</sub> Max	I <sub>cc</sub> (mA)	V <sub>cc</sub> (V)
MB15F02SL	1.2 GHz	1.8	2.7
	0.5 GHz	1.2	2.7
MB15F03SL	1.75 GHz	2.3	2.7
	0.6 GHz	1.2	2.7
MB15F07SL	1.1 GHz	2.5	2.7
	1.1 GHz	2.5	2.7
MB15F08SL	2.5 GHz	4.4	2.7
	1.1 GHz	2.6	2.7

### Discover why Fujitsu is quietly becoming the leader in total wireless solutions.

With Fujitsu's advanced SL series PLLs, you can expect significantly lower phase and spurious noise in all your wireless designs. The key to this superior performance is Fujitsu's new balanced charge pump design. Combined with the SL series' low power consumption and BCC package options, this innovative feature enables us to deliver enhanced integration, longer battery life, and superior price/performance for a variety of wireless solutions.

Plus, we back our fourth-generation SL product family with semi-custom and full-custom PLL solutions to ensure the ideal match for any design need. For more information and a free *Super PLL Application Guide*, contact us today at 1-800-866-8608 or [www.fujitsumicro.com](http://www.fujitsumicro.com).



Wireless/RF

Embedded

Packaging

Flat Panels

Memory

Foundry

# FUJITSU

## FUJITSU MICROELECTRONICS, INC.

# RF calendar

**May 24-26 Markets and Applications for High Frequency Magnetic Materials '99—Santa Clara, CA.** Information: Karen Zacharias, Conference Coordinator, Gorham/Intertech Conferences, 411 US Route One, Portland, ME 04105. Tel 207-781-9800.

**24-26 49th Electronic Components and Technology Conference—San Diego.** Information: Electronic Components, Assemblies, Equipment & Supplies Association, 2500 Wilson Boulevard, Arlington, VA 22201-3834. Tel. 703-907-7536; Web site [www.eia.org](http://www.eia.org).

**June 2-4 1999 Virginia Tech Symposium on Wireless Personal Communications—Blacksburg, VA.** Information: William H. Tranter, MPRG-Bradley Department of Electrical & Computer Engineering, Virginia Tech, 432 NEB, Mail Code 0350, Blacksburg, VA 24061. Web site [www.mprg.ee.vt.edu](http://www.mprg.ee.vt.edu).

**6-10 Supercomm '99—Atlanta.** Information: Supercomm, 549 West Randolph St, Suite 600, Chicago. Tel. 800-278-7372. Web site [www.super-comm.com](http://www.super-comm.com).

**12-19 1999 IEEE MTTs International Microwave**

**Symposium—Anaheim, CA.** Information: Dr. Robert Eisenhart, Microwave Symposium-MTT '99, Eisenhart & Associates, 5982 Ellenvue Ave., Woodland Hills, CA 91367; Tel 818-716-1995; Fax 818-713-1161.

**August 2-6 IEEE 1999 International EMC Symposium—Seattle, WA.** Information: Ghery Pettit, Intel. Tel 253-371-5515; Fax 253-371-5690; e-mail [g.pettit@ieee.org](mailto:g.pettit@ieee.org) Web site [www.seattleemc99.org](http://www.seattleemc99.org).

**25-27 21st Piezoelectric Devices Conference and Exhibition—Reno, NV.** Information: Pete Walsh, Electronic Industries Alliance, 2500 Wilson Blvd., Arlington, VA 22201-3834. Tel. 703-907-7547; Web site [www.eia.org](http://www.eia.org).

**September 21-24 IEEE Wireless Communications and Networking Conference 99—New Orleans—**Information: IEEE Communications Society, 305 East 47th Street, New York, NY 10017-2303. Tel. 212-705-8900; Fax 212-705-8999; Web site [www.comcos.org](http://www.comcos.org).

**27-29 32nd International Connector and**



- High Quality
- Prompt Development
- World's Best Technology in Matching Circuit Solutions

## SAW Filters

/ AMPS / GSM / GPS / WLL / PCS / CDMA /



<http://lgsaw.lgcit.com>



Tel : 82-2-579-6470~2 Fax : 82-2-579-6473

INFO/CARD 18



# ENVIROFLEX™ ...

## The new green cable.

The world of RG cables has changed forever. The European Community already demands low-smoke, zero halogen emission cable; similar North American mandates won't be far behind. ENVIROFLEX coaxial cable from Huber+Suhner is available now for your next telecommunications installation.

Since they are fully compatible with all the popular connector types, you can quickly switch to the halogen-free alternative... ENVIROFLEX.

This environmentally friendly cable is also more flexible and even costs less than teflon cable! Don't settle for yesterday's cable technology! This blue and black cable is truly "green".

Visit our web site for complete information.

***Cable and Assemblies  
You Can Count On***

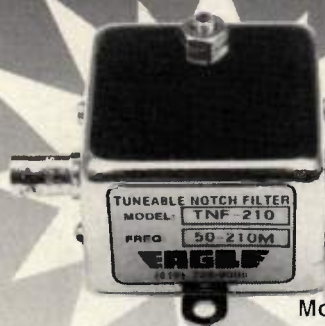


**HUBER+SUHNER**

U.S.A. 802-878-0555 [www.hubersuhnerinc.com](http://www.hubersuhnerinc.com)  
Canada 613-271-9771 [www.hubersuhner.ca](http://www.hubersuhner.ca)



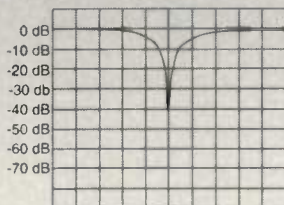
# TUNEABLE NOTCH FILTERS



## FEATURES:

- Low VSWR: <1.2:1
- Low Loss: <0.5 dB
- 25 Watt pass band
- Deep Notch to 35 dB
- Pass band to 3.0 GHz
- Rugged Construction
- Low Cost: starts at \$125
- Models from 0.5 to 850 MHz

The TNF200 filters are available in nine models from 0.5 MHz to 850 MHz. While primarily designed to improve the dynamic range of spectrum analyzers, these filters can also be used to reduce parasitics; or to eliminate or identify out of band interference in communications systems.



Plot of Typical Notch

Please call for FREE application note:  
"Spectrum Analyzer Measurements"

# EAGLE

VOICE: (520) 204-2597 ♥ FAX: (520) 204-2568  
P.O. BOX 4010 ♥ SEDONA, ARIZONA 86340

INFO/CARD 47

## Interconnection Show—Anaheim, CA.

Information: Pete Walsh, Electronic Industries Alliance. Tel. 703-907-7547.

October 17–20

**IEEE GaAs IC Symposium—Monterey, CA**—Information: Harry Kuemmerle, VIP Meeting and Conventions, 1515 Palisades, Suite I, Pacific Palisades, CA 90272-2113. Tel. 310-459-4692; Fax 310-459-0605; Web site [www.gaasic.org](http://www.gaasic.org).

Oct 31–Nov 3

**MILCOM '99—Atlantic City**—Information: Gerald W. Lazaroff, Vice President Corporate Development, Lucent Technologies, 9305-D Gerwig Lane, Columbia, MD 21045. Tel. 410-309-7032; e-mail [Lazaroff@lucent.com](mailto:Lazaroff@lucent.com).

December 5–9

**IEEE Global Communications Conference—Rio de Janeiro**—Information: Roberto de Marca Cetuc-Puc/Rio, Rua Marques de Sao Vicente 225, Rio De Janerio, RJ, 22453, Brazil. Tel +55.21.512.2091; Fax +55.21.294.5748; e-mail [jrbm@equitell.ecetuc.puc-rio.br](mailto:jrbm@equitell.ecetuc.puc-rio.br); Web site [www.globecom99mhw.com.br](http://www.globecom99mhw.com.br)



# Quality

We have designed over 7000 unique RF components.

Many of those devices are application specific for test equipment, medical, automotive and cellular/PCS requirements.

With over 18 years of experience with innovative products and consistently exceeding the expectations of our customers, JFW provides the highest quality and cost effective solutions available in the industry.

### Attenuators:

Fixed: DC-26.5GHz  
Rotary: DC-4GHz  
Programmable: DC-5GHz

### Power Dividers:

Wilkinson: 800-2100MHz  
Resistive: DC-4GHz

### RF Switches:

Solid State  
Reflective  
Absorptive  
Ranges up to 3GHz

### Accessories:

DC Blocks up to 18GHz  
Impedance Matching Pads to 3GHz  
RF Detectors  
Feed thru Terminations

## JFW Industries, Inc.

5134 Commerce Square Drive • Indianapolis, Indiana 46237  
Tele. (317) 887-1340 Fax (317) 881-6790

Internet—<http://www.jfwindustries.com>

E-mail—[sales@jfwindustries.com](mailto:sales@jfwindustries.com)

ISO 9001 Certified

# EXCELLENCE

INFO/CARD 105



# *fast* easy affordable

(We knew you wouldn't want slow,  
difficult, and expensive design software.)

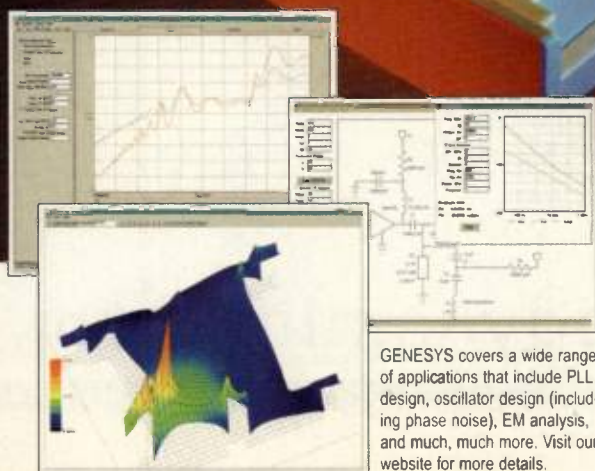
## GENESYS

Without a doubt, our software will help you finish your design faster and with less effort than ever before. Synthesis tools quickly and easily eliminate tedious design tasks: you input the specs, the software delivers the first-pass design. Simulators with just the features you need are incredibly fast. Our "keep it simple" philosophy results in software that's easy to learn and easy to use. So easy, in fact, that technical support is free.

Doing business with Eagleware is also fast and easy. Reach us by phone, fax, e-mail, or through the Web. Order by PO or credit card. Receive the software within days of ordering.

The complete GENESYS/EM design suite is \$8990. For individual products, prices start at \$999, and technical support is **FREE**.

So don't wait. Contact us today to get your own fast, easy, and affordable design software.



GENESYS covers a wide range of applications that include PLL design, oscillator design (including phase noise), EM analysis, and much, much more. Visit our website for more details.

## EAGLEWARE

**RF and Microwave Design Software**

4772 Stone Drive • Tucker, GA 30084 USA  
eagleware@eagleware.com • www.eagleware.com  
Tel: 770.939.0156  
Fax: 770.939.0157



# RF courses

**UCLA Extension**— *Using Design Patterns, Frameworks and Corba to Develop Object-Oriented Communications Systems*—Jun 2-4; *Communications Networking: Local, Metropolitan and Wide-Area Networks*—May 24-28, Los Angeles. Information: UCLA Extension, Department of Engineering, Information Systems and Technical Management, Short Courses, 10995 Le Conte Ave., Suite 542, Los Angeles, CA 90024-2883. Tel. 310-825-3858; Fax 310-206-2815; e-mail [tlawrenc@unex.ucla.edu](mailto:tlawrenc@unex.ucla.edu).

**University of Missouri-Rolla**— *Grounding and Shielding Electronic Systems—How to Diagnose and Solve Electrical Noise Problems*—Jun 1-3, Toronto; Jun 8-10, Ottawa; *Circuit Board Layout to Reduce Noise Emission and Susceptibility*—Jun 1-3, Toronto; Jun 8-10, Ottawa. Information: UMR Continuing Education, Tel 573-341-4132/4200; Fax 573-341-4992.

**University of Oxford**— *High Speed Digital Design*—Jun 7-8; *Digital Signal Processing*—Jun 7-9; *Digital Transceiver Design*—Jun 21-23; *MMIC Design (RF to mm-wave)*—Jul 1-2; *Digital Communications: an Introduction*—Jul 5-6; *CDMA for 2nd and 3rd Generation Communication Systems*—Nov 22-23, University of Oxford, UK. Information: OUSEP (rfdes), CPD Centre, University of Oxford, Department of Continuing Education, 67 St. Giles, Oxford, OXI 3LU. Tel. 44 (0) 1865.288170; e-mail [dee.broquard@conted.ox.ac.uk](mailto:dee.broquard@conted.ox.ac.uk).

**Georgia Institute of Technology**—*CMOS Analog Integrated Circuits*—Jun 14-18, Santa Clara, CA. Information: Distance Learning, Continuing Education and Outreach, Georgia Institute of Technology, Atlanta, GA 30332-0385. Tel 404-894-2547.




**California State University, Northridge**—*Far-Field, Near-Field, Compact Ranges and Anechoic Chambers*—Jun 8-11, Northridge, CA. Information: Shirley Lang, College of Engineering and Computer Science, California State University, Northridge, Northridge, CA 91330-8295. Tel. 818-677-2146; Fax 818-677-5982; e-mail [shirley.lang@csun.edu](mailto:shirley.lang@csun.edu).

**Northeast Consortium for Engineering Education**—*Antennas: Principles, Design and Measurements*—Aug 16-19, Colorado Springs. Information: Kelly Brown, NCEE, 1101 Massachusetts Ave., St. Cloud, FL 34769. Tel. 407-892-6146; Fax 407-892-0406; Web site [www.usit.com/antenna](http://www.usit.com/antenna).

**University of Colorado at Denver**—*Basic Principles of RF and Microwave Network Analysis*—Online course. Information: Kim Penoyer, University of Colorado at Denver Continuing Engineering Education, Campus Box 104, P.O. Box 173364, Denver, CO 80127-3364. Tel. 303-556-4907; Fax 303-556-2511; e-mail [kpenoyer@castle.cudenver.edu](mailto:kpenoyer@castle.cudenver.edu); Web site [www.cudenver.edu/public/engineer](http://www.cudenver.edu/public/engineer).

EDC

WHAT'S NEW

Product Guide

Company Profile

Sales & Marketing

Engineering Manufacturing


Quality Assurance

ISO-9002

Manufacturing Process

Contact Us

QUALITY QUARTZ CRYSTALS & OSCILLATORS



Our entire Product Guide at your fingertips

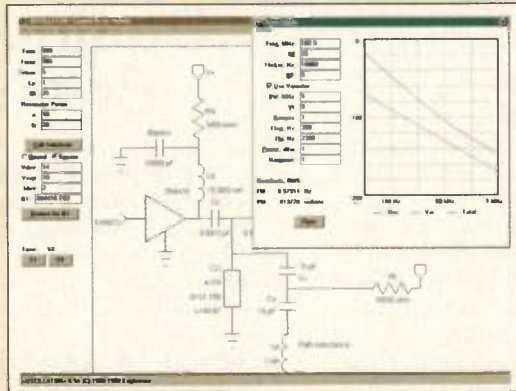
www.electrodynamics.com



# "Eagleware's approach is to **directly solve your problem**"\*

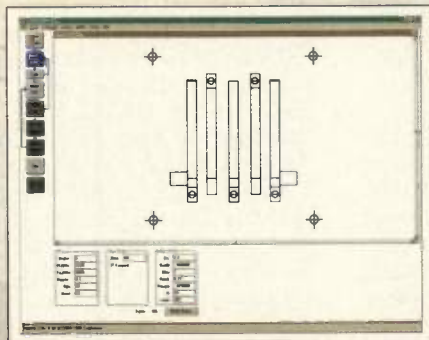
Design automation is the fast, easy, and affordable way to speed design

## SYNTHESIS



### **=OSCILLATOR=**

L-C Colpitts, Clapp, series  
Dielectric resonator  
SAW hybrid, MOSFET, BJT  
Cavity bipolar & hybrid  
T-line and L-C VCO  
Crystal Pierce, Colpitts, Driscoll  
Butler overtone  
VCO with transformer



### **=M/FILTER=**

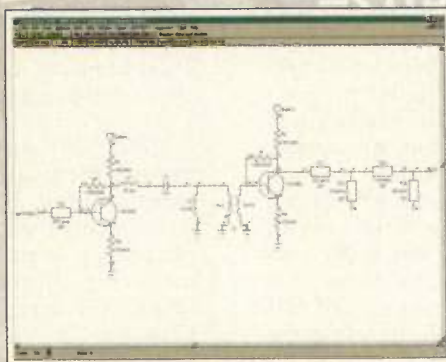
Interdigital  
Edge Coupled  
Hairpin  
Combine  
End Coupled  
Stepped-Z  
Elliptic Lowpass  
Stub Lowpass  
Elliptic Bandpass  
Stub Bandpass  
Stub Bandstop  
Edge Bandstop  
Microstrip, Stripline,  
Slotline and Coaxial

### **=FILTER=**

All-pole and elliptic  
Top-C and -L coupled  
Shunt-C coupled  
Tubular  
Blinchikoff flat delay  
Zig-Zag  
Eagleware Symmetrical  
6 Group Delay Equalizers

### **=A/FILTER=**

GIC transform  
Single & Multiple feedback  
State variable (bi-quad)  
VCVS  
Dual amplifier  
Low Sensitivity  
3 Group Delay Equalizers



### **=MATCH=**

L-C pi and L  
L-C tee  
T-line quarter wave  
T-line single/double stub  
General order bandpass  
L-C & T-line pseudo lowpass  
T-line stepped-Z  
Custom with Rs and transformers

Most design software just simulates circuits. With Eagleware's synthesis products, key parts of the design process are automated. You input your specifications and the synthesizer comes up with a design. It's fast, easy, and automatic.

Take amplifier design. Broadband, multistage matching is sometimes tedious, sometimes frustrating, and always time consuming. But, with **=MATCH=**, you select devices, input performance parameters, and—**BAM!**—out comes the design. **=MATCH=** solves problems that simple optimizers will never solve.

Other synthesis products generate oscillators. And filters. Even PLLs.

Synthesis products start at \$999. The complete GENESYS/EM design suite is \$8990. Technical support for individual Eagleware products is **FREE**.

So don't wait. Contact us today to get your own fast and easy tools that automate your design process.

## EAGLEWARE

**RF and Microwave Design Software**

4772 Stone Drive • Tucker, GA 30084 USA  
eagleware@eagleware.com • www.eagleware.com  
Tel: 770.939.0156  
Fax: 770.939.0157

\* Quote from a satisfied customer

INFO/CARD 87



## Digital think tank formed at MIT

Motorola, Phoenix, AZ, has donated \$5 million to the Massachusetts Institute of Technology (MIT) to establish the DigitalDNA Laboratory at the MIT Media Lab in Cambridge, MA. The Laboratory will focus on actually linking "smart" products such as set-top boxes, automobiles, household appliances, personal digital assistants and wireless communications systems.

The Motorola grant is intended to combine major business and education resources in an effort to develop leading edge embedded systems, software, architecture and applications.

## RFID market to reach \$1.6 billion by 2002

An analysis from Venture Development Corporation (VDC), Natick, MA, "Global Markets and Applications for Radio Frequency Identification Equipment," finds that worldwide shipments of RF identification (RFID) systems reached \$655 million in 1988 and are expected to increase as much as 25% annually, to reach \$1.6 billion by 2002.

The report finds that while market infrastructure issues still plague the industry (including standards development, channel training and end-user education), the RFID market is expected to provide strong near term growth. While the majority of current RFID shipments are directed to security/access control applications, VDC finds the greatest long-term opportunity may be the supply chain, such as cradle-to-grave tracking, closed loop logistics management and high

value asset management.

VDC sees one of the reasons for RFID growth will be the operational advantages RFID offers over competing technologies. These advantages include non-line-of-site requirements, real-time updatability of (read/write) tags, high multiple simultaneous tag read rates (with latest generation anti-collision) and the ability of tags to sustain harsh environments.

## TRW/JPL set high frequency record

TRW, Redondo Beach, CA and the National Air and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL), Pasadena, CA, has produced and demonstrated a new indium phosphide microchip that operates at 190 GHz. According to TRW, this is the highest frequency of any known solid state monolithic microwave integrated circuit (MMIC).

The new circuit is a low-noise amplifier (LNA) that can amplify signals at high frequency with low power consumption. The two-stage LNA chip was designed and fabricated by TRW using its patented indium phosphide high electron mobility transistor (HEMT) MMIC process.

In testing conducted by JPL, the LNA achieved a peak gain of 9.6 dB at 190 GHz and 8 dB gain from 160-190 GHz. TRW notes that the circuit design is unique in that it allows multiple LNA chips to be linked together, or "cascaded" to create an amplifier with 20-30 dB of gain at 190 GHz.

While the initial use of the new LNA targets NASA's environmental and weather satellites, Dwight Stireit, manager of the microelectron department at TRW's electronics and technology division, notes that the technology has other potential. "For wireless communications, this LNA has the most payoff for Ka band (18-38 GHz) and point-to-multipoint," Stireit said. "Noteworthy, the technology offers an ultra low-power consumption by reducing power requirements by 30 %."

## Patent awarded for multiple band amplifier

Anadigics, Warren, NJ, has been awarded a patent for a single chain multiple band amplifier. The patent was granted to Aharon Adar, Anadigics advanced gallium arsenide (GaAs) design manager. "Traditional dual

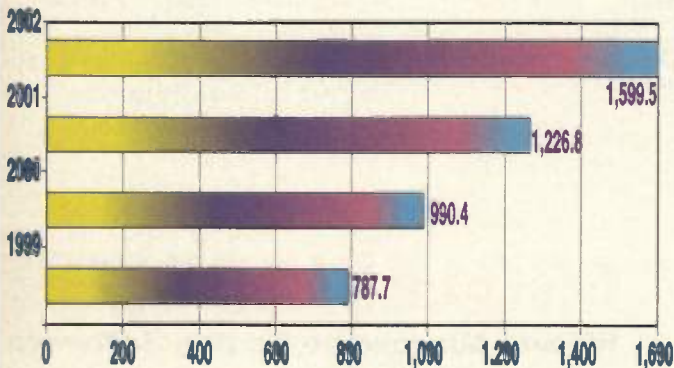
# Business Briefs

**TAS joins HP channel partner program**—Telecom Analysis Systems (TAS), Eatontown, NJ, will partner with Hewlett-Packard (HP), Santa Rosa, CA, to provide advanced code-division, multiple-access (CDMA) test solutions. Through HP's channel partner program, TAS's CDMA test solutions will be combined with HP test equipment to address CDMA handset test requirements.

**MITEQ appoints new UK and Canadian representatives**—MITEQ, Hauppauge, NY, has appointed UKRF Ltd (UK), to exclusively represent its full line of RF/microwave components and satellite communication equipment in the United Kingdom. MITEQ has also appointed Giga-Tron Associates (Canada) to represent its product line in Canada.

**IFR Systems to represent Giga-tronics**—IFR System, Wichita, KS, has entered into an agreement to market microwave synthesizers and power measurement instruments manufactured by Giga-tronics, San Ramon, CA.

**TriQuint and GHz Circuit Design form alliance**—TriQuint Semiconductor, Hillsboro, OR, and GHz Circuit Design, Newberryport, MA, have joined forces to offer turnkey gallium arsenide (GaAs) integrated circuit (IC) services. Under terms of the agreement, TriQuint will be supported by GHz Circuit Design's radio frequency integrated circuit (RFIC) design team. TriQuint will provide wafer manufacturing.



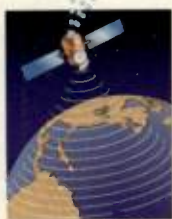
Global Shipments of RFID Systems (millions of dollars)



# THE GLOBAL SOLUTION... AND BEYOND!



## 10MHz to 7GHz AMPLIFIERS **\$99<sup>95</sup>** (1-9 qty.)



From amateur radio to cellular to satellite applications, with medium output power up to 17dBm, Mini-Circuits versatile ZJL and ZKL connectorized amplifiers offer the broad range of choices designers demand for achieving high system performance goals. Ultra-wideband models deliver **gain ranging from 9 to 40dB** and IP3 up to +32dBm. But beyond the performance and reliability built into these miniature 12V amplifiers lies another important feature, the low price...from only \$99.95! Call now for fast delivery.

*Mini-Circuits...we're redefining what VALUE is all about!*

### SPECIFICATIONS

Model	Freq (MHz)	Gain (typ)		Max. P <sub>out1</sub> (dBm)	Dynamic Range (Typ @2GHz <sup>2</sup> )		I(mA) <sup>3</sup>	Price \$ea. (1-9)
		Midband (dB)	Flat (±dB)		NF(dB)	IP3(dBm)		
ZJL-5G	20-5000	9.0	±0.55	15.0	8.5	32.0	80	129.95
ZJL-7G	20-7000	10.0	±1.0	8.0	5.0	24.0	50	99.95
ZJL-4G	20-4000	12.4	±0.25	13.5	5.5	30.5	75	129.95
ZJL-6G	20-6000	13.0	±1.6	9.0	4.5	24.0	50	114.95
ZJL-4HG	20-4000	17.0	±1.5	15.0	4.5	30.5	75	129.95
ZJL-3G	20-3000	19.0	±2.2	8.0	3.8	22.0	45	114.95
ZKL-2R7	10-2700	24.0	±0.7	13.0	5.0	30.0	120	149.95
ZKL-2R5	10-2500	30.0	±1.5	15.0	5.0	31.0	120	149.95
ZKL-2	10-2000	33.5	±1.0	15.0	4.0	31.0	120	149.95
ZKL-1R5	10-1500	40.0	±1.2	15.0	3.0	31.0	115	149.95

### NOTES:

1. Typical at 1dB compression.
2. ZKL dynamic range specified at 1GHz.
3. All units at 12V DC.



## Mini-Circuits®

US 67 INT'L 68

CIRCLE READER SERVICE CARD

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718)332-4661 **INTERNET** <http://www.minicircuits.com>

For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

**ISO 9001 CERTIFIED**

F 232 Rev D



# VCO's *are us*

**100-2500MHz SINGLE & DUAL BAND Voltage Control Oscillators.**

## We are offering:

- Very high performance VCO's.
- Mini size packages.
- Low cost.
- Custom designed VCO's.

## Applications:

- Cellular Sys.Mobile & Base
- Digital Cordless Phone.
- Land mobile radio SMR/LMR.
- GPS.
- WLAN, WWAN, WLL.

**TETRA**  
ELECTRONIC IND. LTD.

5. Hasadan st. Holon 58117 Israel  
Phone: +972-3-5562775, Fax: +972-3-5561944  
E-mail: gadil@tetra.co.il

band phones require a separate power amplifier for each individual band," Adar said. "This solution offers the functionality of two power amplifiers in one."

The patent covers a high efficiency single chain GaAs metal semiconductor field effect transistor (MESFET) monolithic microwave integrated circuit (MMIC) dual-band power amplifier for wireless communications. The amplifier can be used for the advanced mobile phone system (AMPS) 800 MHz, global system for mobile communications (GSM) 900 MHz or personal communications service (PCS) 1900 MHz.

## 3G intellectual property rights issue resolved

Ericsson, Norway, and Qualcomm San Diego, CA, have entered into a series of definitive agreements that resolve the two companies' disputes concerning intellectual property rights (IPR) issues that plagued the International Telecommunications Union (ITU) efforts to establish a standard, or family of standards, for third-generation (3G) technologies. Both companies will jointly support a single code-division multiple-access (CDMA) standard with three optional modes.

The agreements allow the cross licenses for their respective patent portfolios and to settle existing litigation. As part of the agreement, Ericsson will purchase Qualcomm's terrestrial CDMA wireless infrastructure.

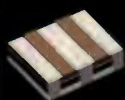
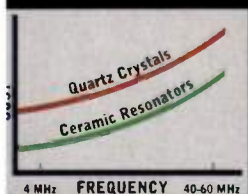
## Contracts

**Celeritek receives \$3.3 million in orders from Motorola**—Celeritek, Santa Clara, CA, has received purchase orders for \$3.3 million from Motorola, Cambridge, MA, for 3.0 V RFIC power amplifier products. The amplifiers are expected to be used in Motorola's code-division, multiple-access (CDMA) personal communications services (PCS) Star Tac phone.

**KDI/triangle wins AT&T contract**—KDI/triangle, Whippany, NJ, has signed a contract with AT&T for multicoupler assemblies for use in cellular base stations. The multicoupler has six inputs and 12 channel outputs and operates from 824-894 MHz.



We're about to shatter the perception that quartz is always  
the best choice for high frequency timing devices.



If you're using quartz crystals for applications such as hard disk drives, digital signal processing, USB, DVD or CD-ROM, here's something you should know. Our surface-mounted high frequency ceramic resonators offer an economical alternative to quartz, with some very compelling advantages - lower profile, greater

reliability, higher durability and frequency up to 60MHz. Not surprisingly, we're the world leader in ceramic resonators. After all, we pioneered the piezoelectric ceramic technology that makes them possible. So contact us before your next design project. We'll help you see new possibilities. Call 1-800-831-9172 or visit [www.murata.com](http://www.murata.com).

**muRata**

*Innovator in Electronics*



## Advantages of SiGe for RF front-ends

*Components manufactured using a SiGe bipolar process exhibit lower noise, better linearity and lower current consumption than their pure, bipolar-only process counterparts.*

By Richard Lodge

The requirements of portable telecommunications equipment are becoming more demanding in terms of integration levels and performance. Achieving high receiver sensitivity requires low noise from the front-end amplifiers and mixers. Low current consumption for improved battery life necessitates the use of high-speed processes to reduce bias currents in transistors.

One of the main noise generation mechanisms in bipolar transistors is the Johnson noise generated by  $r_{bb}$ , or the parasitic resistance within the base region of the npn transistor. Reducing  $r_{bb}$  improves the noise performance of the transistor, and it can be achieved

by shrinking the emitter width (i.e., shortening the base length) or by increasing the doping within the base. Another option is to use an emitter-base heterojunction. This can be done by adding germanium doping within the base, thus reducing  $r_{bb}$  for a given emitter width.

Adding germanium into the p silicon base creates a bandgap reduction of about 80–100 mV within the base, creating a strong electric field. Electrons diffuse into the base and are then swept across the base-collector junction by this electric field. This causes a reduction in the transit time,  $t_b$ , taken for carriers to cross the base [1]. Reducing  $t_b$  provides an increase in  $f_T$  with all other factors remaining constant. In addition to improvements to  $r_{bb}$  and  $f_T$ , silicon germanium (SiGe) transistors offer improvements in beta and *early voltage* (which improves the output resistance of devices) owing to reduced base-width modulation. An increase in beta also helps to reduce base-current shot noise, further improving the low noise performance of SiGe.

One form of a SiGe process, a deep trench-isolated bipolar process, uses three layers of gold metalization to provide the following advantages:

- better electron migration properties compared to aluminium (Al)-based metalization.

- lower sheet resistivity to improve inductor Q and lower resistive drops in gain blocks to reduce Johnson noise generated in the resistance of metal tracks.

By adding a fourth layer of gold metal, the process can also offer high Q inductors used at the main cellular frequencies at around 900 MHz, 1.8 and 1.9 GHz. These can be used for source/load impedance matching and within on-chip resonators for voltage controlled oscillators (VCOs).

### LNAs

Demands on low-noise amplifier (LNA) performance are increasing as handheld digital cellular terminals require higher sensitivity. As explained previously, a SiGe process yields lower base shot noise and Johnson noise generated within the parasitic base resistance  $r_{bb}$ . Furthermore, the higher  $f_T$  improves high-frequency noise performance because beta roll-off occurs at a higher frequency. These effects combine to provide significant improvements.

Furthermore, the output impedance properties of the SiGe transistor provide benefits in improving intermodulation distortion. This is because the  $C_{bc}$  of the device is less voltage-dependent in a SiGe process than in pure bipolar. Figure 1 shows the noise figure measurements on a SiGe LNA optimized for 900 MHz applications over frequency. It shows that the noise figure is around 0.8 dB between 900 MHz to 1 GHz. This reduces to 0.6 dB at  $-40^\circ\text{C}$ . Figure 2 shows the simulated noise figure and demonstrates a close correlation between modeled and measured characteristics. Parts are packaged in a SOT23-6 pin plastic package.

Figure 3 shows  $s_{21}$  and  $s_{11}$  plotted over frequency giving a mid-band for-

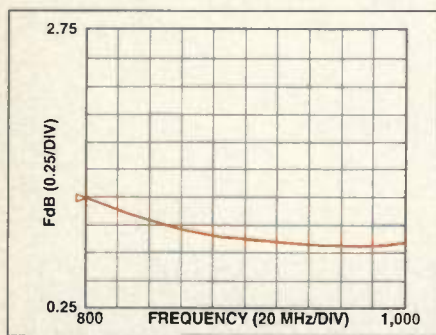


Figure 1. Measured LNA noise figure.

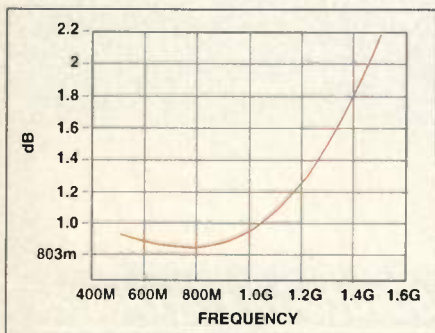


Figure 2. Simulated LNA noise figure.

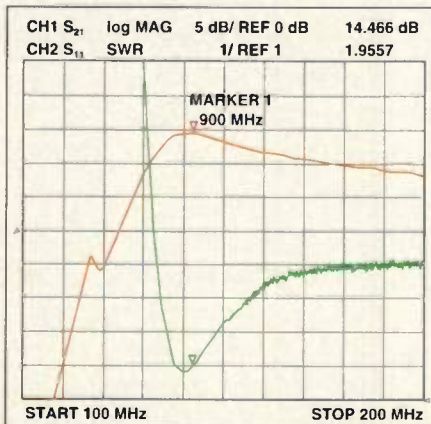


Figure 3. Measured  $S_{11}$  and  $S_{21}$  data for LNA.



A WORLD OF ADVANCED COMPONENTS



# Smaller talk made possible by **AVX**

Have you heard the big news about AVX timing devices? Our SSR Series ceramic resonators are the industry's smallest, giving designers of portable communications equipment something to talk about.

Measuring just 3.2mm x 2.1mm x 1.5mm, the ultra-miniature SSR Series resonators deliver a wide range of frequencies (16 to 60 MHz) with a rugged ceramic element that provides superior resistance to shock and vibration.

Find out how something so small from AVX could make a big difference in your next communications design.

SSR SERIES  
CERAMIC RESONATORS



For more information on  
AVX ceramic resonators, visit:  
**[www.avxcorp.com](http://www.avxcorp.com)**  
or call 843-946-0414

AVX Corporation P.O. Box 867 Myrtle Beach, SC 29578 Faxback Technical Information 1-800-879-1613  
E-mail [avx@avxcorp.com](mailto:avx@avxcorp.com) FAX 843-626-5186

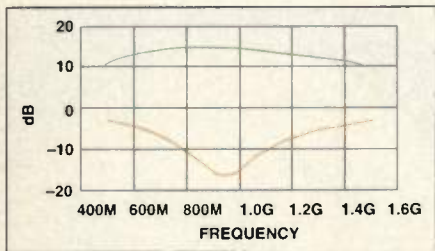


Figure 4. Simulated S11 and S12 LNA performance.

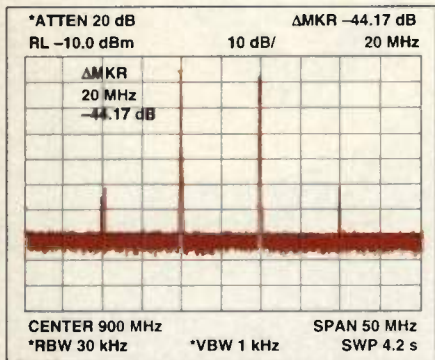


Figure 5. IM3 distortion in LNA.

ward gain at 900 MHz of around 14.5 dB. Figure 4 shows the close agreement with simulated behavior. Figure 5 shows the third-order intermodulation (IM3) distortion of the amplifier giving an input referred third-order intercept (IP3) point of -9.3 dBm. Current consumption is just 3.3 mA. By comparison, a silicon-based amplifier at 900 MHz would have a noise figure at least 0.5 dB higher, with the same current consumption and IIP3. This demonstrates the important benefits of the lower  $r_{bb}$ , higher  $f_T$  and higher beta.

These results illustrate what is possible for 900 MHz applications—a typical noise figure well below 1 dB with an IIP3 better than -10 dBm and current consumption of less than 4 mA. For 1.8 GHz, a noise figure well below 1.5 dB using less than 5 mA is clearly achievable.

### Mixers

Figures 6, 7 and 8 show a comparison of single sideband (SSB) noise figure, conversion gain and IIP3 for three devices. At 900 MHz, SSB noise

figure is around 6 dB. Comparison with a comparable silicon mixer at 900 MHz shows a 4 dB improvement in IIP3, with a 2 dB better noise figure with both devices consuming 9 mA at room temperature off a single 3V supply. Furthermore, SiGe's higher  $f_T$  will permit designs at much higher frequencies than previously possible to include 3.5 GHz applications (such as radio-local-loop) and beyond.

### VCOs

Integrated circuit (IC)-based VCO products are starting to become commonplace in many RF systems. For instance, a VCO with noise performance is shown in Figure 6. With 9 mA of current, a phase noise of -120 dBc/Hz at 100 kHz can be achieved. A planned SiGe derivative part is expected to show an improvement in close phase noise of a few dB with the same circuit configuration and current consumption.

### Conclusion

SiGe provides significant advantages over a pure bipolar process in terms of

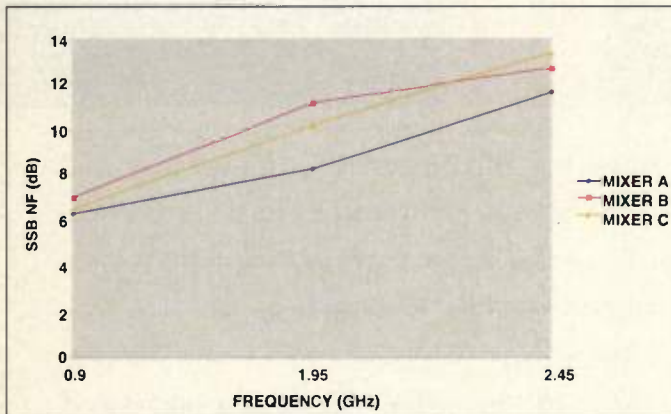


Figure 6. SiGe mixer NF over frequency.

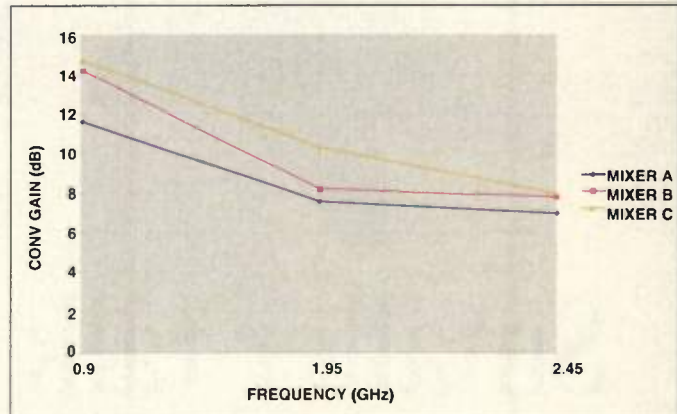


Figure 7. SiGe mixer conversion gain.

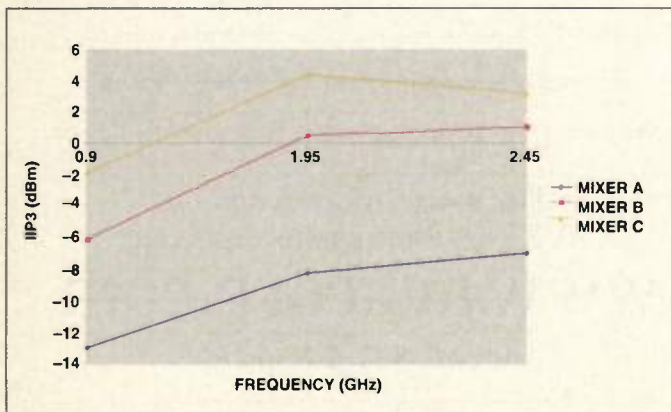


Figure 8. SiGe mixer IIP3 vs. frequency.

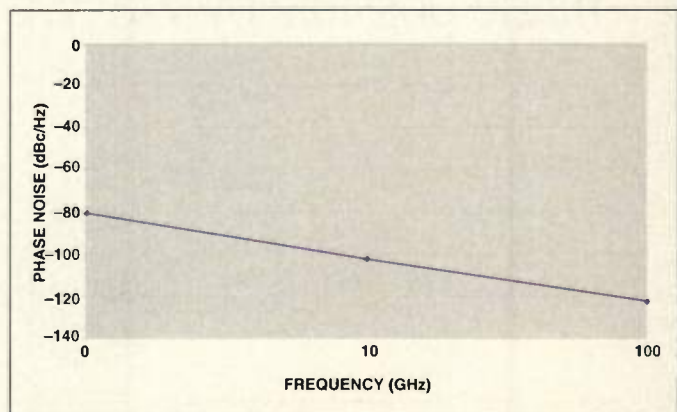


Figure 9. Pure bipolar VCO phase noise.





# WINNING

## COMBINATION

### A WINNING COMBINATION FOR ALL YOUR DIGITAL COMMUNICATIONS DESIGNS.

#### OUR PRODUCTS INCLUDE:



##### **DIRECT DIGITAL SYNTHESIS (DDS)**

- Numerically Controlled Oscillator (NCO) ASICs for FM, PM or chirp generation
- CMOS and GaAs technologies – up to 800 MHz clock rates
- Separate or selectable sine and/or cosine outputs
- Up to 48-bit frequency resolution (STEL-1173)
- Single chip NCO + DAC



##### **PSK, QAM OR CDMA MODULATOR/DEMODULATOR**

- Burst or continuous applications
- Data rates from 19.2 Kbps up to 8 Mbps
- Performance at less than 1/2 dB from theory
- CDMA transceiver for telemetry, wireless Internet access, vehicle positioning
- Single ASIC transceiver for MCNS cable modems



##### **FORWARD ERROR CORRECTION (FEC) ASICS**

- Convolutional encoding / Viterbi decoding
- Data rates to 45 Mbps
- Selectable coding rates of 1/2 through 7/8
- Scrambling and descrambling based on industry standard polynomials
- New 2 Mbps decoder starting at \$20 flat pricing

Stanford Telecom offers a broad selection of ASIC and board-level assemblies for applications including PSK, QAM or CDMA modulation and demodulation, digital down conversion, data transceivers, forward error correction, adaptive equalization and direct digital frequency synthesis. Product highlights are shown at the left.

Contact us for more information, including a copy of our Short Form catalog.

## STANFORD TELECOM®

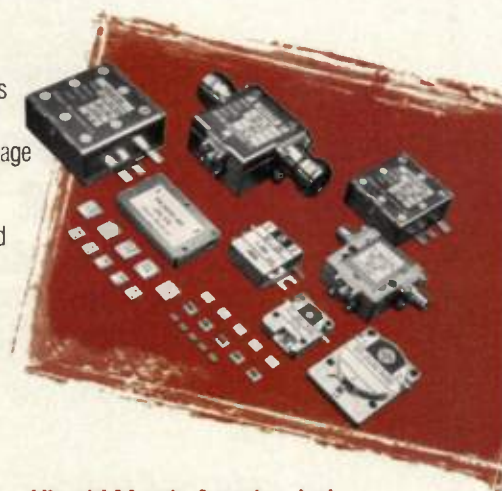
# Cellular — Satellite — Mobile Communications...Hitachi Metals Has The Solution!

**The world's gone mobile. Your design demands top performance. Specify Hitachi Metal's microwave components and get your design moving today.**

The international mobile marketplace demands high performance. Your design requires microwave components with low losses, superior response characteristics, and minimum volume. You need components from Hitachi Metals.

Need to save circuit board area and package volume? Designed with our superior "Multi-Layered" technology, Hitachi components require minimal volume and circuit board area. Specify Hitachi.

Specify Hitachi, a major international supplier of electronic components. Hitachi, setting the highest quality and reliability standards in the world.



**RF TRANSFORMERS**  
**CIRCULATORS, ISOLATORS**  
**COMBINERS AND SPLITTERS**  
**COUPLERS**  
**DOUBLE AND SINGLE BALANCED MIXERS**  
**LOW PASS FILTER, BAND PASS FILTER**  
**ANTENNA SWITCHES, DIPLEXER**

**Hitachi Metals America, Ltd.**  
2101 S. Arlington Heights Rd., Suite 116  
Arlington Heights, IL 60005  
Tel: (847) 364-7200 Fax: (847) 364-7279  
www.hitachimetals.com

INFO/CARD 60

$f_T$ , early voltage, beta and lower current consumption for a given  $f_T$  and reduced voltage dependence of  $C_{bc}$ . These combine to enable LNAs, mixers and oscillators to be built. An LNA at 900 MHz with a typical noise figure of 0.8 dB with over 14 dB of gain, 3.3 mA current consumption and an IIP3 of -9.3 dBm has been shown. A 1,900 MHz LNA consuming 3.2 mA has also been measured and yields a 1.25 dB noise figure, 14.7 dB forward gain and -6.0 dBm IIP3. These noise, IIP3 and current consumption characteristics are considerably better in SiGe technology than are possible using the pure bipolar process upon which it is based. Comparable benefits are possible for mixer and VCO products. **RF**

## References

1. Harame and Cressler, Transactions on Electron Devices, Vol. 42, No. 3, March 1995, pp. 455-468.

## OCXO Replaces Rubidium Clocks

210 SERIES  
220 SERIES  
230 SERIES  
240 SERIES  
250 SERIES



260 SERIES  
400 SERIES  
500 SERIES  
ENTER

### PRODUCT PROFILE

Ultra high reliability --- Thermal stabilities from  $2.00 \times 10^{-10}$  to  $4.00 \times 10^{-9}$  over a 100°C temp. range --- Longer life than rubidium clocks at a fraction of the cost --- Tuned to exact specs --- Call: 978-465-6064



Frequency Range	32 kHz to 30 MHz
Aging	5.00e-011/day 3.00e-080/yr
Phase Noise, 1 Hz Offset	-110 dBc/Hz
100 kHz Offset	-160 dBc/Hz
Output (HCMOS or HCMOS)	0 to +13 dBm Sine
Crystal Cut	SC
Package Size	2.0" x 2.0" x 1.5"

INFO. SOURCE

www.mti-milliren.com

INFO/CARD 103

## About the author

Richard Lodge received his Bachelor of Science in Applied Physics and Electronics in 1985, and his Masters of Science in Microelectronics in 1987 from the University of Durham, UK. He was previously an ASIC applications manager for Maxim Integrated Products, Reading, UK, responsible for assisting customers to develop custom products on high-frequency bipolar, SiGe and BiCMOS process technologies. For information regarding this article, contact Walter Lau at 408-737-7600 Ext. 6986 or by e-mail at [walter\\_lau@ccmail.mxim.com](mailto:walter_lau@ccmail.mxim.com). The parts described in this article are the MAX2641 LNA and the MAX2680 mixer available from Maxim Integrated Products.



# INDUSTRY'S FIRST SiGe MIXER OUTPERFORMS GaAs

**SiGe Mixers  
Available Now!**

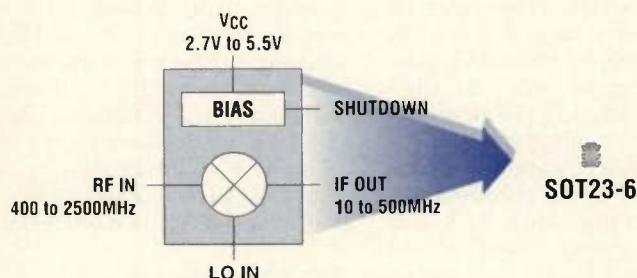
Designed with Maxim's advanced SiGe process technology, the MAX2681 provides the best combination of input IP3, noise figure, and conversion-gain performance at 900MHz.

INCREASING  
PERFORMANCE



TECHNOLOGY	PART	I <sub>CC</sub> (mA)	IIP3* (dBm)	NF* (dB)	CONV. GAIN* (dB)
SiGe	⇒ MAX2681	9	-6	7	14.2
GaAs	⇒ HP IAM91563	9	-6	7	11
Si Bipolar	⇒ NEC UPC8112T	9	-10	9	15

- ◆ Higher Conversion Gain vs. GaAs
- ◆ Higher IIP3 and Lower NF vs. Si Bipolar



With Maxim's family of SiGe downconverters, you can maximize your system performance by selecting the right IIP3, noise figure, and conversion-gain performance vs. supply current.

PART	I <sub>CC</sub> (mA)	RF INPUT (MHz)	IIP3* (dBm)	NF* (dB)	CONV. GAIN* (dB)
MAX2680	5	400 to 2500	-13	6.3	11.6
MAX2681	9	400 to 2500	-6	7.0	14.2
MAX2682	15	400 to 2500	-2	6.5	14.7

\*Performance at 900MHz.

## Features:

- ◆ 400 to 2500MHz Operation
- ◆ Low Noise Figure
- ◆ High Input IP3
- ◆ 2.7V to 5.5V Supply Range
- ◆ Low Supply Current
- ◆ Shutdown Mode
- ◆ Miniature SOT23-6 Package

## Applications:

- ◆ 400MHz/900MHz/2.4GHz ISM Radios
- ◆ Cellular/PCS Handsets
- ◆ Cordless Phones
- ◆ Wireless Local Loop
- ◆ WLAN



**FREE Wireless Design Guide – Sent Within 24 Hours!**  
**Includes: Data Sheets and Cards for Free Samples**

CALL TOLL-FREE 1-800-998-8800 for a Design Guide or Free Sample  
6:00 a.m. – 6:00 p.m. Pacific Daylight Time

**MAXIM**  
[www.maxim-ic.com](http://www.maxim-ic.com)

1999 EDITION!  
FREE FULL-LINE DATA CATALOG  
ON CD-ROM



For Small-Quantity Orders Call (800) 835-8769 or Visit <http://www.maxim-ic.com>

MasterCard® and Visa® are accepted for evaluation kits and small-quantity orders.

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.

Distributed by Arrow, Bell, CAM RPC, Digi-Key, Elmo, Marshall, Nu Horizons, and Zeus.  
Distributed in Canada by Arrow, Bell/Milgray, and Marshall.

MAXIM is a registered trademark of Maxim Integrated Products. © 1999 Maxim Integrated Products

INFOCARD 48

# Performance requirements of communication base station time standards

*Modern communication systems demand high reliability time standards. Understanding the environmental conditions will help in selecting the right oscillator.*

By John A. Kusters  
and Charles A. Adams

Modern communication networks are complex. They can involve one or more central offices, controlling toll offices, mobile switching offices, land and submarine cable, television network transmission and the familiar home telephone. As a wired network, they are connected in one form or another with copper wire or coax cable. There is also the wireless network, involving microwave repeater links, cable television (CATV), satellite links, cell sites and all forms of wireless voice and data communication.

The wireless network depends on base stations, or cell sites that handle the two-way wireless communication as well as providing links to the wired network. Usually, the cell sites are housed in small buildings at the base of an antenna structure. The future will see micro-cells, a collection of electronics in a sealed box hanging on a telephone pole. Micro-cells are unattended communication cell sites without any form of environmental control. This forces the cell site time standard to operate over wide temperature ranges. These operating temperatures can range from  $-40^{\circ}$  to  $+85^{\circ}$  C, humidity from 0–100% (condensing),

and pressure change equivalent to a 10,000-foot elevation change.

Even with loss of the external reference, the time standard must continue to operate with only limited change in performance, which is called holdover. Under holdover conditions, the time standard is not locked to the reference and the cell site accumulates timing errors. System requirements may be as tight as "less than seven microseconds accumulated timing error, 24 hours after loss of the reference, under all environmental conditions" [1]. Acceptance testing involves cycling the environment over the full range while the time standard is in holdover.

### Synchronization

Communication in any network depends on time synchronization between all of the stations and cell sites involved. Loss of synchronization in the wired network can cause many problems. For voice messages, the consequence may be as small as a slight click. For TV signals, video may be lost for as long as six seconds, resulting in a "freeze frame." For secure data communication, a synchronization error will abort the transmission and break the communication link. In the wired network, data buffers are used to couple data between two sites. In the example shown in Figure 1, a clock signal derived from synchronous signals in the incoming data clocks the data into a buffer at the receiving site. The local clock of the receiving site clocks the data out of the buffer. As long as the two clocks are essentially synchronized, data is clocked into the buffer at about the same rate as it is clocked out. If the clocks differ significantly in frequency, the buffer either overflows (data lost) or under-

flows (null data clocked out).

For the wireless network, the problem is more severe because cell phone mobility depends on the use of a variety of cell sites. Propagation delays complicate the use of clocking signals derived from the incoming data. Commonly, the system requires that all cell sites share the common reference. The more sophisticated systems use Navstar global positioning system (GPS) as the common reference [2].

### Recent advances

The Navstar GPS system offers a globally distributed timing system based on a network of satellites that are continuously monitored and controlled. A timing signal that is ultimately referenced to Coordinated Universal Time (UTC) is available as an output from GPS receivers. The timing specification for the GPS system is  $\pm 340$  ns at the 95% confidence level (170 ns root mean squared—RMS) when receiving signals from four satellites.

Current GPS timing engines using eight or more channels simultaneously can reduce this to about 40 ns RMS, or an overall timing uncertainty of about 200 ns peak-to-peak.

Using the GPS timing as a reference, technology reduces this further to about 16 ns RMS or about 80 ns peak-to-peak [2].

### Customer requirements

A typical customer may expect a timing source to meet its specifications over temperature ranges from  $-40^{\circ}$  C to  $+85^{\circ}$  C, humidity from 0–100% (condensing), pressure changes equivalent to 10,000-feet elevation change, and have 100,000 hours mean time between failure (MTBF) at a low price.

The customer also expects that after

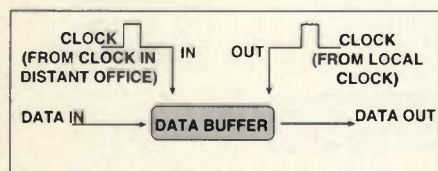


Figure 1. Data buffers for wired communication networks.



# Responsive...

from your Design to Prototype to Production to Delivery.

**SIWARD Manufactures Crystals, Oscillators, Filters, VCXOs, TCXOs, VC-TCXOs, and SAW Resonators. Richardson Delivers.**



For standard or custom frequency control products, you won't find a more reliable manufacturer than Siward or a more dependable supplier than Richardson Electronics. The combined manufacturing and distribution expertise of Siward and Richardson translates into the responsive source you are looking for.

- Worldwide Logistics Services
- Inventory Management/JIT
- Applications Engineering Support

Your cost-effective choice for SIWARD frequency control products is Richardson Electronics.

Call, fax or E-mail Richardson to get Siward's full line catalog.

 **Richardson Electronics**  
**Engineered Solutions**



**SIWARD**

www.siward.com • 973-898-1234

More than 60 locations worldwide to serve you. Toll Free US/Canada: 1-800-RF POWER or 1-800-737-6937, Argentina: +54 (327) 55750, Australia: Bayswater +61 (3) 9738 0733, Castle Hill +61 (2) 9894 7288, Brazil: Sao Paulo +55 (11) 820-6199, Canada: (905) 795-6300, Colombia: (57-1) 636-1028 France: +33.1.55.66.00.30, Germany: Puchheim +49 (89) 890 214-0, Indonesia: +62 (21) 912-0727, Italy: Agrate Brianza (MI) +39 (039) 653 145, Roma +39 (06) 41.73.37.51, Sesto Fiorentino (FI) +39 (055) 42.08.31, Japan: Osaka +81 (6) 314-5557, Tokyo +81 (3) 5215-1577, Korea: +82 2 539-4731, Mexico: Mexico City +52 (5) 674-2228, Guadalajara +52 (3) 123-0041, Singapore: +65 744-2128, Spain: Barcelona +34 (93) 415 83 03, Madrid +34 (91) 528-3700, Sweden: +46 8 760 4660, Taiwan: +886 (2) 86915238, Thailand: +66 (2) 749-4402, The Netherlands: +31 20 446 7070, United Kingdom: Lincoln +44 (01522) 542631, Slough +44 (01753) 733010, Vietnam: +84 8.8428775, Corporate Headquarters: LaFox, IL (630) 208-2200, Fax (630) 208-2550. ©1999 Richardson Electronics, Ltd. MK9449

ISO9002 Registered • 1-800-RF POWER • www.rfpowernet.com • ssc@rell.com



**THE WORLD'S LARGEST SELECTION**

# **POWER SPLITTERS/ COMBINERS**

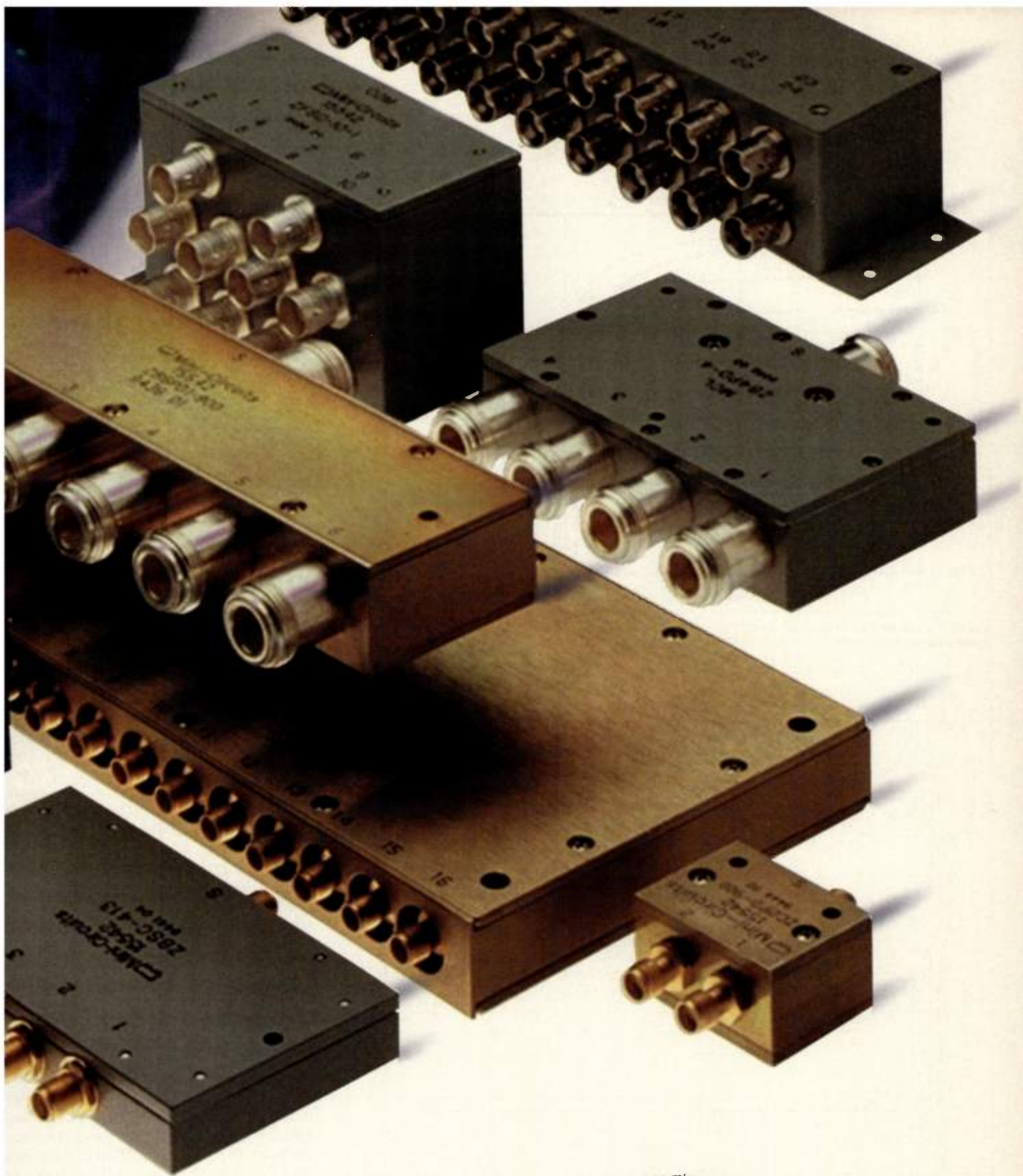


**2kHz-10GHz** from **\$2<sup>95</sup>**

Choose from over 480 standard off-the-shelf models from 2-way to 48-way; 0°, 90° and 180°; 50 and 75 ohms; covering 2kHz to 10GHz. Mini-Circuits will also supply your special needs such as wider bandwidths, higher isolation, lower insertion loss, and phase matched ports...all at catalog prices with rapid turnaround time. Models include surface mount, plug-in, flat-pack and standard connectorized designs such as SMA, N, TNC, C, and F connectors as well as custom designs. Ultra-miniature surface mount units provide excellent solutions in cellular communications, cable systems and countless wireless applications. All units come with a 1 year guarantee and "skinny" 4.5 sigma repeatability unit-to-unit and production run to production run. Catalog models are guaranteed to ship within one week.

***Mini-Circuits...we're redefining what VALUE is all about!***





see us on the web  
<http://www.minicircuits.com>



 **Mini-Circuits®**

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 **INTERNET** <http://www.minicircuits.com>  
 For detailed specs on all Mini-Circuits products refer to • 760- pg. HANDBOOK • INTERNET • THOMAS REGISTER • MICROWAVE PRODUCT DATA DIRECTORY • EEM

**ISO 9001 CERTIFIED**

US 10 INT'L 15  
 CIRCLE READER SERVICE CARD

F 194 Rev A



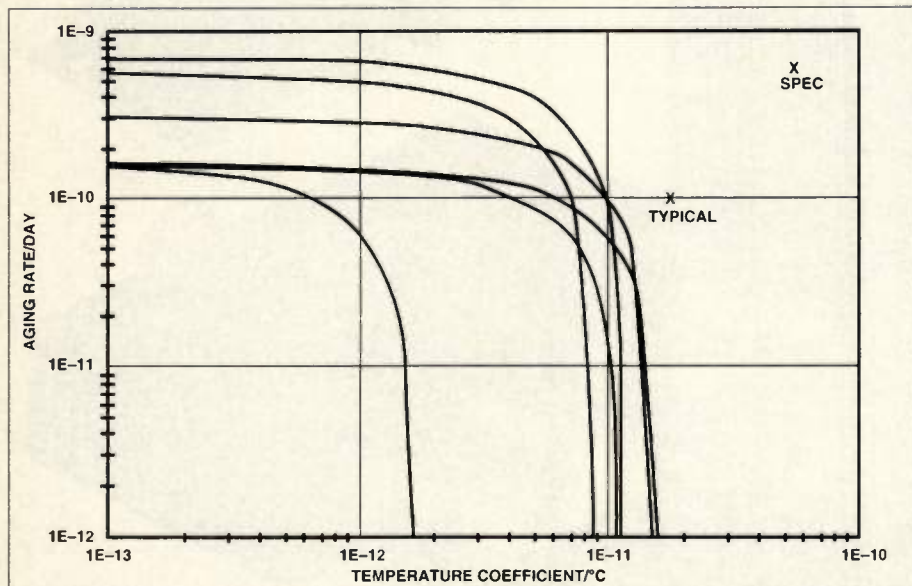


Figure 2. Each of the six lines represents the locus of linear aging rate and temperature coefficient that exactly meets the minimum customer holdover requirements.

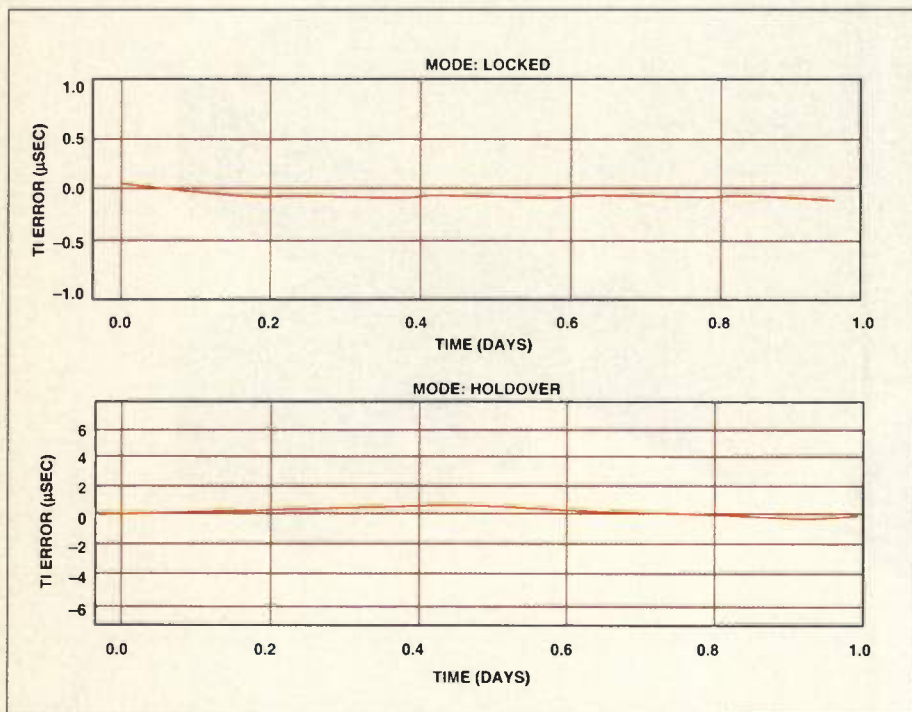


Figure 3. The top graph shows time interval error over a 24-hour stabilization period. The bottom curve shows the holdover results using the aging and temperature data learned during stabilization. Unit passes test even with a small frequency jump.

24 hours of operation locked to the external reference, that the timing unit will continue to operate without the external reference. After 24 hours of unlocked operation, the total accumulated timing error has to be less than 7  $\mu$ s. This is equivalent to an average fre-

quency offset of  $8.1 \times 10^{-11}$ . Operation not locked to the external reference is termed holdover and is the major challenge to any oscillator provider.

### The oscillator problem

The total timing error of a clock in

terms of its variables can be expressed as

$$x = x_0 + y_0 t + \frac{1}{2} A t^2 + \int_0^t E(T, P, M, H, G) dt + \epsilon(t) \quad (1)$$

where:

$x_0$  = the starting time offset or synchronization error

$y_0$  = the starting frequency offset or syntonization error

$A$  = a linear aging of the oscillator, the integral represents all of the environmental factors

$\epsilon$  = the effect of system noise and frequency jumps

In general, all of the environmental factors can be minimized, except perhaps temperature, by sealing the oscillator and using adequate shock and vibration isolation. Synchronization and syntonization errors may also be eliminated through careful calibration and algorithmic designs.

However, the effects of aging or of unpredictable events such as frequency jumps cannot be eliminated. In any practical case, the effects of temperature cannot be eliminated, either. The best quartz oscillator in production still has a temperature coefficient of  $4.4 \times 10^{-13}$  per  $^{\circ}\text{C}$  [3]. To further complicate the situation, aging is seldom linear over any significant period of time.

Figure 2 is a plot of the assumed linear aging rate and temperature coefficient that exactly meets the customer holdover requirements. In this plot, requirements for six cases are shown. Even the typical performance does not meet any of the customer requirements.

Figure 2 assumes that there is no synchronization error, no syntonization error, no linear aging, no environmental effects beyond temperature and that there are no frequency jumps or other perturbations to the oscillator frequency. Even with these assumptions, it is apparent that a typical quartz oscillator will not meet the requirements without further help. The figure further assumes that there is no retrace or hysteresis in the oscillator and that the aging in the 24-hour stabilization period is linear and stable.

In a new family of timing standards, the difference is the use of algorithms that learn the oscillator aging characteristics and its temperature performance while locked to the external reference. In holdover, the learned characteristics are used to keep the oscillator on frequency by compensating



# One

## source

### DOUBLE OVEN OCXOs

**Exceptional Stability  
and Long Life  
Performance.**

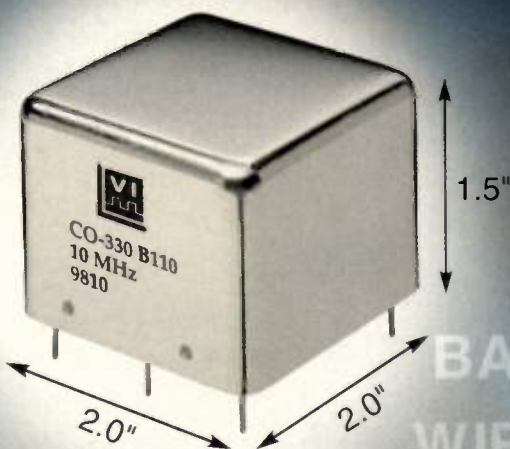
**Cost Effective Solution to  
Rubidium and other Ultra-  
High Stability Applications.**

**Frequency: 5 MHz and  
10 MHz standard**

**Stability:  $\pm 1 \times 10^{-10}$   
0°C to +70°C  
(includes 24 hrs)**

**Aging:  $5 \times 10^{-11}$  / day avg.  
 $3 \times 10^{-7}$  over 20 years**

**Package: 2"x 2"x 1.5"**



INSTRUMENTATION

GPS TIMING  
SYSTEMS

STRATUM 2

CELLULAR  
BASE STATIONS

WIRELESS  
COMMUNICATIONS

**We are the One!**



**VECTRON  
INTERNATIONAL**

A **DOVER** TECHNOLOGIES COMPANY

166 Glover Avenue, Norwalk, CT 06856  
Tel. 1-88-VECTRON-1 • Fax. 1-888-FAX-VECTRON  
e-mail: [vector@vector.com](mailto:vector@vector.com)  
[www.vector.com](http://www.vector.com)



Call Shorecliff Communications for details • 800-608-9641

# RF COMPLIANCE

# 2000

## RF Engineers and Carriers:

Learn how to comply with the latest FCC Guidelines on radio frequency emissions

### Why attend RF Compliance 2000?

- Gain clarity of the language in OET Bulletin 65
- Hear case studies on the dangers of RF emissions
- Find out what options you have to meet RF compliance
- Learn what the liability issues are
- Learn how to help your company develop on-going RF safety programs
- Find out who is offering technological solutions to help you make necessary modifications

### Hear From:

- Jerry L. Ulcek, Electronics Engineer, Federal Communications Commission
- Richard Berliner, President & CEO, Berliner Communications, Inc.
- Dr. John Osipchuk, Chairman, Standards Committee, SCC 28 (IEEE)
- Robert Schwinniger, Esq., Principal, Schwinniger & Associates
- Michael Long, Associate, Whyte Hirschbeck Duxek S.C.
- Dr. Robert Mawry, Vice President of Systems & Technology, UNISite, Inc.
- Richard Ritz, Vice President of Engineering, Sitewise LLC

## May 18, 1999

### The Biltmore Hotel Coral Gables, Florida

A one-day seminar for RF Engineers, Carriers/Licensees for all spectrum, Engineering Consultants, Site Developers and Managers, Tower Owners, Solution Software Companies, and Antenna Manufacturers

Sponsored by:

**berliner**  
COMMUNICATIONS INC

Co-sponsored by:

**UNISite**

Presented by:

**RCR**  
-GW  
wireless news

Produced by:



**Shorecliff**  
Communications  
Inc.

"[Carriers] need to be aware of this from a liability standpoint. In the long run, compliance with these guidelines could possibly save them from litigation, which could be a lot of money."

— Jerry Ulcek, FCC

Call Today for  
Information on  
the Golf Tournament  
Sponsored by:

**SiteSafe**





# I'll expect this in the mail.

- ☐ Please send me more information about the HP 53181A frequency counter.
- ☐ Please send me a FREE copy of *8 Hints for Making Better RF Counter Measurements*.

Just fill out and send in this card, or call us at  
**1-800-452-4844, Ext. 6071.**



☐ Mr. ☐ Ms. ☐ Dr.

First/M.I./Last

Title

(       )

Telephone

Extension

E-Mail

Company

Dept./Bldg./Mail Stop

Address

City/State/ZIP





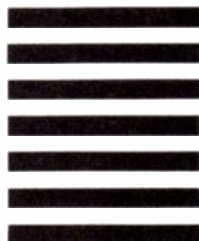
NO POSTAGE  
NECESSARY  
IF MAILED  
IN THE  
UNITED STATES

**BUSINESS REPLY MAIL**

FIRST-CLASS MAIL    PERMIT NO. 226    PALO ALTO, CA

POSTAGE WILL BE PAID BY ADDRESSEE

Hewlett-Packard Company  
Test & Measurement Organization  
PO BOX 50637  
PALO ALTO CA 94303-9511





EVERYTHING  
YOU'D EXPECT  
FROM THE COMPANY  
THAT INVENTED  
THE COUNTER.



STARTING AT \$1,575\*

AND LESS.

#### HP 53181A FREQUENCY COUNTER

##### Performance

10 digits of resolution per second

##### Frequency Range

225 MHz and 1.5, 3, 5 and 12.4 GHz  
additional channel options

##### Measurements

Up to 200 measurements per second

##### Ease of Use

One button frequency measurements

##### Price

Starting as low as \$1,575\*

#### MORE DIGITS, LESS MONEY.

**E**ver since we developed the first frequency counter, we've been improving on it. Now we're even improving on the price.

Starting at just \$1,575, the HP 53181A gives you an amazing 10 digits of resolution per second. Buy just the performance you need—the HP 53181A has 225 MHz bandwidth and 1.5, 3, 5, and 12.4 GHz additional channel options. And for ease of use, you get a high-visibility display and one-button frequency measurements. What you don't get are complicated features you don't want or need.

The HP 53181A frequency counter. It may be more than you'd expect for the price. But not less than you'd expect from HP.

For more information about the HP 53181A frequency counter, help selecting the counter that's right for you, or for a free booklet titled *8 Hints for Making Better RF Counter Measurements*, fill out the attached card or call HP DIRECT.



CALL HP DIRECT RIGHT AWAY!  
1-800-452-4844, EXT. 6071

\*U.S. list price  
©1993 Hewlett-Packard Co. TMEMDS38/RFD

**hp** HEWLETT  
PACKARD  
Expanding Possibilities



# WORKING THE WEB

Interested in  
learning more  
about a company  
mentioned  
in an article  
or product listing?

Check out the  
RF Design  
editorial link at  
[www.rfdesign.com](http://www.rfdesign.com).

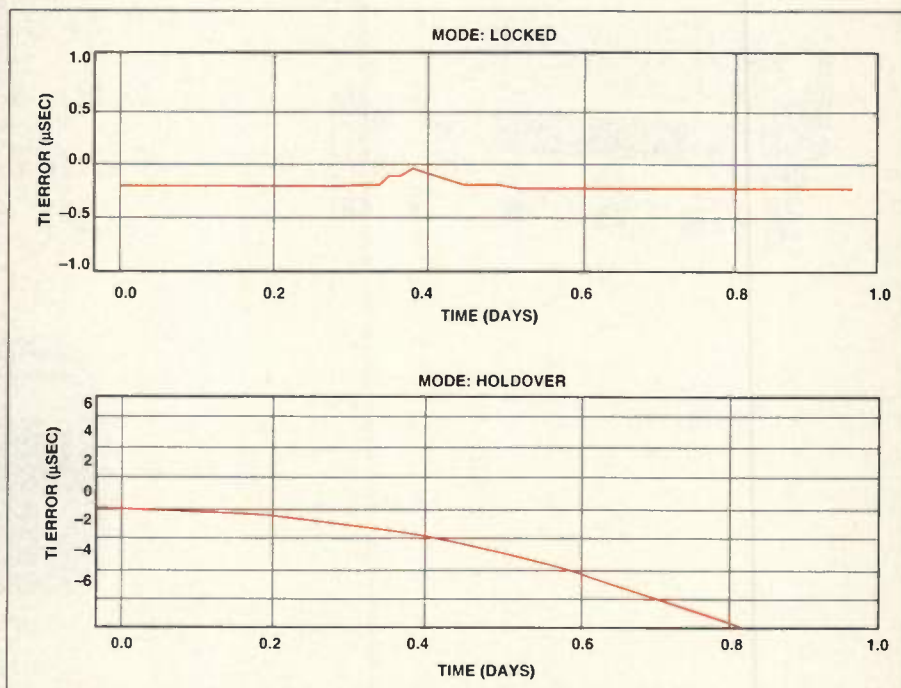


Figure 4. The top graph shows time interval error over a 24-hour stabilization period. The bottom curve shows the holdover results using the aging and temperature data learned during stabilization. Unit fails holdover specification because of a frequency jump during the learning process.

for aging and temperature changes. Obviously, what is needed is an oscillator that has the sum of all environmental effects below  $1 \times 10^{-11}$ , never jumps, never needs calibration, has no retrace or hysteresis and costs less than \$100.

## Reality

Partial solutions do exist. The oscillator can be hermetically sealed. Multiple ovens or other radical designs can be used to reduce the temperature coefficient below  $2 \times 10^{-13}$  per  $^{\circ}\text{C}$  over a  $50^{\circ}\text{C}$  range. Extensive pre-aging, intelligent aging and compensation systems can be used. Oscillators can be selected by doing extensive holdover testing over the required environmental ranges.

With partial solutions, one gets partial results. None of the conventional oscillator testing used anywhere in the industry will guarantee that the final unit will pass customer testing. Current processes require multiple holdover testing at the factory. A single fail ends the test—a “test until failure” philosophy. Total yield is below expectations; the major problems are retrace and frequency jumps. Figures 3 and 4 illustrate the problem.

From the clock equation given previously, a synchronization error results in a static offset in the holdover re-

sponse. A syntonization error results in a linear time interval error. A linear aging error results in a second-order time interval error. In actual performance, all three exist. Further, in most practical cases, the time dependence of aging is not linear. Temperature coefficients may be a function of both time and temperature. Retrace or hysteresis may give a false estimate of linear aging during the first 24 hours of stabilization. The three figures are examples of actual production testing.

Figure 3 shows a slight time synchronization error that carries over to the holdover mode. Of significance in the holdover mode response is that the slope changes at about day 0.4. The holdover results show a break after 0.4 days of holdover corresponding to a frequency jump of  $3.5 \times 10^{-11}$ . Even with the frequency jump, this unit passes the holdover requirement of  $\pm 7 \mu\text{s}$  over 24 hours.

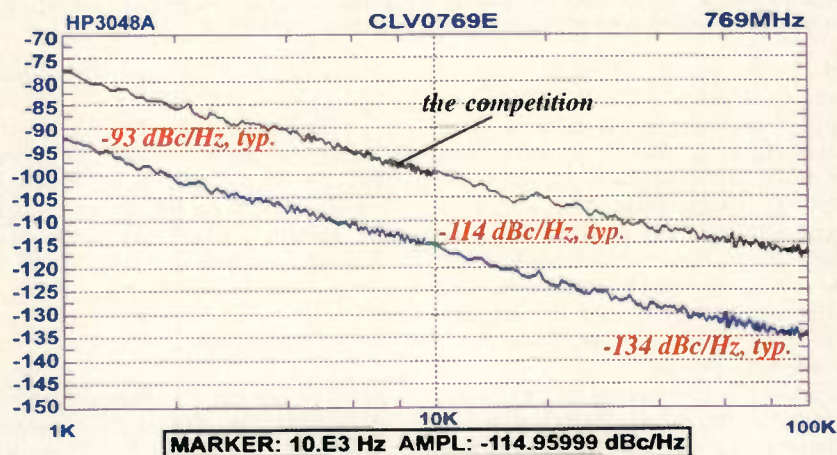
Figure 4 shows a disturbance at about day 0.4 in the locked mode caused by a frequency jump. Because of the servo nature of the locked mode, the frequency offset or syntonization of the oscillator is adjusted until there is no longer an apparent time interval error. The problem is that plotted in the frequency domain, we would see at least two distinct frequencies for the

# All VCOs should be this good ...

*Setting the standard for VCO performance.*

Designing today's advanced radios is tough enough when you have VCOs that don't give you the margin you need. Our CLV line of patented ultra-low noise VCOs will give you that margin ... and more!

Part No:	Freq. Range:	V <sub>tune</sub>	$\Phi_n$ at 10kHz	V <sub>supply</sub>
CLV0769E	734-804	1-4	-112	5
CLV0815E	806-824	0.5-4.5	-113	5
CLV0945E	936-953	0.5-4.5	-114	5
CLV1320E	1295-1335	1-5	-113	5
CLV1525E	1500-1550	0.3-4.7	-110	5



Learn more about Z-COMM's CLV product line by visiting our web site at <http://www.zcomm.com/> for datasheets, outline drawings, tape and reel specifications, and application notes, as well as our complete product catalog and custom VCO inquiry form.

**Come to the source ...**

**Z-COMM.**

 **Z-Communications, Inc.**  
 9939 Via Pasar • San Diego, CA 92126  
 (619) 621-2700 • Fax: (619) 621-2722  
 WWW: <http://www.zcomm.com/>





# Responsive

from your Design to Prototype  
to Production,

**SIWARD MANUFACTURES  
CRYSTALS, OSCILLATORS,  
FILTERS, VCXOS, TCXOS,  
VC-TCXOS AND  
SAW RESONATORS.**



- ISO-9002 Certified
- Standard and Custom Units
- Local Contacts
- Application Engineering Support
- Safety Stock - J.I.T. Commitment



Call, fax or  
e-mail to get  
our full line  
Catalog.

## SIWARD

SIWARD International, Inc.  
One Gatehall Drive, Plaza Level  
Parsippany, NJ 07054  
Tel: 973-898-1234 Fax: 973-898-1235  
www.siward.com  
e-mail: sales@siward.com

INFO/CARD 102

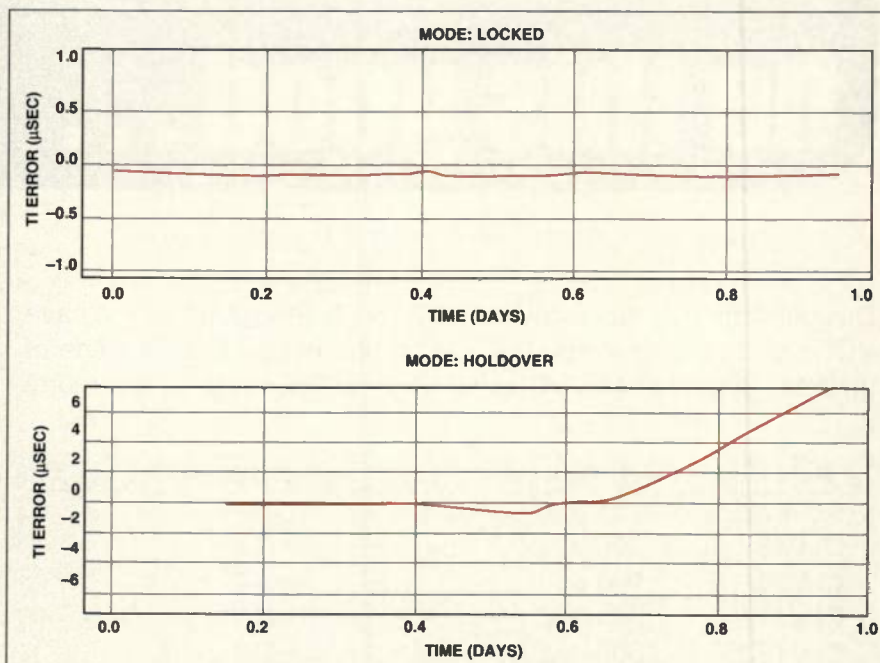


Figure 5. The top graph shows time interval error over a 24-hour stabilization period. The bottom curve shows the holdover results using the aging and temperature data learned during stabilization. The unit fails holdover specification because of a frequency jump during holdover.

locked data over the first 24 hours. A linear fit through this data would be seriously in error. The consequence of this is shown in the locked data. Here we reach the test limit at about 0.8 days. This unit fails. The apparent aging error is  $2.7 \times 10^{-10}$  per day. Another test run would probably pass this oscillator, but the confidence that the customer would also see satisfactory performance is lower. This unit is considered a reject.

Figure 5 shows good performance during the locked mode, but although unlocked, the unit shows a significant change in frequency at about day 0.7. The change in slope amounts to a frequency change of about  $3.4 \times 10^{-10}$ .

### Conclusion

Modern communication requirements need quartz oscillators that may be beyond the current state of the art. Retrace and frequency jumps are the worst offenders. Careful design backed up with extensive testing is the only way to meet the exacting requirements of modern communication systems. **RF**

### References

1. Customer specification.
2. Kusters, J.A. et al, "A no-drift and less than  $1 \times 10^{-13}$  long-term stability quartz oscillator using a GPS SA filter," *Proceedings of the 1994 IEEE*

*International Frequency Control Symposium*, p 572 ff.

3. Karlquist, R.K, et al, "A low-profile high-performance crystal oscillator for timekeeping applications," *Proceedings of the 1997 IEEE International Frequency Control Symposium*, pp 873-908 (3 articles).

### About the authors

John A. Kusters (Jack) started with Hewlett-Packard (HP) in 1965. His areas of speciality are piezoelectric devices, especially quartz resonators, acousto-optic devices and automatic frequency standards. He currently heads the Precision Frequency Standards group at HP's Santa Clara division. He can be contacted at 408-553-2041 or by e-mail at [jack\\_kusters@hp.com](mailto:jack_kusters@hp.com).

Charles A. Adams has been with HP for 38 years. His technical background includes work in piezoelectric, acoustic and acousto-optic devices. His current position is as the chief technical consultant to the Precision Frequency Standards group at HP's Santa Clara division. He can be contacted at 408-553-2440 or by e-mail at [charles\\_adams@hp.com](mailto:charles_adams@hp.com).

This paper was presented at the 1998 Piezoelectric devices conference.





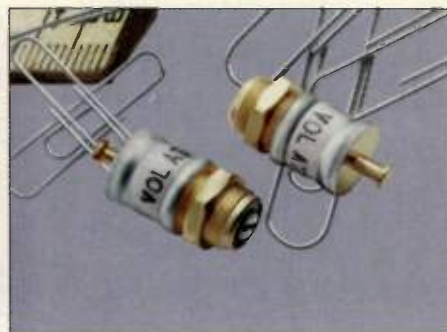
#### A\_2 Series

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



#### A\_1 Series

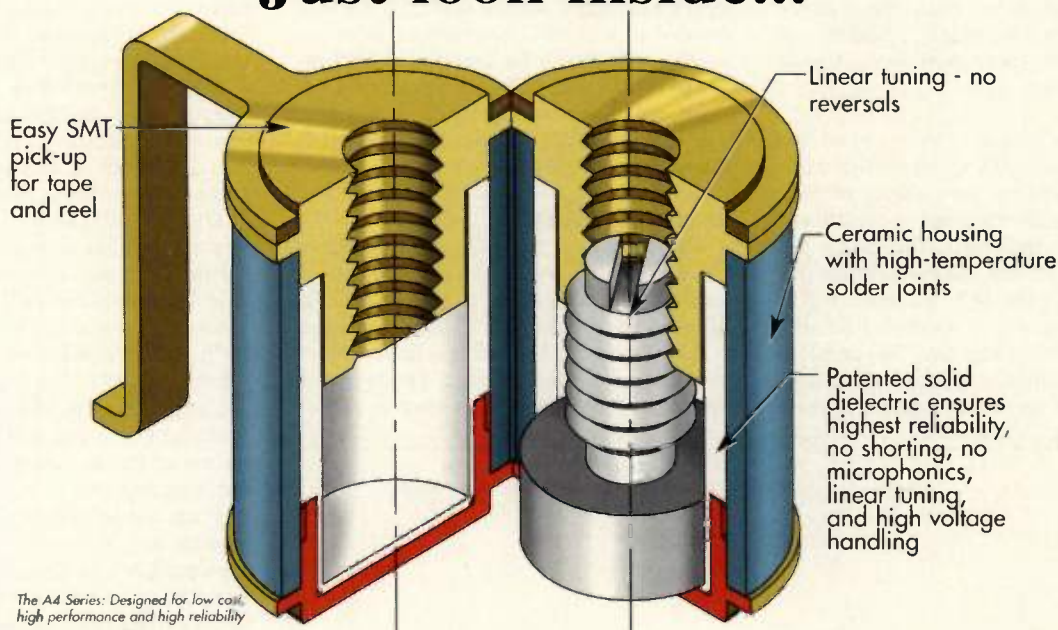
- 3 capacitance ranges from 0.45 to 12 pF
- Working voltage from 125 to 1000 VDC
- Q: 2000 min. at 100 MHz
- Self-resonant frequency to 2.3 GHz
- High reliability solid dielectric
- Up to 10 turns of linear tuning resolution
- Replaces expensive air and sapphire dielectric piston trimmers



#### A\_30 Series

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

## What makes Voltronics trimmer capacitors the world's best? Just look inside...



Voltronics trimmer capacitors provide:

- Long-term reliability designed-in
- Low cost - under \$1 in quantity
- Self-resonant frequency range to 5 GHz
- Lowest profile in the industry
- Available on tape-and-reel
- High-voltage options
- Capacitance ranges from 0.2 to 1.0 pF, 1.5 to 55 pF

**Only Voltronics trimmers  
give you all this...  
for less than \$1**

**Voltronics**   
CORPORATION

*The Trimmer Capacitor Company*

Call Voltronics today, or check out our  
complete catalog on-line at  
[www.voltronicscorp.com](http://www.voltronicscorp.com)

100 Ford Road • Denville, NJ 07834  
973.586.8585 • FAX : 973.586.3404  
e-mail: [info@voltronicscorp.com](mailto:info@voltronicscorp.com)



# Advances in broadcast technology— MMDS's rocky past and promising future

*MMDS, aka wireless cable, has been around for several years now. Recent advances in both distribution technology and infrastructure will open new avenues of opportunities for the RF industry.*

By Ernest Worthman,  
Contributing Editor

*In the first of a two-part series about local multipoint distribution service (LMDS) and multichannel multipoint distribution service (MMDS), this article will look at the broadband wireless cable broadcast technology, MMDS. LMDS will be featured as the cover story in the August issue of RF Design.*

MMDS is a Federal Communications Commission (FCC)-regulated wireless cable system for the delivery of multiple video signals via point-to-multipoint microwave transmission. MMDS is a derivative of multipoint distribution service (MDS). In 1963, the FCC allocated a portion of the commercial spectrum for distributing television signals. The problem was that it consisted of only one or two channels. This obviously could not com-

pete in the cable market so these channels were used for alternatives such as adult shows and other unique programming. Realizing the problem, the FCC bumped the frequencies up, allowing for more channels to be carried, and it also hoped to produce some competition in the cable market. This expansion created instructional television fixed service (ITFS) and operations fixed service (OFS). OFS was created to allow the government as many as three channels for training. ITFS allowed schools and colleges to broadcast educational programming. By the 1980s, this spectrum was being underused and MDS developed into MMDS.

## Its place in the sun

Presently, all wireless cable services (MMDS, LMDS and direct broadcast satellite (DBS)) account for less than 10% of the broadcast cable television (CATV) market. MMDS has about 2% of the United States market. Deployment outside of the United States is some-

what better because of the lack of the wired infrastructure that exists in the United States.

Third-world countries, almost all of which have no wired infrastructure, prefer MMDS to DBS because content can be previewed and edited, which is not possible with DBS. Some experts predict MMDS and related wireless broadcast services could eventually have as much as 30% of the broadcast television market outside of the United States.

Seen as a competitor to DBS and traditional CATV, MMDS (also called multichannel multipoint distribution systems) has a number of advantages, as well as some disadvantages, over its competition.

On the plus side, like all wireless services, MMDS eliminates the need for premise and interconnect wiring. It also requires a smaller receiving dish than DBS systems (18" compared with 36"). It can provide service to locations where direct cable installation is impractical because of distance or location and can be viewed within that premise by using the homes that are pre-wired cable or copper.

From the provider's side, MMDS is less expensive to roll out, and the infrastructure payback is immediate because the system is open-ended. Additionally, today's MMDS is (or will be shortly) digital-based and has more flexibility in adapting new technologies and integrating new services (such as interactive services and wireless Internet). Finally, personal experience has shown that reception quality is better and more reliable than that of cable.

Although its detriments are few, MMDS has some major obstacles. MMDS's significant advantage is also its significant disadvantage. MMDS is line-of-site, so topography is the major deployment consideration. Technologies available such as "beam benders" (low-power

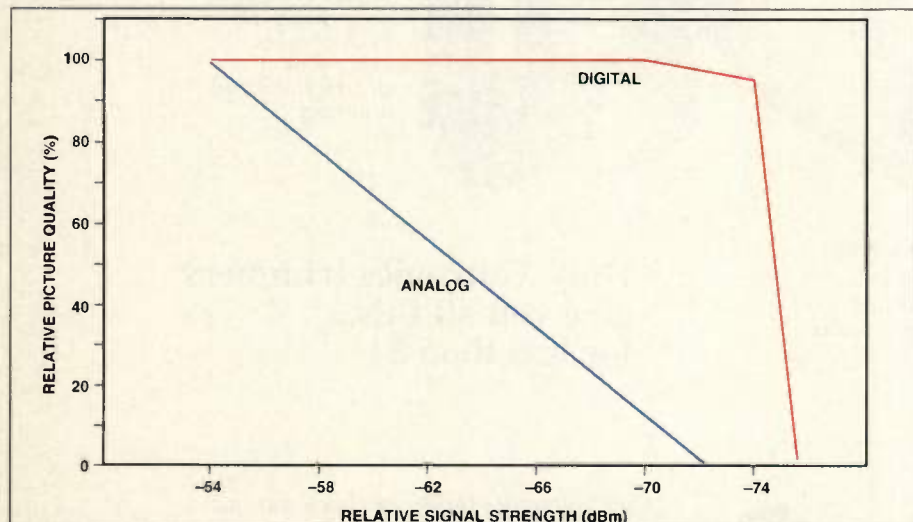


Figure 1. Digital signals retain their quality until they reach a point that the signal is so weak that the receiver loses the picture. Analog, on the other hand, gets progressively worse as signal strength weakens.



# 1W AMPLIFIERS

## HIGH IP3 & IP2



**\$19<sup>95</sup>**  
only ea. (qty. 1-9)

Amplify RF signals and **minimize distortion** in multi-carrier environments such as cable TV and cellular with Mini-Circuits broad band 5MHz to 1000MHz HELA-10 amplifiers. These state-of-the-art 12V amplifiers deliver high linearity, 12dB typical gain response  $\pm 0.4$ dB flat over the frequency range, and provide very high IP2 and IP3. Plus, HELA-10's are equipped with a self contained heat slug allowing thermal dissipation for highly efficient 1W RF output and are supplied with matching transformers for 50 or 75 ohm operation. Leap frog ahead of the competition. Select the version that meets your needs and put high octane HELA-10 performance to work for you today!

For connectorized and higher gain models, see ZHL medium high power amplifier series section in our Designer's Guide or Online Catalog.

Mini-Circuits...we're redefining what VALUE is all about!



#### HELA TYPICAL SPECIFICATIONS:

MODEL: HELA	-10A	-10C	-10B	-10D
Impedance ( $\Omega$ )	75	75	50	50
Freq. Range (MHz)	50-1000	5-450	50-1000	8-300
Gain, dB	12	11.4	12	11.0
Flatness, dB	$\pm 0.4$	$\pm 0.4$	$\pm 0.4$	$\pm 0.4$
Power Output, dBm (@ 1dB comp.)	30	30	30	30
Dynamic Range				
IP2, dBm	88	88	88	88
IP3, dBm	47	48	47	48
NF, dB	3.5	3.5	3.5	3.5

Notes: Price and performance include matching transformers.  
DC power 12V, current 525mA.

#### APPLICATION DIAGRAM



**Mini-Circuits®**

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 **INTERNET** <http://www.minicircuits.com>

For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

**ISO 9001 CERTIFIED**

US 62 INTL 63  
CIRCLE READER SERVICE CARD

F 281 Rev A



Frequency Range	Type of Service	Channel Groups	Number of Channels
2.150–2.162 GHz	MDS	1, 2, 2(A)	2
2.500–2.596 GHz	ITFS	A, B, C, D	16
2.596–2.644 GHz*	MMDS	E, F	8
2.644–2.686 GHz**	ITFS	G	4
2.644–2.686 GHz**	MMDS	H	3
2.686–2.689875 GHz	MMDS	Response channels	31

Table 1. Breakdown of current offerings and what type of service is in each band. Some of the frequencies are MMDS only\*, while others still share with ITFS channels\*\*.

directional repeaters) can help alleviate some of the problems, but basically, if you can't see the antenna, you can't get the picture. Some future services, such as interactive capabilities, require a wireless return path, which has not yet been approved by the FCC.

Second, weather affects signal quality. Because heavy rain and fog tend to absorb or reflect microwave signals, picture quality is affected under such conditions. If the broadcast signal is analog, the picture will deteriorate linearly with the loss of signal strength. With digitally broadcast signals, the curve is a bit different. Digital signals retain most of their quality until they reach a point that the signal is so weak that the receiver loses lock and the picture gets "muddy" (see Figure 1). (Note: The figure's numbers are used as a reasonable approximation only.)

### Its makeup

MMDS is deployed at frequencies in the super high frequency (SHF) band. Table 1 is a breakdown of the current offerings and the type of service available in each band. Because some MMDS and ITFS share the same band, MMDS can't broadcast on all of the channels all of the time. However, this is a dynamic relationship, and once the FCC-required ITFS educational broadcast hours are met, MMDS operators can use the ITFS channels if the ITFS licensee grants permission.

Additionally, the last row of channels is response channels only with a 125 kHz bandwidth. Response channels (also called talk-back channels) were originally designed to allow interactivity on the ITFS channels. There was one response channel for each broadcast channel. In effect, the instructors could get live feedback during the classes.

These voice channels are broadcasted back to the source via standard FM techniques with FM's 25 kHz deviation, at about 100 mW. Today, in MMDS broadcasts, these channels are used for data and overhead rather than voice. They can also be used to send program material, but their bandwidth limits their application.

Assuming future two-way communications, the distribution system's building blocks consist of a microwave antenna, a central office (CO) and the customer premise equipment (CPE). Figure 2 is a simplified block diagram of a system.

### Its technology

MMDS broadcast systems are usually low power (compared to major broadcast networks) with small coverage areas. Although the maximum effective isotropic

**Killer Connector**  
New BNC for Digital Applications

At last there are BNC connectors designed and built for the "killer applications" - Trompeter's new 75 ohm UPL2000 50 ohm PL2000. Specially engineered for high bit-rate digital video signal transmissions, at these new BNC's offer a significant performance advantage over products from other suppliers at 1.485 Gbps > 8db return loss improvement. Built rugged to deliver reliable performance over time, these connectors are competitively priced and available today.

This new series includes straight, 45° and 90° models. Various diameter cable sizes support transmission in stations, post-production and CATV headends, including all popular Belden, CommScope and GEPCO cable models.

Don't compromise your signal with yesterday's connectors...get digital BNC's from Trompeter!

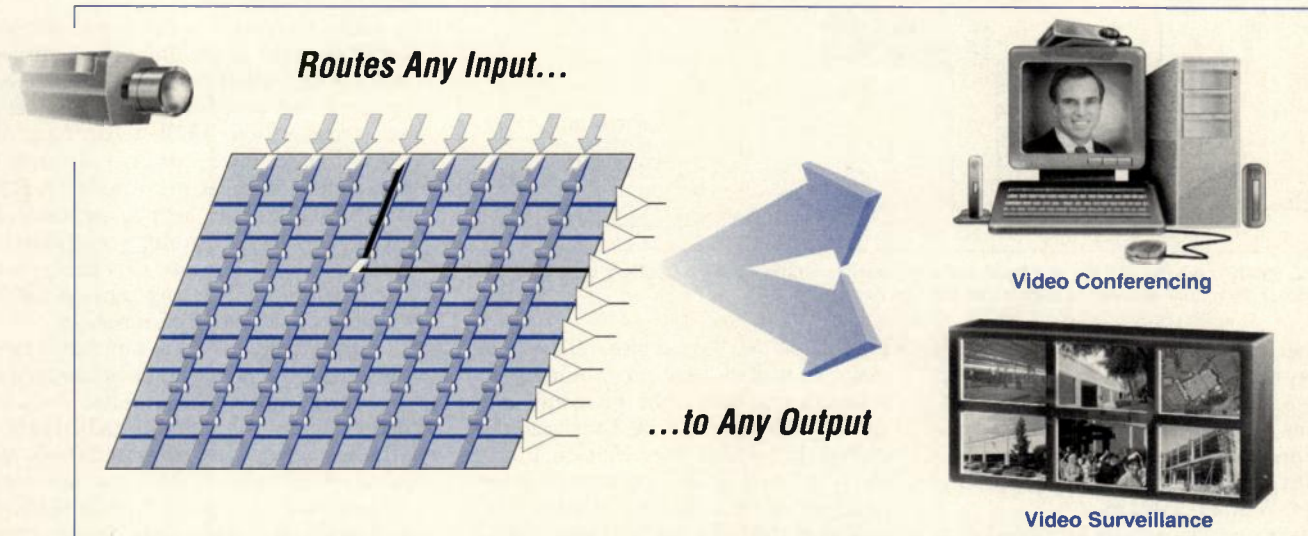
**TROMPETER**  
ELECTRONICS, INC.

**GET QUOTES FAST... VISIT OUR WEBSITE TODAY!**  
**www.trompeter.com or call: 800 982-2629**



# COMPLETE 8x8 VIDEO CROSSPOINT SWITCH FOR ONLY \$6.00<sup>†</sup>

Ideal for Any Video Switching Application—Cut Cost by Over 50%!

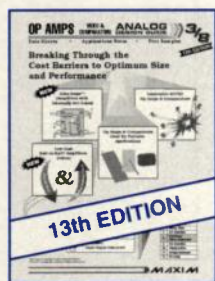


- ◆ 35MHz Bandwidth
- ◆ Low-Power Shutdown Mode
- ◆ \$6.00 for 50k Quantities
- ◆ 80dB All-Channel Off-Isolation @ 5MHz
- ◆ Internal Output Buffers with 250V/μs Slew Rate
- ◆ Pin-for-Pin Compatible with MAX456

## Choose Maxim for Your Video Crosspoint Switch Needs

PART	CONFIGURATION	MIN STABLE GAIN (V/V)	-3dB BANDWIDTH (MHz)	ALL-CHANNEL OFF-ISOLATION (dB)	SLEW RATE (V/μs)	PRICE <sup>††</sup> 1k (\$)	PRICE <sup>†</sup> 50k (\$)
MAX4456	8x8	+1	35	80	250	9.98	6.00
MAX458	8x4	+1	100	60	200	21.85	—
MAX459	8x4	+2	90	60	200	21.85	—

†50,000 pc., FOB USA. ††1,000 pc., FOB USA.



**FREE Op Amp/Video Design Guide—Sent Within 24 Hours!**  
**Includes: Data Sheets and Cards for Free Samples**

CALL TOLL-FREE 1-800-998-8800 for a Design Guide or Free Sample  
6:00 a.m. – 6:00 p.m. Pacific Daylight Time

**MAXIM**

[www.maxim-ic.com](http://www.maxim-ic.com)

1999 EDITION!  
FREE FULL-LINE DATA CATALOG  
ON CD-ROM



For Small-Quantity Orders Call (800) 835-8769 or Visit <http://www.maxim-ic.com>

MasterCard® and Visa® are accepted for evaluation kits and small-quantity orders.

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.

Distributed by Arrow, Bell, CAM RPC, Digi-Key, Elmo, Marshall, Nu Horizons, and Zeus.

Distributed in Canada by Arrow, Bell/Milgray, and Marshall.

MAXIM is a registered trademark of Maxim Integrated Products. © 1999 Maxim Integrated Products.



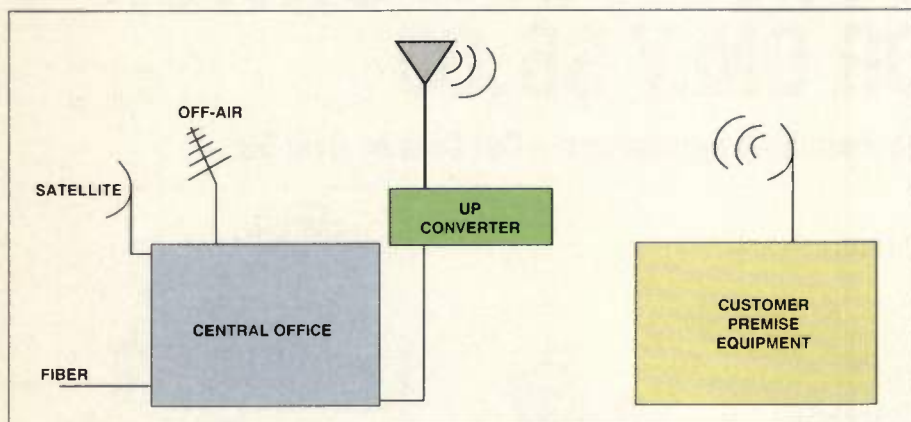


Figure 2. MMDS's receive signals at a head-end from satellites, fiber cables and off-air broadcasts and rebroadcast them from microwave sites within their service area.

radiated power (EIRP) allowed is 2 kW, most systems use 10–50 W transmitters with gain antennas (it saves money). Systems typically use a +13 dB gain antenna and, taking a 3 dB return loss into account, produces systems radiating 100–500 W at the antenna.

MMDS's receive signals at a head-end,

from satellites, fiber cables, off-air broadcasts, as well as local programming, and rebroadcast them from microwave sites within their service area. Broadcast technology presently uses Motion Picture Experts Group MPEG-2 compression technology, which allows excellent picture quality in the limited 6 MHz bandwidth.

However, only 33 analog channels are allocated to MMDS. No self-respecting broadcast service can expect to compete with DBS and cable services, capable of offering 100 plus channels. Therefore, wireless cable technology was a prime market for digital conversion.

What has come to the aid of wireless cable services (including other services mentioned further on), is the rapid development and proliferation of very large scale integration (VLSI) technology, application specific integrated circuits (ASICs), and most significantly, fast, powerful digital signal processors (DSPs). This technology warrants a quick overview because it is likely to be the fundamental coding scheme for future digital wireless broadcasting.

Currently, quadrature amplitude modulation (QAM) seems to have emerged as the coding scheme yielding the best cost-benefit relationship. Essentially, QAM is a technique that combines amplitude and phase modulation. Modulation techniques used in MMDS include QAM-16 and QAM-64. QAM can be implemented

## CRYSTALS OSCILLATORS




Web Address:  
frequencymanagement.com

Phone:  
**(800) 800-XTAL**  
(9825)

Fax:  
[714] 890-1832

15302 Bolsa Chica St.  
Huntington Beach, CA. 92649

E-mail:  
sales@frequencymanagement.com




## Frequency Management

A DIVISION OF THE D.W. THOMAS COMPANIES, INC.

- Domestic Manufacturing
- Quick Turn Specialists
- Tight Tolerances
- Standards to Customs
- Prototype through Production
- ISO Compliant


INFO/CARD 109

# We Want to Show You How *Quick Circuit* Stacks up.



- Accurate Drilling, Milling, Routing
- Plated Through Holes
- Multilayer Capability
- Better Registration and Mechanics

\*Sample Boards and Demos  
show why we  
offer the best solution.



## T-TECH, INC.

5591-B New Peachtree Rd. • Atlanta, Georgia 30341 USA  
voice: 770.455.0676 fax: 770.455.0970  
email: sales@t-tech.com • http://www.t-tech.com

See us at MTT-S Booth #634

INFO/CARD 59



Not  
So

RF Micro Devices Presents

# Great Moments in Wireless Communication



**1963 A.D. – A fly-by, two barrel rolls and a hammerhead turn...**

**The engine roars as the pilot banks, climbs, twists and dives, stringing letters across the cloudless blue.**

**A sudden sputter, a spit of flame, a belch of black – there's trouble at 10,000 feet.**

**Welcome to Skywriting 101... the crash course.**

**1999 A.D. – Your project's taken a nose dive.**

This new design won't fly unless you find a low-cost FM transceiver right now.

If you need a fully integrated device

to handle digital applications in North American and European ISM bands – a chip that includes a VCO with buffered output, a 10dB cascaded noise figure

**IMMEDIATE  
DELIVERY**

**RF**  **MICRO-DEVICES**

**Proprietary, State-Of-The-Art  
RF Integrated Circuits**

and a data output bandwidth of 1.4MHz – then you need the RF2945. One of our newest silicon-based components, this feature-packed transceiver is ready for shipment today.

So if you're headed for a crash landing, call RFMD...we'll be your parachute.

7625 Thorndike Road  
Greensboro, NC 27409-9421  
Phone 336.664.1233

FAX 336.664.0454

Online: <http://www.rfmd.com>

**Mention NSG#6 when contacting us.**

©1999, RF Micro Devices, Inc.



# HDTV and in-station coaxial transmission lines

High definition television (HDTV) is bringing significant changes to the broadcast market, especially the coax wireline that connects the station equipment (tape players, downlink feeds, and cameras right through the switches, routers, editors, patch equipment, and monitors) together to process the broadcast signals.

One of the factors driving the bandwidth requirements is the pixel count. On plain old television service (POTVS), the matrix is 525 x 487 for 256k points of address. Stepping up to one of the several versions of digital definition (480 x 640) produces a matrix of 307k address points, but the screen ratio is still 4 x 3 (x to y axis). Assuming that the industry settles on full digital HDTV (screen ratio of 16 x 9) and something like 1080i as the standard, the matrix count is now as high as 2,074k discrete address points, an increase of 8x today's standard. Even with compression, this requires significantly more bandwidth capacity than current coaxial wireless can transmit without unacceptable loss or signal degradation.

One good solution is using high frequency wave forms, which allows more discrete data points (changing states) per unit of time. However, high frequency RF transmission lines engage entirely new issues in physics that a designer needs to consider and provide for (such as reflection).

The technical issues that make a wireline into a transmission line include insertion loss and reflection. And related to reflection is the voltage standing wave ratio (VSWR). In elementary terms, it's enough to know that electromagnetic effects can degrade signal strength and interfere with the primary signal, causing a breakdown in clarity, even where only ones and zeros are at stake. Further, the concept of reflection is important to issues of signal meaning since, at high frequency, wave forms are additive. Adding a strong plus wave to a strong reflected negative wave (180° out of phase) creates

a null or standing wave that is "seen" by the system as no signal at all. This is potentially fairly serious. High frequency waves used in HDTV transport sufficiently well in coax since there is usually no discontinuity or difference in physical construction, dielectric or spacing in the cable. Once the cable is terminated into a connector, a considerable potential for discontinuity exists, creating reflection of the signal energy.

## What frequency?

Assuming 1080i uncompressed signals (a data rate of 1.485 Gbps), the use of alternate mark inversion coding technology (translates into a basic "clock" rate of 750 MHz) and use of the third harmonic to achieve the square waveform (Fourier transform technology), the maximum frequency needed is 2.25 GHz. There is some question regarding the need for upside "headroom" in frequency because of assumptions about the use of compression technology. Obviously, the more compressed a signal, the less bandwidth is needed to transport it. On the other hand, it seems to be the case that as soon as some plateau of bandwidth use is about to be reached, a new application or add-on is found that requires more. In the course of a few short years, the Internet advanced from "text only" to graphics to photos to streaming audio and video. It seems reasonable to assume that the broadcast industry will follow suit.

The key products that comprise the in-station transmission line are the cable wireline itself, the patchjacks and connectors (including equipment jacks, distribution panel jacks, and cable terminating plugs). Let's take these one at a time.

The coax cable used in transporting the HDTV digital signal within a facility is quite good. However, existing cable still needs to be replaced since it was designed for lower frequency and higher insertion loss conditions. The innovation of major manufacturers is resulting in cable

products with better and better insertion loss performance. Use of low loss dielectric materials and lower dielectric constant materials is growing. Typical values on some new cable types today are less than 1 dB loss for 100 meters of length. (Note that the key technical issue for cable selection is insertion loss over distance.) Further, the tradeoff of overall cable diameter, cable weight and cost are being attended.

Digital video patchjacks are used to insert new signal content into a signal stream that is in place. For that reason, patchjacks are usually specified as "normal through," meaning that the "back end" (or BNC jack side) is wired to pass the energy through the jack, and onward if nothing is in the "front panel" or patch side. The interior of the jack itself is a tough engineering assignment because the switching function must co-exist with multiple signal paths, all of which need shielding and dielectric controls for optimum signal processing. The key test is how it performs in normal through mode as well as how it does with front side patching in progress. It is important to test for make/break sureness of contact. Comprehensive testing is the only sure way to successfully select the right hardware for the life cycle of your station. Also needed is a monitor plug that can be inserted into the front side of the patch-jack to sample the normal through signal going through, without degrading that signal significantly.

Another key element of the transmission line is the coax cable connector. The North American broadcast market has traditionally used BNC connector technology for this assignment and will continue doing so with HDTV. Until recently it was not uncommon for stations to use 50 Ω connectors on 75 Ω cable. In any case, an upgrade is strongly recommended with HDTV, since many low-end BNC connectors are not capable beyond 1 GHz.

—Dale Reed, Trompeter Electronics

CHARACTERISTIC	POTVS	HDTV
Frequency	45 MHz	1.5 GHz
Conductor	full cross section	surface only or "skin"
Dielectric	voltage barrier	constant media, tight tolerance, low loss
Electromagnetic Field	weak, not noticeable	significant source of signal degradation
Ground	return path	boundary condition for field
Connectors	insertion loss resistance (heat)	reflection (VSWR) signal canceling
Losses	conductors (heat)	dielectric (radiation)

POTVS differs significantly from HDTV technology.



75 ohm BNC connectors for HDTV.



# VERY HIGH IP3 1W POWER AMPLIFIERS

\$149<sup>95</sup>  
from (1-9)

Reduce spurious signals and intermodulation products in high traffic environments such as CATV, cellular base stations, and VHF/UHF transmitters with Mini-Circuits low distortion high IP3 connectorized amplifiers. At the core of these unconditionally stable 12V amplifiers is state-of-the-art technology providing very high 88dBm second order and 48dBm third order intercept point, medium high output power up to 30dBm, and flat gain over the broad **5MHz to 1000MHz** band. Enhance your ability to compete in today's congested communications bands with Mini-Circuits 50 and 75 ohm high IP3 amplifiers. They're immediately available off-the-shelf, so call Mini-Circuits today.

**Mini-Circuits...we're redefining what VALUE is all about!**



## ZHL SPECIFICATIONS:

Model	Freq. MHz	Gain (dB) Min.	Max. P <sub>out</sub> * (dBm) Min.	Current mA@ 12V	IP3 dBm Typ.	Price \$ ea. Qty. 1-9
■ ZHL-450-75	5-450	9.3	+26	525	+48	149.95
■ ZHL-1010-75	50-1000	9.5	+26	525	+47	149.95
△ ZHL-1010	50-1000	9.5	+26	525	+46	149.95
△ ZHL-2010	50-1000	20	+26	900	+46	169.95
△ ZHL-3010	50-1000	30	+26	1000	+46	179.95

■ Denotes 75 ohm model, BNC Female connectors only.

△ Available only with SMA connectors.

\*At 1dB compression.

## Mini-Circuits®

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 INTERNET <http://www.minicircuits.com>

For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

**ISO 9001 CERTIFIED**

US 32 INT'L 33  
CIRCLE READER SERVICE CARD

F 299 Rev Org.



Modulation	Bits/Hertz	Data rate within the 6 MHz band (Mbps)	+/- S/N for 10 <sup>-6</sup> bit error rate. <sup>1</sup>
BPSK	1	5	11
QPSK	2	10	14
QAM-16	4	20	21
QAM-64	6	30	27
QAM-256	8	40	33

Table 2. Increased data rates result in increased S/N.

from quadrature phase shift keying (QPSK or QAM-4) to QAM-256. Basically this is a bit-coding scheme in binary as high as 8 b/Hz.

QAM in-phase (I) and quadrature (Q) outputs are derived by combining two separate binary phase shift keying (BPSK) channels transmitted in the same band in quadrature to each other. This makes one of the outputs I and the other Q to it, relative to the carrier. The major advantage of applying QAM is that, once the carrier is suppressed, two signals are occupying the same bandwidth, with no increase in S/N—not bad!

Increasing the bit-per-hertz rate results in increased throughput. As the bit-per-hertz rate is increased, i.e. increasing from QAM-4 to QAM 256, the accuracy of the

sample is increased by sampling the waveform more frequently. However, there are trade-offs. Increased sampling improves on data rates and increases spectral efficiency, but at the cost of S/N (see Table 2).

However, even fundamental digitization requires significant digital signal processing resources. The higher the modulation rate, the faster and more complex the processors need to be. Today's DSPs have reached speed and processing levels that make them reasonably adaptable and cost effective to QAM schemes as high as 8 b/Hz. When choosing QAM schemes, the only real limiting factor is the tolerable S/N of the channel.

#### Its future

How much of the market can wireless

cable garner? Early on, MMDS as a ubiquitous, pervasive broadcast technology showed promise, but several attempts to deploy large systems did not fare well, especially those that were undertaken by the Regional Bell Operating Companies (RBOCs).

Competition from sources such as DBS and wired cable has been gaining ground. They, too, have been moving to the digital domain. Cable modems promise a number of interactive applications, and DBS services are becoming more affordable as the payback period for early up-front costs is dropping out of the equation.

It is likely that MMDS, because of the attractive benefits that are appealing to developing countries as well as other first-world countries, will fare better outside of the United States. To reiterate, the most promising are regions that don't have any real wired infrastructure.

However, MMDS's future seems to be with wireless Internet, and other interactive services. 6 MHz channels offer a tremendous bandwidth for features such as home office voice and data, local area network (LAN) interconnect, videoconferencing, telemedicine, distance learning, residential multimedia and a host of other, mostly two-way services, especially for business installations. The overall success of this, however, depends on both up and downstream data rates. And currently, upstream (return) doesn't have the same transmission paths or speeds as the downstream path. There is a movement to allow 6 MHz channels in both directions.

So, the frequencies are there, the technology is there, and the opportunity is there. Although MMDS has had a turbulent past, there is a quiet stirring and jockeying for position from some of the players. This is sure to offer new opportunities for the RF industry.

Finally, just to put a fly in the ointment, the jury is still out on what role low earth orbit (LEO) satellites will play in broadcast technology over the next few years. If the projects come off as ambitious as has been touted by the LEO players, we could have a whole new ball game. **RF**

#### Acknowledgment

The author thanks John Saul, vice president at EMCEE Broadcast Products ([www.emceebroadcast.com](http://www.emceebroadcast.com)), for his input into preparing this article.

#### Reference

1. 10<sup>-6</sup> BER is generally recognized as the minimum standard for acceptable data transmission errors.

## RF Design Handbooks CLOSE OUT SALE \$100

for all nine handbooks

plus shipping \$15 in U.S.

\$45 outside U.S.

Payment must accompany order. All payments must be in U.S. funds.

No wire transfers accepted. In U.S. call for applicable sales tax.

call toll free:  
**877-296-3125**

or Send to:

Intertec Publishing Corporation  
Direct Marketing Department  
6151 Powers Ferry Road NW  
Atlanta, GA 30339-2941

**INTERTEC**  
PUBLISHING  
A PRIMEDIA COMPANY

INFO/CARD 51



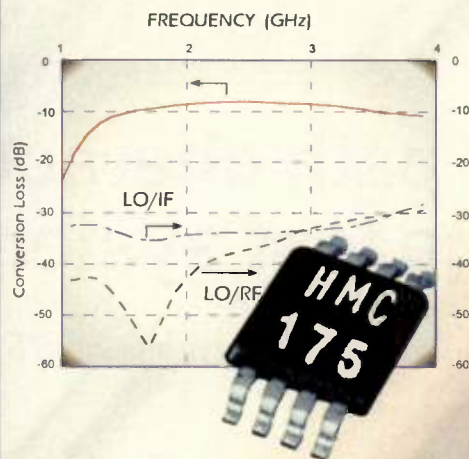
# SURFACE MOUNT PASSIVE IC MIXERS

HIGH ISOLATION  
& IP<sub>3</sub>,

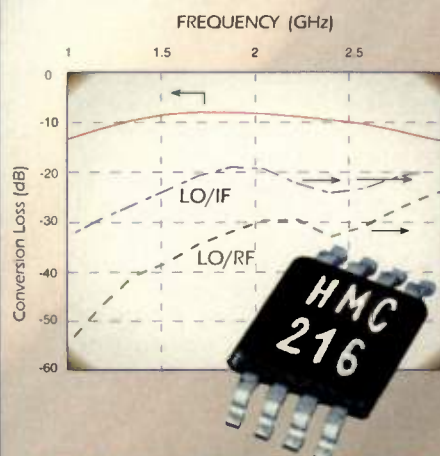
SMALLEST  
IN SIZE,  
AND.....

CONSISTENT  
PERFORMANCE!

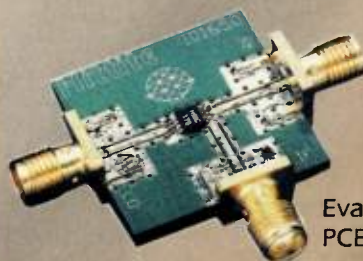
- ◆ AVE = 8.75 dB
- ◆ SD = 0.23 dB
- ◆ Cpk = 2.4



**1.7 - 3.5 GHz PASSIVE MIXER**  
+18 dBm Input IP<sub>3</sub>  
PCS, WLL, & ISM 2.4 Applications!

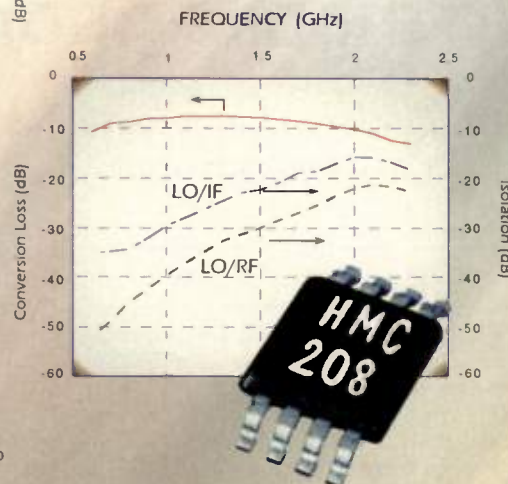


**1.3 - 2.5 GHz BALANCED FET MIXER**  
+25 dBm Input IP<sub>3</sub>  
Very Low Cost PCS & WLL Solution!

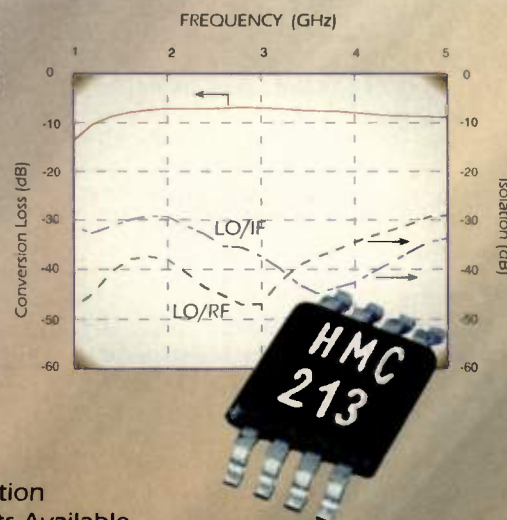


Evaluation  
PCB Kits Available

**Actual Size**  
  
**MSOP8 LEAD!**



**0.7 - 2.0 GHz PASSIVE MIXER**  
+17 dBm Input IP<sub>3</sub>  
Dual 900/1900 MHz Band Applications!



**1.5 - 4.5 GHz BROADBAND MIXER**  
+19 dBm Input IP<sub>3</sub>  
VSAT, WLL, & LMDS Solution!

**DATA SHEET PRODUCT SPECIFICATIONS ARE**

**-40 °C TO +85 °C... GUARANTEED !**

DOWNLOAD DATA SHEET AND S-PARAMETERS

@[www.hittite.com](http://www.hittite.com)

Visit Our Web Page for Job Opportunities



Request  
Our  
Catalog

**Hittite**  
MICROWAVE CORPORATION

21 Cabot Road  
Woburn, MA 01801  
Phone: 781-933-7267  
Fax: 781-932-8903





# Automated RF path characterization in mobile phone test systems

*An automated application can make the process of RF path characterization easier and more accurate.*

By Dennis Thiers

Today's mobile phone test systems make accurate RF level measurements. To ensure accuracy, offsets in RF levels caused by cabling, instrumentation or active components in the RF path must be considered. Methods used for characterizing and compensating for these offsets include the use of power meters and signal sources, as well as calibrated mobile radios. The problems in identifying RF paths in the system and associating path offsets by frequency with a given path are also part of the process that is used to correct measurements. Using a Visual Basic application, a test engineer can quickly define the RF paths in a test system, produce a table of offsets for each path and store these for use by the mobile phone test system.

### RF paths

An RF path in a mobile phone test system is comprised of a series of components through which the radio signal is transmitted or received by the phone under test. The most obvious component is usually a coaxial cable and its connectors that lead from the phone, or a fixture carrying the phone, to RF instrumentation. Other common components of the

path are RF relays, attenuators and amplifiers. A fixture is often used to contain the phone under test, and this fixture may have RF connectors and cabling that are also components of the path.

Experience has shown that this collection of components can be crucial to making accurate measurements of RF power levels transmitted and received by the phone. Variations in the RF power offsets caused by minor changes in the path can introduce significant error into these measurements. A method for capturing, storing and compensating for these offsets can improve the accuracy of power level measurements.

### RF measurements

A straightforward method for measuring path offsets is to connect the path between an RF signal generator and an RF power meter. The signal generator is programmed to a known frequency and power level, without modulation. The RF power level at the signal generator output is then compared to the power measured at the power meter input. The difference is the RF offset for that particular frequency. Offsets are usually measured for the range of frequencies used in testing the phone. These frequencies correspond to the forward and reverse cellular or personal communications

service (PCS) channel frequencies. However, disconnecting and reconnecting an RF path can influence the offset measurements by as much as 0.5 dB.

When an RF mobile station test set is connected to the path in normal testing use, it is possible to avoid disconnecting the RF path during path characterization. The RF mobile test station can act as a programmable source of RF power and can also make RF power level measurements at the appropriate channel frequencies. In this case, the phone end of the RF path is connected to a power meter. The test set is programmed to output a known frequency signal and power level, and the power meter reading is compared to the known level. The result is the RF offset including any inaccuracies in the RF test set. The RF path offset has thus been extended to include any offset introduced by the RF test set.

Another process for measuring RF offsets caused by RF path components in mobile phone test systems is the *Golden Phone* method. This idea is to use a calibrated phone and the RF test-set to source and measure all of the RF signals. In this way, it is possible to avoid disconnecting the RF path at either end. The calibrated phone is programmed to transmit at known levels on various channels, and those levels are then measured with the RF test set. The calculated offsets are stored and used exactly as those obtained by the other characterization methods. This method has the advantage of minimizing error caused by changing connections, but it has the limitations of accuracy and programmability imposed by the phone and the RF test set.

### RF offsets

As an example, when characterizing an RF path that is part of a test system for advanced mobile phone ser-

AMPS Channel	Applied Frequency (Hz)	Measured RF Power (dBm)	Offset RF Power (dBm)	Value (dB)
1	869040000	0	-0.2	-0.2
71	871140000	0	-0.3	-0.3
141	873240000	0	-0.3	-0.3
211	875340000	0	-0.4	-0.4
281	877440000	0	-0.4	-0.4
351	879540000	0	-0.3	-0.3
421	881640000	0	-0.3	-0.3
491	883740000	0	-0.2	-0.2
561	885840000	0	-0.3	-0.3
631	887940000	0	-0.2	-0.2
701	890040000	0	-0.2	-0.2
771	892140000	0	-0.1	-0.1

Table 1. RF path offsets by AMPS channel.



G L O B A L I Z A T I O N

Globalización

Globalização

I N N O V A T I O N

Innovación

Inovação

C O N V E R G E N C E

Convergencia

Convergência



[www.telecomlatina.com](http://www.telecomlatina.com)

**TelecomLatina**

17-19 November 1999

Miami Beach Convention Center Miami Beach, Florida USA

**99**

**TelecomLatina**

**TelecomLatina '99 delivers the information and technology that communications professionals in Latin America need to prosper in this new marketplace.**

You'll see innovative ideas on the show floor. Find the solutions you're looking for in TelecomLatina's comprehensive program, taught in Spanish and Portuguese.

You'll take home tips, techniques and strategies that you can put to use right away.

TelecomLatina is the only multi-lingual conference and trade show covering the full-spectrum of communications. Don't miss the event of the year for the Latin American communications marketplace!

**For more information on attending or exhibiting, please call:  
+1-303-741-2901**

**TelecomLatina '99 entrega la información y tecnología que los profesionales de las comunicaciones de América Latina necesitan para prosperar en este nuevo mercado.**

Usted verá ideas innovadoras en el salón de exhibiciones y encontrará las soluciones que está buscando en el interesante programa de TelecomLatina, dictado en español y portugués.

Aquí se enterará de nuevas aplicaciones técnicas y estrategias que podrá poner en práctica de inmediato.

TelecomLatina es la única muestra comercial con conferencias multilingüe que cubre el espectro total de las comunicaciones. ¡No se pierda el evento del año para el mercado de las comunicaciones de América Latina!

**Obtenga mayor información para asistir como visitante o para exhibir llamando al:  
+1-303-741-2901**

**A TelecomLatina '99 coloca à disposição a informação e tecnologia que os profissionais de comunicação da América Latina precisam para prosperar neste novo mercado.**

Você conhecerá idéias inovativas no salão da mostra e encontrará as soluções que procura, no abrangente programa de conferências da TelecomLatina, apresentadas em espanhol e português.

Você aprenderá dicas, técnicas e estratégias que poderá aplicar imediatamente.

A TelecomLatina é a única conferência e mostra multilingüe que cobre todas as variedades de comunicações:

Não perca o evento do ano do mercado latino-americano de comunicações!

**Para obter informações de como visitar ou exibir, por favor, ligue para:  
+1-303-741-2901**

[trade\\_shows@intertec.com](mailto:trade_shows@intertec.com)

Brought to you by Intertec Exhibitions, a division of Intertec Publishing, A PRIMEDIA Company.

INFO/CARD 50



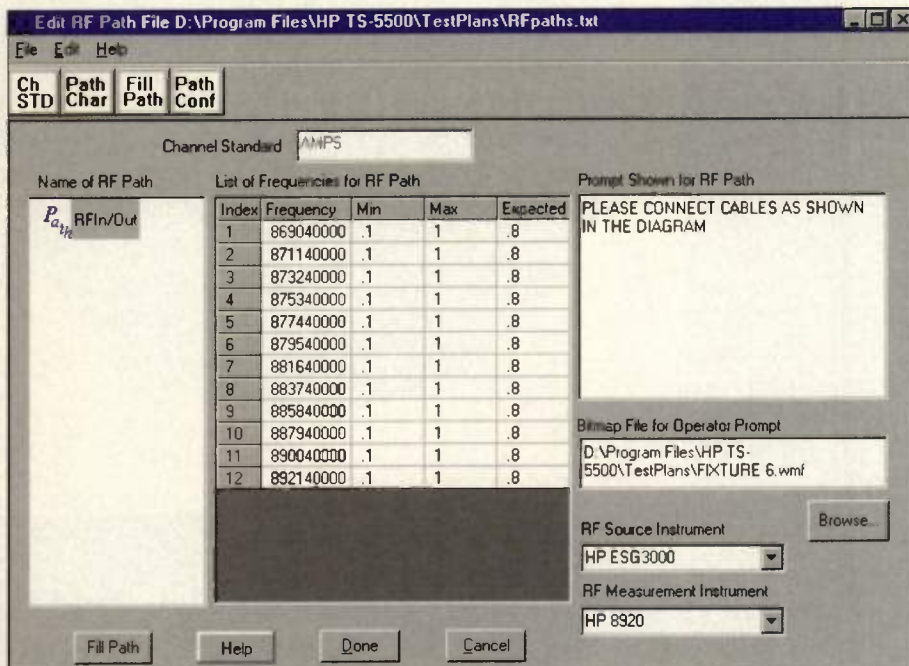


Figure 1. RF Path Characterization screen.

vice (AMPS) devices, several channels throughout the forward (base station transmitting) frequency range might be selected and 0 dBm signals applied to the RF path at those frequencies using an RF signal generator. Assume that the results, measured at the other end of the RF path using a power meter, are as listed in Table 1.

These offsets can now be stored and used to adjust the measured values or signal levels applied during the testing of phones connected to the above RF path. Assume that the required power level at the phone under test is -50 dBm and the channel used for the test is 211. The proper programmed setting of the RF test set is

computed as

- 50 dBm  $\Rightarrow$  Forward transmit power level (at phone)
- -0.4 dB  $\Rightarrow$  RF path offset
- 49.6 dBm  $\Rightarrow$  Programmed power level (at RF test set,

## Tools for defining RF paths and characterization data

Test software provides for the use of tables of offsets for selected channel frequencies that are accessible for compensating all RF measurements and RF source settings. The RF offset tables are stored in a file that is loaded at runtime into the environment of the test executive program. The test executive makes the offsets available to tests and measurements contained in the phone test plan so that RF power levels can be adjusted as needed.

Because RF path offsets tend to vary with time, temperature and mechanical changes to the test system, it is necessary to periodically update the offset tables. A Visual Basic application has been developed that allows for automatic updates, once the RF channels and several other options have been selected. Some operator intervention is required to make any necessary connections to instruments.

The test engineer must decide what RF paths in the system are to be characterized. In most systems, only one RF path for each phone under test is needed. This RF path will connect the phone to the RF test set for both transmitting and receiving. In some cases, a separate path will carry the forward (base station transmitting) and reverse (mobile phone transmitting) signals. In more complex instances, paths to peripheral RF instrumentation will need to be characterized.

The test engineer must also choose which channels (frequencies) are to be measured, as well as operator or technician instructions to ensure that the proper connections have been made. Consider a simple case where there is one path. Figure 1 shows the *RF Path Configuration* screen of the path characterization program.

The test engineer first chooses a channel standard such as AMPS, PCS, global system for mobile communications (GSM) or digital communications system (DCS)-1800 that determines the forward and reverse channels and frequencies. The next step is to choose a set of channels from which the RF path offset measurements will be made. It is desirable to

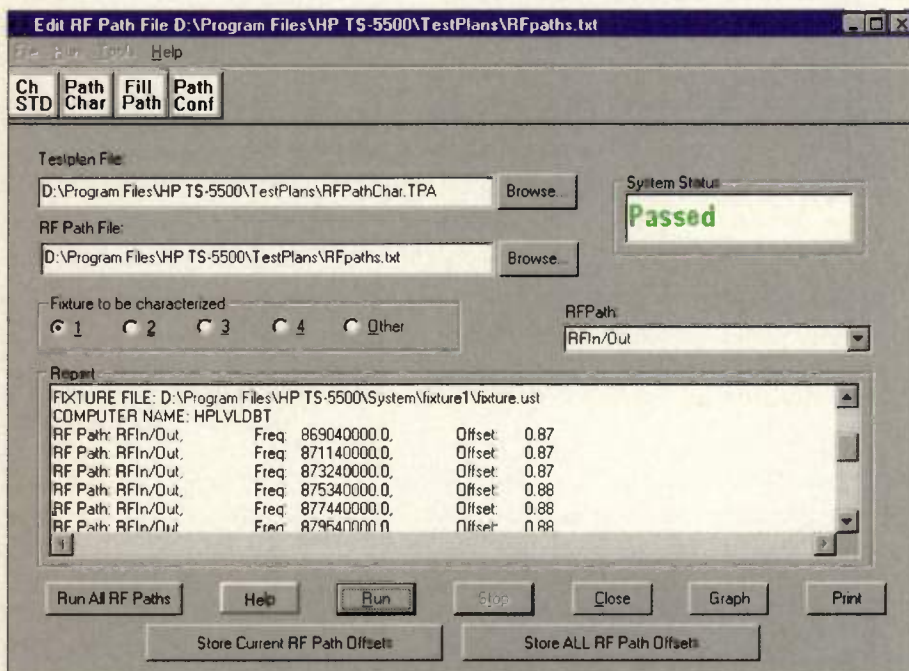


Figure 2. RF Path Characterization screen.



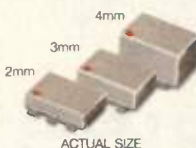
# INNOVATIVE MIXERS

**WOW!**

**.smaller size .better performance .lower cost** 500kHz to 4200MHz **\$1.99** from (10-49)

**it**  
innovative  
technology

Searching high and low for a better frequency mixer? Then take a closer look at the Innovative Technology built into Mini-Circuits ADE mixers. **Smaller size** is achieved using an ultra-slim, patent pending package with a profile as low as 0.080 inches (2mm) in height. Electrically, ADE mixers deliver **better performance** than previous generation mixers through all welded connections and unique assembly construction which reduces parasitic inductance. The result is dramatically improved high frequency and IP2-IP3 performance. Plus, ADE's innovative package design allows water wash to drain and eliminates the possibility of residue entrapment. Another ADE high point is the **lower cost**...priced from only \$1.99 each (qty.10-49). So, if you've been searching high and low for a mixer to exceed expectations...ADE is **it**™



ACTUAL SIZE

**ADE Mixers...Innovations Without Traditional Limitations!**

## ADE\* TYPICAL SPECIFICATIONS:

Model	Height (mm)	Freq. (MHz)	LO (dBm)	Conv. Loss Midband (dB)	L-R Isol Bandwidth (dB)	IP3 (dBm) @ Midband	Price (\$ea.) Qty. 10-49
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-12	2	50-1000	+7	7.0	35	17	2.95
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-30	3	200-3000	+7	4.5	35	14	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-1MH	3	2-500	+13	5.2	50..	17	5.95
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-10H	3	400-1000	+17	7.0	39	30	7.95
ADE-12H	3	500-1200	+17	6.7	34	28	8.95
ADE-20H	3	1500-2000	+17	5.2	29	24	8.95

Component mounting area on customer PC board is 0.320"x 0.290".

--Specified midband.

\*Patent Pending.

**Mini-Circuits®**

US 69 INTL 70  
CIRCLE READER SERVICE CARD

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718)332-4661 INTERNET <http://www.minicircuits.com>

For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

**ISO 9001 CERTIFIED**

F 267 Rev.F



have expected offset values, so that the measuring instruments can be set to the correct range, as well as maximum and minimum values, so the test operator can be informed if erroneous RF path offset values are measured.

Instructions to the test operator may also be entered in the appropriate field as text. There is a field that can be used to select a picture file of any standard format, such as .bmp, .wmf or .jpg. The picture file may contain a drawing or a photograph of the test system and any cable connections that may need to be made by the operator.

The program also associates a source instrument and a measurement instrument to be used in the measurement of all of the offsets for each RF path.

The previous data is entered for each RF path to be characterized. All of the path data is then stored into a file that is used when the RF path characterization test plan is run.

#### Measuring and storing offsets

Figure 2 shows the *RF Path*

*Characterization* screen of the RF path characterization program. The test operator or technician runs the RF path characterization test plan generating tables of RF path offsets. As these offsets are computed, they are compared to the minimum and maximum values, and an error is raised if these limits are exceeded. The operator has the option of graphing the offsets vs. frequency along with the minimum, maximum and expected values.

If no errors exist, the operator or technician may store the offset values into configuration files that are used in the manufacturing test of mobile phones. Once these values are stored in the configuration files, they are automatically used in every measurement and source setting.

#### Conclusion

This system is flexible enough to allow for multiple RF paths, different channel standards, various types of source and measuring instruments, as

well as RF paths that are a composite of different channel standards. At the same time, it is easy to use, and it allows for rapid configuration of RF path offset measurements and rapid updating and accessing of these important test system parameters. **RF**

#### About the author

Dennis B. Thiers received his B.S. in physics from the University of Illinois and his B.S. in computer science from Colorado State University. He has worked for Hewlett-Packard (HP) for 14 years, nine of those years as a software development engineer. He can be contacted at 970-679-2022 or by e-mail at [thiers@lvld.hp.com](mailto:thiers@lvld.hp.com). The RF path characterization program described in this article is the HP TS-5500 RF path characterization and measurement software program.

## Ultra-High Frequency Test Sockets...

**Higher Performance,  
Longer Life and  
Lower Cost!**

Only Aries' ultra high frequency (10 GHz and above) test sockets offer you:

- Higher Performance - 1 dB loss at 10 GHz
- Longer Life - tested to more than a half million insertions with no loss in electrical performance
- Lower Cost - approximately half the cost of other versions
- Ideal for zero insertion force installation QFP, SOIC, Flatpacks and other high density devices
- Adapters available to match existing board footprints
- Delivery in just 4-6 weeks

Call, fax or visit us on the web now for the Aries RF sockets that'll pass your toughest tests!



For automatic (left) and manual (right) applications



**ARIES®**  
ELECTRONICS, INC.

P.O. Box 130 • Frenchtown, NJ 08825  
(908) 996-6841 • FAX (908) 996-3891  
e-mail: [info@arieselec.com](mailto:info@arieselec.com) • web: [www.arieselec.com](http://www.arieselec.com)

**Sensible Solutions... Fast!**

INFO/CARD 111

## CERAMIC RF CAPACITORS

**C-D/SANGAMO**  
MICA RF CAPACITORS



**JENNINGS**  
VACUUM CAPACITORS  
VACUUM RELAYS

SURCOM ASSOCIATES, INC.

TEL (760) 438-4420  
FAX (760) 438-4759

Web: [www.surcom.com](http://www.surcom.com)  
E-mail: [link@surcom.com](mailto:link@surcom.com)

INFO/CARD 73



# It's a wireless revolution if only they could decide what kind.

CDMA, GSM, NADC, TDMA, PDC, PHS, DECT, CT2. These days speeding up production means being ready to manufacture anything. And losing no time doing it. The way to accomplish both is with the HP 8590 E-series.

They're a family of spectrum analyzers you can easily configure to almost any format. And make accurate transmitter measurements the first time. So you can adapt quickly to capacity changes—and get more quality products out the door faster.



HP 8590 E-Series Spectrum Analyzers

## TEST AT THE SPEED OF THE REVOLUTION.

For more information on the HP 8590 E-series spectrum analyzers, and a free copy of *Digital Modulation in Communications Systems—An Introduction*, call HP DIRECT at 1-800-452-4844, Ext. 6056. It should make at least one decision easier.

[www.hp.com/go/wireless](http://www.hp.com/go/wireless)



## An (almost) all-digital HF communications receiver

*CMOS monolithic digital downconverters permit the construction of low-cost receivers using digital signal processing.*

By Peter Traneus Anderson

Communications receivers for the high-frequency (HF) band from 3–30 MHz are asked to perform under difficult conditions, extracting weak signals on frequencies close to the frequencies of unwanted strong signals. These receivers use analog circuitry in the signal path, with basic designs descended from Armstrong's original superheterodyne design [1].

Over the past few years, monolithic analog-to-digital converters (ADCs) and digital downconverters (DDCs) have appeared on the commercial market. These devices permit the construction of inexpensive HF receivers using a signal path that is almost entirely digital.

This article considers HF communications receivers used primarily for aural reception of single-sideband (SSB) amplitude-modulated voice signals and on-off keyed (OOK) continuous-wave (CW) Morse-code signals.

Receiver Type	Minimum Discernible Signal (MDS)	Blocking Dynamic Range (BDR)	Intermod Dynamic Range (IMDDR)
Analog	-128 dBm	142 dB	97 dB
ADC	-113 dBm	111 dB	80 dB

Table 1. Analog receiver vs. ADC performance at 14 MHz with 500 Hz bandwidth.

### Architecture of digital HF receiver

The block diagram of a basic digital receiver for aural reception is shown in Figure 1 [2][3]. The signal from the antenna passes through a lowpass filter (LPF), a low-gain broadband amplifier and a second LPF to the input of the ADC.

The ADC digital output goes to the input of the DDC. The DDC is set to output a real signal, rather than the usual in-phase/quadrature (I/Q) complex signal. When operating in real mode, the DDC uses Weaver's method of SSB demodulation [4] to shift the desired signal frequency down to the audio frequency range and to bandpass-filter the signal. In Weaver's method, the incoming HF signal is downconverted to a complex baseband lowpass signal and then upconverted to a real bandpass audio signal.

The DDC also decimates the samples, reducing the high-input sample rate to a rate appropriate for the audio-frequency output. The output of the DDC drives one input of a scaling multiplier. The other input of the multiplier is a gain parameter. The gain parameter is adjusted to compensate for varying signal strengths, to keep the audio output at a desired level.

The output of the multiplier drives a digital-to-analog converter (DAC). The DAC's output passes through an

LPF to remove aliases, giving the desired analog audio signal. The audio signal is amplified and sent to the loudspeaker.

In the receiver described in [3], the LPFs pass frequencies below 22 MHz and have unity gain in the passband. The preamp has a gain of 10 dB. The ADC is 12-bit, capable of operating as high as 65 MSPS (megasamples per second), with a fullscale input (from 50 ohms through a 2:1 step-up transformer considered as part of the ADC) of -2 dBm. The DDC can operate as high as 52 MSPS.

Both the ADC and the DDC operate at 50 MSPS in this receiver. The 50 MSPS sample rate limits the frequency coverage to frequencies below 22 MHz.

### Dynamic range of digital vs. analog receivers

The dynamic range of a digital receiver is limited primarily by the ADC linearity and noise level. Table 1 compares the specified performance of the ADC with the reported measured performance of a high-performance commercial analog receiver, the receiver portion of an amateur-radio transceiver [7].

The transceiver's data in Table 1 comes directly from a product review by Lindquist and Swanson [8]. The ADC data is calculated from specifications in a data sheet [5]. Both receivers are operating at a signal frequency of 14 MHz with a bandwidth of 500 Hz. The transceiver is operating with its RF preamp turned off. The ADC has a 2:1 step-up transformer at its input, and is operating at 50 MSPS.

The blocking dynamic range (BDR) is taken as the signal-to-noise ratio (SNR) in dB at the ADC output of a signal 1 dB down from full-scale, increased by the SNR process gain in dB incurred in the DDC (where the signal bandwidth is reduced from 25

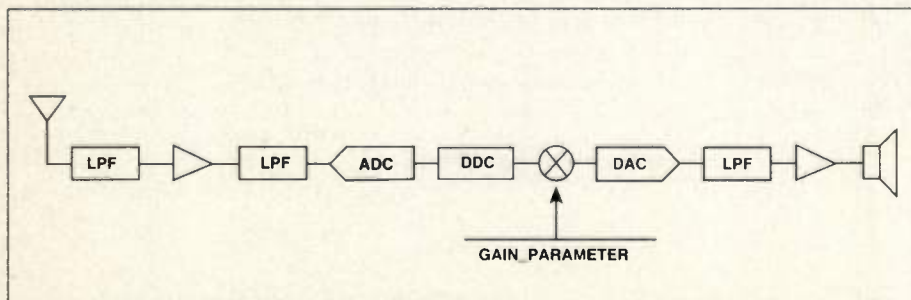


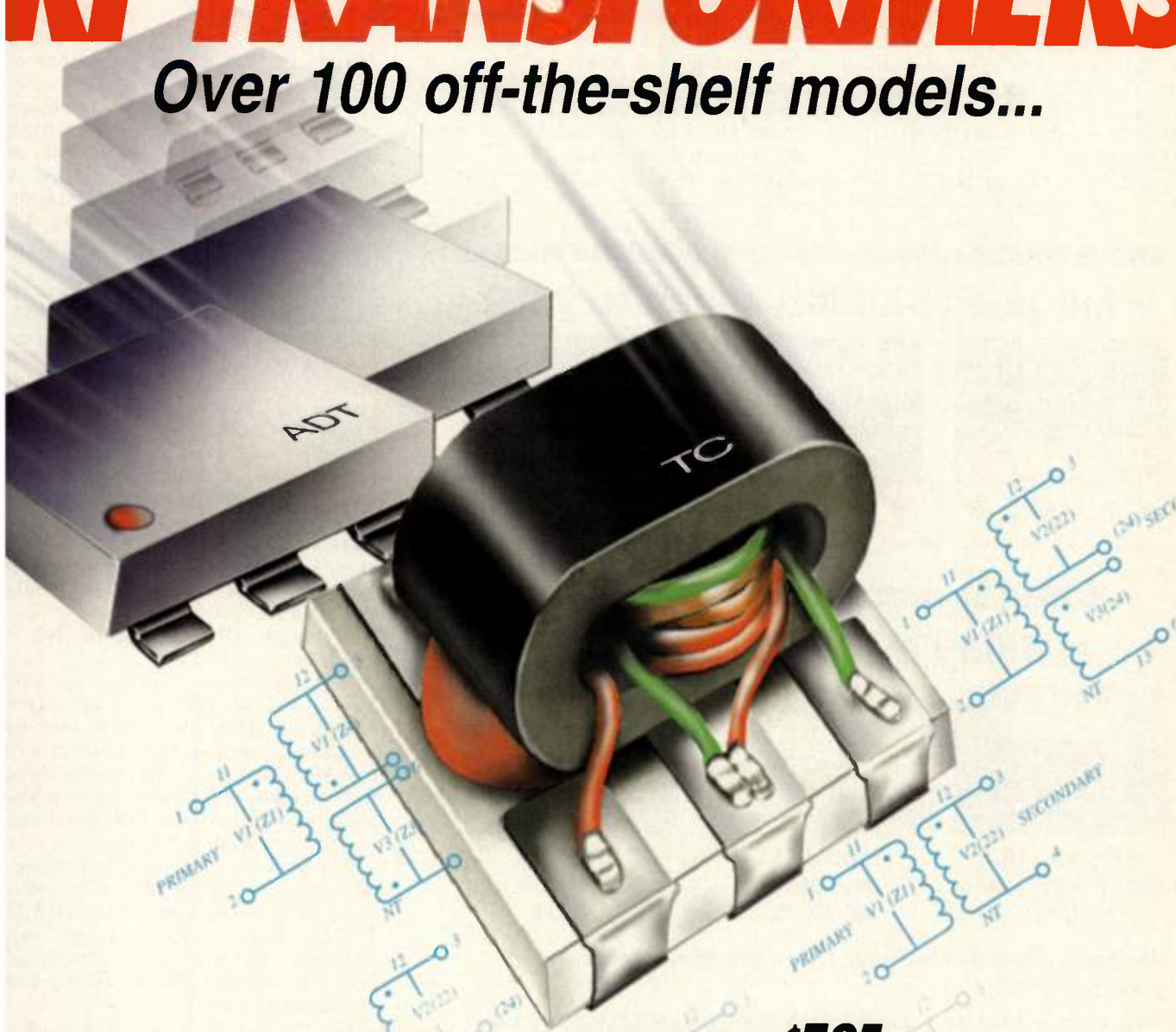
Figure 1. Block diagram of digital receiver for aural reception.



**SURFACE MOUNT**

# **RF TRANSFORMERS**

**Over 100 off-the-shelf models...**



**4kHz to 2200MHz** from **\$195** ea. (qty. 1-9)

What makes Mini-Circuits your single source for surface mount RF transformers? Variety, availability, performance, and price! From wide band transformers with low droop and fast risetime capabilities for pulse applications, to a particular impedance ratio from 1:1 through 1:36 specified for a wide range of impedance coverage, we will work with you on your design challenges. Tangible benefits such as very high dielectric breakdown voltage, excellent amplitude and phase unbalance for balanced to unbalanced applications, and easy to use surface mount package styles make Mini-Circuits

surface mount transformers a great value. Our new ADT transformers are changing the face of RF transformer design with patent pending **it** Innovative Technology delivering small size, low cost, and better performance. This same leading edge transformer expertise can also develop your custom designs at catalog prices. So, simplify your transformer search...Big Time! Capitalize on the quality, design know-how, and off-the-shelf variety from Mini-Circuits. Call today!

**Mini-Circuits...we're redefining what VALUE is all about!**

 **Mini-Circuits®**

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 **INTERNET** <http://www.minicircuits.com>

For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

**ISO 9001 CERTIFIED**

US 77 INTL 79  
CIRCLE READER SERVICE CARD

F 290 Rev Orig



MHz to 500 Hz). The minimum discernible signal (MDS) is taken as the full-scale signal in dBm minus the BDR. The third-order intermodulation-distortion dynamic range (IMDDR) is taken directly from the ADC's data sheet.

The ADC is one of the best cur-

rently available, and its performance is clearly not as good as that of the transceiver. The ADC's IMD dynamic range is 17 dB worse than that of the transceiver. According to the ADC's data sheet, dither (out-of passband noise) can be applied to the ADC to improve its IMD performance by 10

dB, giving a spurious-free dynamic range (SFDR) of 90 dB. This is just 7 dB poorer than the performance of the transceiver.

The ADC's MDS can easily be improved in a receiver by providing some gain in a preamplifier ahead of the ADC. The receiver described in [3] uses 10 dB of gain for this reason. The preamplifier can, of course, degrade the intermodulation distortion (IMD) performance of the ADC.

The ADC's BDR is determined by SNR in the ADC's data output. Improving the BDR requires improving the SNR. Improving the SNR requires increasing the number of bits in the ADC data word. This requires the least-significant bit (LSB) becoming smaller, the fullscale signal becoming larger, or both.

The ADC's SNR is 67 dB, good for a 12-bit converter. To equal the transceiver's performance, the ADC's SNR must increase by 31 dB, implying an increase in the word length of 5 bits (at 6 dB per bit). This would give a word length of 17 bits and an SNR of 98 dB.

A longer word implies a smaller LSB or a larger fullscale or both. In a sampling ADC, the LSB cannot be made much smaller than the value in the ADC because of the analog noise floor set by wideband analog noise being aliased into the ADC passband by the sampler in the ADC.

The Johnson noise of a 50  $\Omega$  room-temperature signal source is about -138 dBm for a noise bandwidth of 500 Hz. Thus the ADC's noise floor, -113 dBm for a noise bandwidth of 500 Hz, is only 25 dB above the Johnson noise level.

For the overall receiver to have a noise floor limited by Johnson noise of the 50  $\Omega$  input signal source, there must be some gain and filtering between the receiver input and the ADC analog input, so the bandlimited amplified input noise will be large compared to the ADC internal noise.

Reducing the noise floor by 11 dB might help. This leaves 20 dB to be gained by increasing the fullscale input by a factor of 10. The ADC has a full-scale input at the chip of 1 V peak-to-peak. Increasing the full-scale input to 10 V peak-to-peak is difficult in modern mixed-signal chips, as the trend is to supply rails of 5 V or less.

Another alternative is the oversam-

## What does stability mean to you?



S T A B L E



S T A B L E



S T A B L E

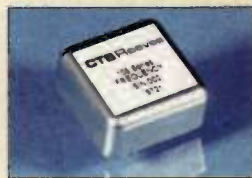
## When it comes to oscillators, stability means CTS Reeves



**Model 115**  
**Ultra High Stability**  
**OCXO**



**Model 111**  
**Miniature**  
**HF OCXO**



**Model 108**  
**Mini TH/SMT**  
**OCXO**

**We know you want the most stable, highest quality, crystal controlled products available.**

That's why our half century of experience in the development of high stability, ovenized, temperature compensated and voltage controlled oscillator products is important to you. From raw quartz bars to finished high precision oscillators, we control the technology and the processes to assure the highest possible stability to meet your most demanding product specifications.

**We know you want to do business with a stable, reliable company.**

CTS Reeves has been in the business of developing and producing crystal products for more than **50 years** and our quality is backed by ISO 9001 certification. In addition, our experienced engineering staff provides support services and design solutions to meet all your crystal product needs.

For more information call:  
Marketing Department: 815-786-8411,  
or visit our **WEB** site at: [www.ctscorp.com](http://www.ctscorp.com)

**CTS Reeves**  
**FREQUENCY PRODUCTS**



# The Power of 4.

# In 1 Power Meter.



Thermal Sensor  
Power Meter

90 dB  
Diode-Based  
Power Meter

Voltmeter

Peak  
Power Meter

>35K Samples/Sec.  
90 dB Dynamic Range  
-78 dBm Noise Floor  
10:1 Faster Thermal Sensors  
0.5% Instrument Accuracy  
2x - 10x Productivity  
Improvement  
2 Graphics Modes  
2 Inputs  
100% GPIB Emulation  
6 Hours Battery

1 ML2430A



Introducing speed, accuracy and convenience in one versatile instrument. Anritsu's ML2430A Series Power Meters.

Speed is the key. Over 35,000 samples and 300 GPIB readings a second deliver the fastest continuous GPIB for ATE applications. And thanks to the -78 dBm noise floor, dynamic range is a true 90 dB. Then there's Anritsu's new thermal sensors. Settling time is 4 msec, not the usual 50. A 10x advantage. What's that mean? Cycle times cut in half. Instrument

inventory, maintenance and calibrations cut to the bone.

Specs don't tell the whole story, either. There's a new, dual-mode graphical interface. A wealth of triggering functions. A lightweight, rugged case. A 6-hour battery. And a built-in voltmeter that completes a total measurement solution.

So to do the work of 4 meters at the cost of one, call 1-800-ANRITSU (1-800-267-4878) today. Or for a demo, see your nearest sales office below.



Peak Power displays profile fast cellular and PCS signals



**ML2430A Power Meter**

## Anritsu

One world. One name. Anritsu.

©1997 Anritsu Company. Sales Offices: United States: 1-800-ANRITSU, Canada: (613)828-4090, Europe: 44(0)1582433200. Japan: 81(0)3(3446)1111. Asia-Pacific: 65 2822400, South America: 55(21)286 9141. <http://www.global.anritsu.com>.

INFOCARD 35

WRN



pling, or deltastigma, ADC. This type of ADC has built-in antialiasing be-

cause of the high sample rates used, so the in-band LSB noise can be

pushed down to the Johnson-noise floor. Deltastigma ADCs are well-known for potential high SNR and linearity.

Adams, et. al., describes an audio deltastigma ADC with 100 dB of SNR available at an oversampling ratio of 64 [9][10]. Recent experiments have demonstrated the potential of deltastigma ADCs at HF signal frequencies. Gao, et. al., describes a registered comparator intended for use in deltastigma ADCs at a clock speed of 5 GHz [11]. With an oversampling ratio of 64, the signal frequency range would be DC to  $5 \text{ GHz}/128 = 39 \text{ MHz}$ . Jensen, et. al., describes a working deltastigma ADC running with a clock speed of 3.2 GHz and an oversampling ratio of 32 [12]. This gives a signal frequency range of DC to 50 MHz. This ADC has an SFDR of 72 dB and an SNR of 55 dB using a second-order design. Higher orders and higher oversampling ratios will lead to improved performance.

### Oscillator phase noise and tuning steps

A superheterodyne analog receiver must have at least one variable-frequency oscillator (VFO) to permit tuning to the desired input frequency. This oscillator is always a difficult part of analog receiver design. Mechanically-tuned VFOs are diffi-

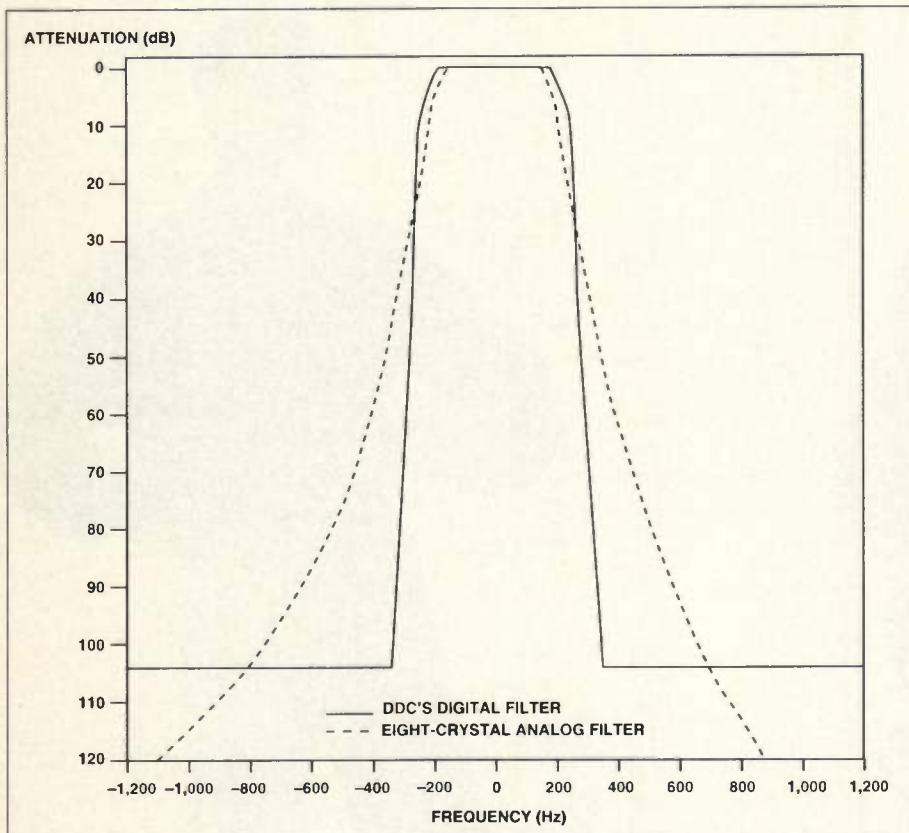


Figure 2. Frequency responses of eight-crystal analog filter (dashed line) and the DDC's digital filter (solid line). The digital filter attenuation floor is actually ragged, always below the straight lines shown.

## RF Printed Circuit Board Manufacturing

Specializing in TEFLON & DUROID Materials

# "Earth to Mark?"

Marlo Electronics, building pc boards for communications.

Multilayer circuit boards, double sided circuit boards, high volume imported circuit boards, prototypes, flex circuits, smt, snr, bcb, tin/lead circuit boards, teflon double/multilayer, select gold, duroid, polyimide, high aspect ratio, blind and buried vias, backplanes, deep gold, deep nickel, controlled impedance, military circuit boards (mil-spec 55110 approved).



MARLO ELECTRONICS, INC.  
Ft. Lauderdale, Florida USA  
1-954-565-4839 Fax 1-954-563-1309  
www.MARLO1.com

# Your Single Signal Source.



From high performance to economy-priced, IFR signal sources offer the lowest phase noise performance in the widest variety of modulation modes and carrier frequency coverage.

More and more engineers are choosing IFR signal sources. The reasons are clear: Our advanced synthesizer technology delivers excellent phase noise performance. Plus, with a wide variety of models, each offering multiple modulation modes and carrier frequency coverage, IFR has a source to fit any need.

**Need high performance and low noise?** The 2040 series, with  $-140$  dBc/Hz at 20 kHz offset from a 1 GHz carrier and a choice of operating modes, is an industry-leader.

**What about multi-source generators?** Our 2026 features three built-in high quality signal sources to 2.4 GHz,

with built-in switched combiner network that virtually eliminates measurement uncertainties.

**If cost of ownership is your number one priority** consider the popularly priced 2023A/B series, featuring carrier frequencies from 9 kHz to 2.51 GHz, and a wide choice of modulation modes.

**If your work involves digital,** IFR generators test a variety of digital systems under real-world conditions, including GSM, CDMA, TDMA, DECT, TETRA and APCO-25.

To find out more, contact your nearest IFR office today or visit our web site.



For more information call your local IFR office - USA Tel +1 (316) 522-4981 Toll Free 1-800-835-2352 (U.S. Only) Fax +1 (316) 522-1360  
Latin America Tel +1 (817) 430-5842 Fax +1 (817) 430-5843 UK Tel +44 1438 742200 Free phone (UK only) 0800 282388 Fax +44 1438 727601  
France Tel +33 1 60 79 96 00 Fax +33 1 60 77 69 22 Benelux Tel +31 13 463 95 40 Fax +31 13 463 96 63 Germany Tel +49 81 31 2926-0 Fax +49 81 31 2926-130  
Spain Tel +34 1 640 11 34 Fax +34 1 640 06 40 Hong Kong Tel +852 2-832-7988 Fax +852 2-834-5364  
E-mail: [info@ifrsys.com](mailto:info@ifrsys.com)

[www.ifrinternational.com](http://www.ifrinternational.com)

INFOCARD 45



# 10 MHz OCXO

## MOTAC 511



2" x 2" x 1.5"  
(50mm x 50mm x 38mm)

The MOTAC 511 has a glass sealed SC Cut crystal for fast warm-up and low aging. It utilizes double oven technology for improved frequency vs. temp. performance.

### Applications:

**CDMA & GSM Base Stations  
Test & Measurement  
GPS Timing**

### STANDARD SPECIFICATIONS at 10 MHz

Stability 0 to +70°C	$\pm 1 \times 10^{-10}$
Aging/year*	$< 3 \times 10^{-8}$
Supply	+12 Vdc
Output	+7 dBm

\*After 2 weeks continuous operation

**Custom specifications  
welcomed.**



**Crystals, Filters,  
Oscillators, VCXO's,  
TCXO's, OCXO's &  
Rubidium Atomic Clocks**

PH: 602-780-1995

FAX: 602-780-9622

e-mail: sales@temex-az.com

www.temex-az.com

TEMEX ELECTRONICS, INC.  
3030 W. Deer Valley Rd. Phoenix, AZ 85027

cult to control digitally, and are difficult to set to precise frequencies. Phase-locked-loop (PLL) frequency synthesizers have difficult trade-offs between phase noise and tuning step size. Direct digital synthesizers (DDSs) have no problem with small tuning steps, but are limited by the noise and nonlinearities in the DAC used to convert the digital sinewave to analog. The DDC sidesteps all these problems by using a DDS without a DAC.

### Characteristics of digital vs. analog filters

Every HF communications receiver exhibits a narrow passband, set by lowpass or bandpass filters. The narrowest filters are used for CW reception. Figure 2 compares the frequency responses of analog and digital CW filters. The dashed line shows the calculated frequency response of an analog bandpass filter using eight quartz crystals, having a -3 dB bandwidth of 400 Hz. The filter consists of two identical four-crystal sections cascaded with an isolating buffer between the sections. Each four-crystal section is a Cohn filter [13][14]. The measured attenuation in dB of one section, was doubled to give the calculated attenuation of two sections cascaded. The solid line shows the specified bandpass response of the DDC operating in real mode. The DDC's filter is set for a -3 dB bandwidth of 427 Hz.

The digital filter shows an attenuation floor at -104 dB not present in the analog filter. The floor is actually ragged, always below the straight lines shown. The floor is caused by the design of the finite impulse response (FIR) filter and to the finite-precision integer arithmetic used to implement the filter. The level of the floor in the digital filter is set by economic tradeoffs (a lower floor requires a more complex chip), rather than by physical feasibility. The digital filter response is wider in the passband and narrower in the stopband, exhibiting the narrow skirts common in digital filters.

### Improvements needed in DDC's for HF receivers

Once excellent ADCs, with dynamic ranges as good as or better than those of analog receivers, are available, the DDC performance will

have to be improved. The dynamic range must be improved, and the real-mode audio passband must be made shiftable for receiving various signals.

### Dynamic range

From Table 1, the analog receiver BDR is at least 142 dB for a receiver bandwidth of 500 Hz. Some applications use much smaller bandwidths. Coherent CW uses time-quantized transmitter keying and synchronous (hence the name coherent) receiver baseband sampling to communicate by Morse code at 12 words per minute using a noise bandwidth of 9 Hz [15]. The narrower bandwidth increases the SNR process gain by 18 dB, giving an analog receiver BDR of 160 dB. A good DDC must have an SFDR greater than the intended receiver BDR, as DDC spurious outputs appear after the process gain in SNR that comes with narrowband filtering in the DDC. Thus, a good DDC for HF radios must have an SFDR of 160 dB or better. The DDC is the best currently available, with an SFDR of 102 dB [6]. On-air listening tests of the receiver in reference [2] showed that this is insufficient: the DDC exhibits a center-of-passband spurious tone 102 dB down from the fullscale signal (note that this is within the DDC's specification limits), which interferes with weak-signal reception.

The spurious tone is caused by nonexact calculations in the DDC. Fortunately, when the DDC's decimation ratio is set to exactly a power of two, the offending tone is absent. With the tone absent, the DDC exhibits output SNR equal to that expected from the ADC's SNR and the bandwidth-reduction SNR process gain. The DDC is useable in an HF receiver because, when used carefully, it exhibits SNR greater than its SFDR.

Fortunately, the restriction on the decimation ratio permits the bandwidths needed for SSB and CW reception. An improved DDC with high SFDR, will permit wider choice of bandwidths, as the DDC's SFDR will be greater than the receiver's SNR at any bandwidth.

### Shiftable audio passband

Recall that the DDC down converts the incoming HF signal to a complex baseband lowpass signal, and then

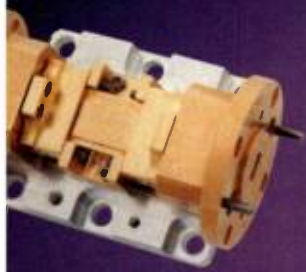


# MILLIMETER WAVE

# COMPONENTS

## AMPLIFIERS • MIXERS • MULTIPLIERS

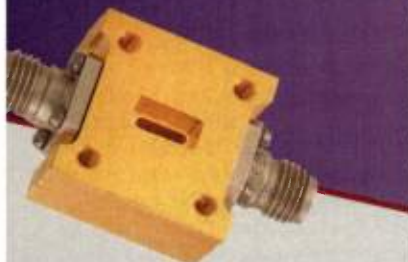
### AMPLIFIERS



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


\* Higher output power options available

### MIXER/CONVERTER PRODUCTS



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

### MULTIPLIERS



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

\* Higher output power options available

MITEQ also offers custom designs to meet your specific requirements.  
For further information, please contact David Krautheimer  
at (516) 439-9413 or e-mail [dkrautheimer@miteq.com](mailto:dkrautheimer@miteq.com)



100 Davids Drive • Hauppauge, NY 11788  
TEL.: (516) 436-7400 • FAX: (516) 436-7430  
[www.miteq.com](http://www.miteq.com)



Signal Type	Passband Width	Passband Center	Passband Range
CW	214 Hz	191 Hz	84–298 Hz
CW	427 Hz	382 Hz	168–595 Hz
CW	854 Hz	763 Hz	336–1,190 Hz
CW/SSB	1,709 Hz	1,526 Hz	671–2,380 Hz
NONE	3,418 Hz	3,052 Hz	1,343–4,761 Hz

Table 2. Audio passbands available from DDC at 50 MHz clock.

upconverts the baseband signal to a real bandpass audio signal. In the DDC, the ratio of the center frequency of the real passband to the bandwidth, is fixed. This ratio needs to be made variable, so the center frequency can be varied without changing the passband. Table 2 shows the audio passbands of the receiver in reference [2] for various bandwidths used for SSB voice and CW Morse reception. The 427 Hz and 214 Hz bandwidths should have their passbands moved higher in frequency, so the passband is entirely in the audible range, and so that the passband center is independent of filter bandwidth.

CW passband center frequencies should be adjustable, as different operators prefer to listen to different tone frequencies. Also, the CW center frequency should be independent of bandwidth, so the tone does not change as bandwidth changes. The 1,709 Hz bandwidth, passing frequencies from 671–2,380 Hz, when used for SSB voice reception, is narrower than usually desired. The passband includes barely enough low frequencies and high frequencies for intelligibility [2].

The next wider bandwidth useable with the DDC, is twice 1,709 Hz or 3,418 Hz. This bandwidth doubles the low-frequency band edge to 1,343 Hz. This is too high for voice intelligibility, rendering the wider bandwidth useless. If the passband could be lowered by 1,000 Hz, giving a 344–3,760 Hz passband providing excellent voice reception.

### Subjective performance

Because this receiver is intended primarily for aural reception, the subjective response of listeners is significant. Overall, the subjective performance is excellent. Receiver noise levels are below the noise level coming from the antenna. The audio exhibits negligible distortion. The

SSB passband, though audibly narrow, is clearly intelligible for both male and female voices. The filter edges are sharp, with no hint of ringing, giving clear response to the on-off keying of CW signals. Mallet [16] reports excellent tuning stability and filter response in listening to CW signals on a similar receiver.

### Conclusion

Digital HF receivers are now capable of excellent operation at low cost if the signal environment does not exceed the limited dynamic range and frequency range of the digital receiver. Expected improvements in ADCs and DDCs will soon permit the construction of digital HF receivers with better performance than that obtained in analog receivers. **RF**

### References

1. E. H. Armstrong, "A New System of Short Wave Amplification," *Proceedings of the IRE*, Vol. 9, No. 1, pp. 3-11, February 1921.
2. Peter T. Anderson, "A Simple Synchronous-AM Demodulator and Complete Schematics for the DDC-Based Receiver," *QEX*, pp 3-14, September 1997.
3. Peter T. Anderson, "A Faster and Better ADC for the DDC-Based Receiver," *QEX*, pp 30-32, September/October 1998.
4. D. K. Weaver, "A Third Method of Generation and Detection of Single-Sideband Signals," *Proceedings of the IRE*, Vol. 44, pp. 1703-1705, December 1956.
5. Analog Devices, "AD6640 12-bit, 65 MSPS Monolithic A/D Converter, Preliminary 5/17/97," Analog Devices, Norwood, MA.
6. Harris Semiconductor, "HSP50016 Digital Down Converter, June 1994," Harris Semiconductor, Melbourne, FL.
7. FT-1000MP transceiver, Yaesu USA, Cerritos, CA.
8. R. Lindquist and G. Swanson, "Product Review, Yaesu FT-1000MP MF/HF Transceiver," *QST*, Vol. 80, No. 4, pp. 68-73, April 1996.
9. R. W. Adams, P. F. Ferguson, Jr., A. Ganesan, S. Vincelette, A. Volpe, and R. Libert, "Theory and Practical Implementation of a Fifth-Order Sigma-Delta A/D Converter," *Journal of the Audio Engineering Society*, Vol. 39, No. 7/8, pp. 515-528,

July/August 1991.

10. Analog Devices, "AD1878/AD1879 High Performance 16-/18-Bit Sigma-Delta Stereo ADCs," Rev. 0, Analog Devices, Norwood, MA.

11. W. Gao, W. M. Snelgrove, T. Varelas, S. J. Kovacic, and D. L. Harame, "A 5-GHz SiGe HBT Return-to-Zero Comparator," *Proceedings of the 1995 Bipolar/BiCMOS Circuits and Technology Meeting*, pp. 166-169, 1995.

12. J. F. Jensen, G. Raghavan, A. E. Cosand, and R. H. Walden, "A 3.2-GHz Second-Order Delta-Sigma Modulator Implemented in InP HBT Technology," *IEEE Journal of Solid-State Circuits*, Vol. 30, No. 10, pp. 1119-1127, October 1995.

13. S. B. Cohn, "Dissipation Loss in Multiple-Coupled-Resonator Filters," *Proceedings of the IRE*, Vol. 47, No. 8, pp. 1342-1348, August 1959.

14. B. O. Williams, "ARRL Lab Experiments with the Cohn Filter," *QST*, Vol. 71, No. 7, pp. 26-27, July 1987.

15. Headquarters Staff of the American Radio Relay League, "The Radio Amateur's Handbook," *Fifty-Eighth Edition 1981*, The American Radio Relay League, Newington, CT.

16. J.-P. Mallet, "Introduction a la radio numerique, Seconde et derniere partie," *Radio-REF*, France, pp. 19-24, December 1996.

### About the author

Peter Traneus Anderson is a senior electronics engineer with Visualization Technology. He has been building HF receivers for 40 years and is working on his Ph.D. thesis (on improved loop antennas) in the department of Electrical and Computer Engineering, University of Vermont. He can be contacted at 978-933-1009 or by e-mail at [peteand@vitech.com](mailto:peteand@vitech.com).

# Daico Offers Wireless Solutions With a Switch

## Customized Performance Featuring

surface-mount control products with performance that exceeds MMIC technology, Daico offers customized solutions for your specific basestation designs. And with over 30 years of IF/RF and microwave experience, you can switch to Daico to do it right.

## Affordable Prices Imagine getting

customized high-performance products that fit your budget. For your Wireless applications, our surface-mount High Dynamic Range Power/VSWR Detector provides 27dB dynamic range with temperature stability of  $\pm 1$ db over its full operating temperature and goes for under \$50 in 1K quantities. Best of all, you can get this kind of price and performance from Daico's full line of wireless components.

## Production Quantities Daico now

delivers quality components in the quantities you need for all your basestation networks. From switches to detectors to subassemblies, we offer quantities of 1K, 10K, 50K or more. And with our fast development turnarounds, you can't lose.

Lower prices, higher volumes, customized performance. If the application is wireless, the solution is Daico.



We've Got Your Bases Covered™

1070 East 233rd Street Carson, CA 90745

Tel: 310-507-3242 Fax: 310-507-5701

Web: [www.daico.com](http://www.daico.com)

INFOCARD9

Switches / Attenuators / Phase Shifters / MMICS / Detectors / Couplers / Modulators / Amplifiers / Subassemblies



# Get the Data Now!!

Find out information on all the products, software and literature described in this issue. Circle the reader service number on the right and mail in the card today...



or go to **www.rfdesign.com** and choose from two options.

## Option 1: Home Page Links

Link directly to the home page of any of the companies listed below (where available).

## Option 2: Product Directory (advertisers only)

Link directly to the web page that relates to the data on the product advertised (where available).

### ADVERTISERS

COMPANY NAME	PAGE NO.	READER SVC. NO.	PRODUCT CAT.	COMPANY NAME	PAGE NO.	READER SVC. NO.	PRODUCT CAT.
Anritsu Company	59	35	Power Meter	Mini-Circuits	4,5,6,19, 30,31,41, 47,53,57, 75,95	83,84,27,28, 30,31,67,68, 10,15,62,63, 32,33,69,70, 65,66	Amplifiers Attenuators Couplers Mixers Oscillators Switches
Aries Electronics	54	111	Test Accessories	MITEQ	63	97	Mixers
AVX	23	40	Resonators	Monitor Products	76	78	Oscillators
California Eastern Labs/NEC	96	55	Transistors	MTI Milliren	26	103	Oscillators
Charles E. Gillman	78	99	Cable Assemblies	M-tron Industries	80	21	Oscillators
CTS Reeves	58	44	Oscillators	Murata Electronics	21	—	Resonators
Daico Industries	65	9	Detectors	National Semiconductor	3	2	Freq. Synth/PLLs
Eagle	14	47	Filters	Nemal Electronics	86	29	Connectors
Eagleware	15,17	86,87	Software	Noble Publishing	79	16	Training
Electro Dynamics				Noise/Com	2	1	Test Systems
Crystal (EDC)	16	76	Crystals	Rakon	82,83	20	Crystals
Frequency Management	44	109	Crystals	Raltron	77	74	Oscillators
Fujitsu Microelectronics	11	25	Freq. Synth/PLLs	RF Micro Devices	45	58	RFICs
Hewlett-Packard				Richardson Electronics	29	4	Distributor
Microwave Instruments	34a,35	3	Frequency Counter	Shorecliff Communications	34	52	RF Conference
	55	23	Spectrum Analyzer	Siward International	38	102	Oscillators
	73	43	EMC Test System	Stanford Telecom	25	7	ASICs
Hitachi Metals America	26	60	Transformers	SunriseTek	78	95	Oscillators
Hittite Microwave	49	14	Mixers	Surcom Associates	54	73	Capacitors
Huber + Suhner	13	53	Coaxial Cable	Temex Electronics	62,81	12,72	Oscillators
IFR	61	45	Signal Generator	Tetra Electronic	20	71	Oscillators
International Crystal				Trompeter Electronics	42	107	Connectors
Manufacturing (ICM)	86	34	Crystals	TrueTime	76	81	Clocks
JCA Technology	8	19	Amplifiers	T-Tech	44	59	Circuit Prototyping
JFW Industries	14	105	Attenuators	Vectron International	33	61	Oscillators
Johanson Technology	72	56	Inductors	Voltronics	39	96	Capacitors
Kalmus	9	6	Amplifiers	Voltronics International	50a	—	Capacitors
LGP	12	18	Filters	Z-Communications	37	41	Oscillators
Marlo Electronics	60	13	PC Boards				
Matrix Systems	86	54,57	Relays				
Maxim Integrated Products	27,43	48,49	Mixers,Switches				

### EDITORIAL

COMPANY NAME	PAGE NO.	READER SVC. NO.	COMPANY NAME	PAGE NO.	READER SVC. NO.	COMPANY NAME	PAGE NO.	READER SVC. NO.
Amplifier Research	80	160	Goodfellow	85	133	Nova Microwave	81	170
Anadigics	78	158	Hittite Microwave	85	125	Philips Semiconductors	82	172
Anaren Microwave	83	175	Huber + Suhner	74	154	Photofabrication Engineering	72	147
Anritsu Company	84	121	IFR Systems	86	127	Protek Devices	71	140
APM	71	143	Instrument Specialties	72	144	Rakon	74	151
Applied Computational Sciences	84	118	Interconnect Devices	85	135	Raltron	74	150
Aries Electronics	76	156	Ivex Design International	84	120	Raychem	71	139
Avnet RF	72	145	JCA Technology	80	162	Renaissance Electronics	85	122
AVX	85	138	JFW Industries	81	168	RF Micro Devices	80	161
Berkeley Varitronics Systems	81	167	K&L Microwave	82	174	Schaffner	72	146
California Eastern Laboratories	78	157	K&L	85	124	Signal Processing Technologies	86	129
Centurion International	80	164	Kota Microcircuits	78	159	Snaketech	84	115
Champion Technologies	83	179	Lambda Electronics	80	163	Tanner EDA	84	117
Chomerics	71	142	Maury Microwave	84	119	Times Microwave Systems	83	176
C-MAC Frequency Products	85	123	Microchip Technology	81	165	Trompeter Electronics	85	137
Connor-Winfield	83	178	Micro-Coax	86	132	Tru-Connector	83	177
Connor-Winfield	86	131	Microwave Filter	74	153	Ute Microwave	82	173
Ecliptek	86	128	Mini-Circuits	82	171	Venkel	86	130
Eltest	84	116	MITEQ	74	152	Venture Tape	85	126
EMC Test Systems (ETS)	72	149	MMC	85	134	Wireless Technologies	81	169
EMP Connectors	72	148	Morrow Technologies	76	155	Young Design	81	166
Fischer Custom Comm.	71	141	National Instruments	85	136			



## EMC/RFI products

*Each month, the product focus highlights a specific area of RF products and provides selected product information. This month, the product focus highlights EMC/RFI products.*

### Gel rope gaskets simplify equipment designs

The dBseal electromagnetic interference (EMI) gel rope gaskets use wire mesh impregnated with cured silicone gel to simultaneously provide EMI shielding, electrical grounding and environmental sealing in electronic and telecommunications equipment. The multifunctional gaskets provide an alternative to using two-piece rubber and metal mesh gaskets or one-piece metal-filled conductive elastomers for sealing and shielding designs. The gel rope gaskets fit into a wide variety of designs. The gaskets are suited for use in electronic equipment, including telecommunication amplifiers, line extenders and taps, cellular phone base stations, cable television boxes, global positioning system (GPS) electronics and other products exposed to moist environments and the threat of EMI.

**Raychem**  
INFO/CARD 139

### EMC protector reduces effects of radiation

The EMCxxF-LC series is a combination lowpass inductor-capacitor (LC) filter and transient voltage protector. The device provides electromagnetic compatibility (EMC) network interface protection by reducing the harmful effects of electromagnetic/radio frequency interference (EMI/RFI) as well as providing complete transient immunity. The device incorporates four low-capacitance diode clamp and EMI/RFI filter networks into a standard SO-16 surface-mount package. Although the device is designed for 500 MHz circuit applications, filter elements are changeable for -3 dB roll-off from 50-1,000 MHz. The roll-off is also adjustable by changing from a Bessel to a Butterworth type filter. Specific circuit applications can be matched by interchanging LC elements with resistive-capacitive (RC) elements. The low-capacitance series offers as many as

four lines of protection and is available in voltages ranging from 3.3-15 V. The device is designed for 50  $\Omega$  interface circuit terminations. Suitable for the reduction of noise reflections and ringing associated with high-speed data line circuits, the device is used at board level in wireless communications, graphics, video cards and notebook computers.

**Protek Devices**  
INFO/CARD 140

### Test system develops current waveform

The IEC 1000-4-10 magnetic field damped sine immunity test system develops the damped sinusoid current waveform in the uniform area of the loop. The system can generate as much as 100 A/m peak in a one-meter loop for the 100 kHz or 1 MHz waveforms. The output waveform can be monitored with a broadband magnetic field sensor or a current probe. The generator output level, and either a single pulse or the specified burst of pulses, can be selected manually from the front panel or from a PC using control software. The system includes a digital oscilloscope to capture the waveform.

**Fischer Custom Communications**  
INFO/CARD 141

### Plastic covers shield selected portions

The Cho-ver Shield electromagnetic interference (EMI) shielding covers are designed for cellular handsets, personal communications service (PCS) and other small packages. The covers combine a slim-profile, metallized plastic with a low-closure force conductive elastomer gasket. They can be used to shield selected portions of a printed circuit boards (PCBs), eliminating the need to shield a device's outer housing. Custom-shaped covers replace the use of solder-mounted metal cans over board components. They are easily removed for PCB access during assembly or after testing. The covers provide 100 dB of shielding effectiveness at 500 MHz. Pins, holes and other locating features can be designed in for fast, precise installation. The covers feature plastic with nickel/copper plating on

interior surfaces. The plastic can be compartmentalized to provide shielding against component cross-talk. The integral EMI gaskets are made from over-molded Cho-seal 1310 silver-plated, glass-filled conductive elastomer.

**Chomerics**  
INFO/CARD 142

### EMI shielding products offer lightweight designs

A full range of electromagnetic interference (EMI) shielding products are designed to make EMI shielding easier. The products feature thin, lightweight, resilient designs that can conform to a variety of mating surfaces and are simple to install. They meet such diverse applications as leak reduction in computer and telecommunication shielded enclosures; grounding around I/O ports; notebook and portable equipment shielding and distributed grounding for high-frequency RF devices.

**APM**  
INFO/CARD 143

### EMI gasketing offers more packaging space

The Electroform series 8558 compounds are single-component silicone-based compounds that provide more packaging space for board-level components and smaller package dimensions. The compounds reduce raw material, labor and assembly requirements for substrates, enclosure panels and shielding and grounding metal and plastic housings. Filled with proprietary conductive particles, they provide shielding effectiveness of greater than 120 dB at 1 GHz. Because they do not have to be mixed, the compounds shorten production cycles and reduce waste. The compounds cure quickly at normal room temperature and humidity, eliminating the need for heat curing systems and permitting the use of inexpensive plastic or metal substrates. They provide adhesion to a variety of materials, including aluminum and other cast alloys, stainless steel, nickel-copper plating over plastics, and copper-, silver- and nickel-filled paint on plastics. Their low compression force accommodates mating surfaces that lack mechanical stiffness.



Programmable location and dispensing equipment applies the compounds onto intricate multicompart ment parts with accuracy and consistency, providing a secure bond to the substrate.  
**Instrument Specialties**  
**INFO/CARD 144**

## Absorptive microwave attenuator

The EMC Thermopad is an absorptive microwave attenuator—a revolutionary approach to amplifier temperature compensation. The thermopad replaces elaborate active multicomponent schemes with a single, passive component. It offers high reliability, produces no distortion and takes up less circuit board space. The EMC Technology Thermopad Evaluation kit includes samples of both planar chips plus triple wrapped terminations chips. Each kit also includes the new Thermopad Selection Software Tool, which can be used to select the Thermopad that optimizes amplified

gain over temperature.

**Avnet RF**  
**INFO/CARD 145**

## IEC inlet filter similar to chassis-mount units

The FN9246 IEC inlet filter combines a small form factor with high attenuation characteristics. The noise suppression performance is more typical of a chassis-mount unit. Designed primarily for applications involving fast-switching semiconductors, the filter is a suitable electromagnetic interference (EMI) suppression product for use when space is at a premium. Typical applications include switch-mode power supplies and small- and medium-sized uninterruptible power supplies. The filters are available with a choice of eight current ratings, spanning 1–20 A. The 16 A and 20 A versions measure 35 × 75 mm, and the lower current models are smaller at 30 × 47 mm. The filters have high inductance and X capacitor values to ensure high attenuation of differential and

common-mode noise. As a typical example, the 3 A model provides some 40 dB asymmetric attenuation at 100 kHz, rising to 50 dB from 200 kHz to 30 MHz.

**Schaffner**  
**INFO/CARD 146**

## RF/EMI shielding line protects components

A line of photochemically etched radio frequency/electromagnetic interference (RF/EMI) shielding and filter screen is designed to protect components from RF/EMI and environmental hazards and to provide electrical grounding. RF/EMI shields are hand formed and can be custom-designed to meet stringent customer requirements. Custom bend lines, logos, soldered or welded corners and RF cans with removable top covers are also offered.

**Photofabrication Engineering**  
**INFO/CARD 147**

## Filtered terminal blocks

The EMPac series of filtered terminal blocks are engineered to accommodate customer-specific requirements such as high power handling, enhanced filtering and custom mechanical configurations. EMPac's mechanical design eliminates capacitor failures from over-torquing screws, provides capacitance as high as 10,000 pF, and can incorporate integrated transient suppression. EMPac filtered terminal blocks are available with any number of terminals and standard or custom dimensions.

**EMP Connectors**  
**INFO/CARD 148**

## Low-profile turntables

Model 2088 EuroPro turntable family is designed for today's electromagnetic compatibility (EMC) test applications where height is a concern and installation options may be limited. All three low profile turntables in this series are metal topped, have variable speed operation and feature a ground plane interface system to simplify installation.

**EMC Test Systems (ETS)**  
**INFO/CARD 149**



# RF INDUCTORS

### KEY FEATURES

- Small sizes to 0402
- High Q / Low ESR
- SRF's to 6.0 GHz
- Low cost

### APPLICATIONS

- Mobile Communications
- Wireless LAN & Modems
- GPS Receivers
- CATV / SAT TV

Visit our website today for detailed technical information.

**JOHANSON**  
**TECHNOLOGY**

Camarillo, California  
 TEL 805-389-1166  
[www.johanson-caps.com](http://www.johanson-caps.com)





# OPERATING HP'S EMC ANALYZER REQUIRES VERY LITTLE EXPERTISE.



HP E7400 A-series  
EMC analyzer

## Easy to use, right out of the box.

As a design engineer, you solve a lot of complex problems. Your test equipment shouldn't be one of them. So we made the E7400A EMC analyzer so easy to use, you can be up and testing 30 minutes out of the box. And in record time, you'll be implementing EMC testing throughout your design and evaluation processes, dramatically reducing your time-to-market.

## No training, no programming, no problem.

With HP's EMC precompliance solution, you get all the features that make in-house EMC precompliance testing a simple reality:

- Preprogrammed, automated measurements that require no special knowledge or training, so you can begin making EMC measurements as soon as your EMC analyzer arrives.
- Interactive software that allows you to perform tests from your PC, or capture measurements made directly from the front panel.
- Automatic remeasure functions for consistent, repeatable results.

For complete information on our easy-to-use EMC test solutions, call 1-800-452-4844,\* Ext. 6452, and order a free copy of our *Cookbook for EMC Precompliance*. Or visit our Web site:

[www.hp.com/go/emc](http://www.hp.com/go/emc)

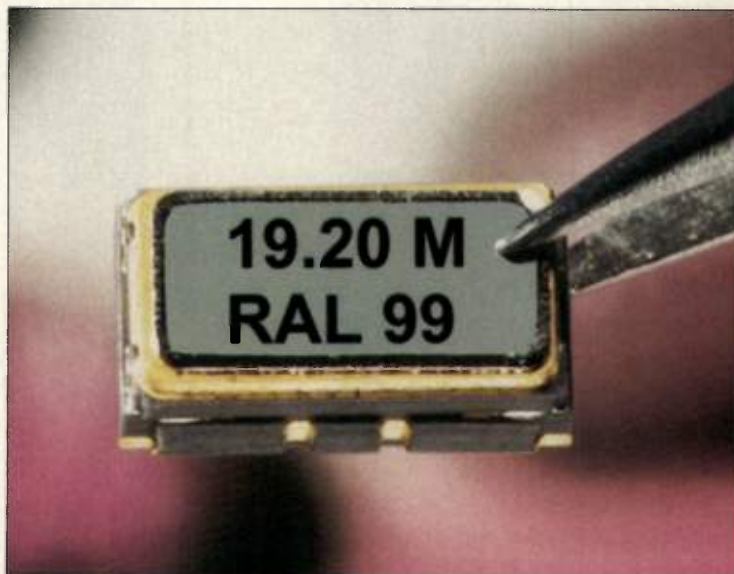


# RF products

## Surface-mount TCXO uses custom IC to slash size, cost

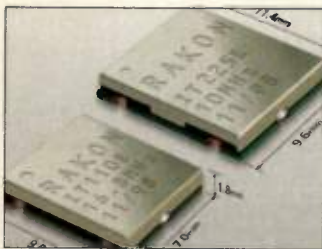
The RTVY-174 temperature compensated-crystal oscillator (TCXO) incorporates a custom integrated circuit (IC) chip to reduce size and improve efficiency. Designed for use in pagers, cell phones, two-way radios and other wireless systems worldwide, the RTVY-174 has a footprint of 6 x 3.5 mm. The device offers  $\pm 2.5$  ppm stability over the  $-30^{\circ}\text{C}$  to  $80^{\circ}\text{C}$  temperature range as a standard feature. Other features include an output voltage of 0.9V p-p minimum clipped sinewave, current drain of 2 mA maximum and is powered by a single 3.0 V supply. The unit is available in standard frequencies from 12.6–19.8 MHz. Stability variation with aging is better than  $\pm 1$  ppm per year. The RTVY-174 is priced at less than \$5.95 each in quantities of 10,000.

**Raltron**  
INFO/CARD 150



## Crystal oscillators

A range of crystal oscillators features an analog integrated circuit (IC) for oscillator and temperature compensation. The IT100 and IT200 series are capable of achieving a frequency stability of  $\pm 1$  ppm over a temperature range of  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . Other features include a phase noise of  $-105\text{dBc/Hz}$

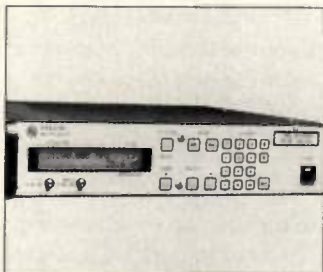


at a 100 Hz offset, a regulated power supply that allows the unit to operate anywhere from 2.7–5.5 V, a typical energy consumption of 1.2 mA and a unit weight of 0.172 g for the IT100 series. Frequency slope and perturbation specifications can be customized to suit application requirements.

**Rakon**  
INFO/CARD 151

## Synthesized converters

This series of Ka-band converters offers upconverters in the 27.5–31.0 GHz frequency bands and down-



converters in the 17.7–21.2 GHz bands, not only for existing Ka band satellites, but also for satellites currently being planned. Frequency tuning is in 125 kHz minimum step size. Both frequency and level control is available via the front panel keypad or by the remote interface. Phase noise is data quality.

**MITEQ**  
INFO/CARD 152

## VHF TV channel bandpass filter

Model 11990N bandpass filter isolates a VHF channel while maintaining a low loss of 0.5 dB maximum at the final output of the transmitter. It can be custom tuned to any VHF high-band frequency and is available for different channel formats. Features include a video-audio separation of 6.5 MHz, a passband loss of 0.5 dB maximum and voltage standing wave ratio (VSWR) of 1.3:1 maximum. Rejection is  $20\text{ dB} \pm 12.5\text{ MHz}$  from the



center frequency. The unit handles 500 W of power and measures approximately  $18.25'' \times 16.30'' \times 5.0''$ .

**Microwave Filter**  
INFO/CARD 153

## Environmental coaxial cable

The Enviroflex family of fluorine-free coaxial cables enables users to switch from cables containing fluorine to



halogen-free alternatives for RG 316D, 142, 400 and 393. Compatible with all standard connector types, they possess equivalent mechanical and electrical performance to fluorine-containing counterparts. An extended temperature range and increased flexibility allow them to be used in broader applications over conventional PE cables. It is less expensive than teflon cable and does not require special disposal.

**Huber + Suhner**  
INFO/CARD 154



# NEW PRODUCTS

## RF/IF MICROWAVE COMPONENTS

NO.58



FROM  
\$36.95

### 2W PRECISION ATTENUATORS FOR DC TO 18GHz BAND

New BW-S30W2 fixed attenuators from Mini-Circuits provide precision 30dB nominal attenuation with  $\pm 0.85$ dB accuracy (add 0.5dB typ above 12.4GHz) over the wide DC to 18GHz frequency band. These low cost 50 ohm units are built tough to handle 2W average with 125W peak power and exhibit high temperature stability, outstanding phase linearity, and excellent VSWR. They're miniature in size measuring only .99" long and .312" across hex flats, and are ideal for impedance matching and test set-up. Maximum operating temperature range is -55°C to +100°C.



### FEATURED PRODUCT

FROM  
\$8.95

### it<sup>TM</sup> 2WAY SPLITTER/COMBINER FOR 0.5 TO 400MHz BAND

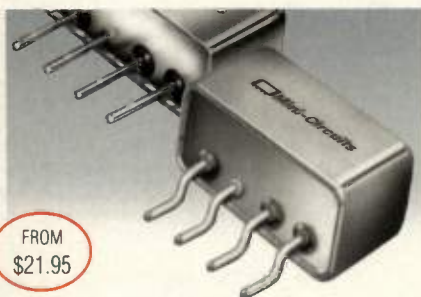
Mini-Circuits introduced the ADP-2-1, a 2way-0° power splitter/combiner for the 0.5MHz to 400MHz band. Uniquely engineered in a 0.155" low profile water washable package, this device exhibits low 0.3dB insertion loss (above 3.0dB), excellent 0.10dB amplitude unbalance and very good 0.5 degree phase unbalance (all typ). Ideal for 50 ohm instrumentation use. Patent pending.



FROM  
\$149.95

### 5 TO 450MHz HIGH IP2 AND IP3 AMPLIFIERS

Engineers working in the high traffic 5 to 450MHz band can choose Mini-Circuits new ZHL-450-75 connectorized amplifiers typically providing high 48dBm IP3 and 88dBm IP2 to help suppress noisy intermodulation products. These broad band 75 ohm amplifiers also display very low 3.5dB (typ) noise figure and 11.4dB typical gain ( $\pm 0.7$ dB max. flat) for CATV and instrumentation applications. Equipped with BNC-Female connectors and available off-the-shelf.



FROM  
\$21.95

### 100 TO 1800MHz MIXERS IN PLUG-IN AND SM VERSIONS

Mini-Circuits new plug-in TUF-18DH and TUF-18DHSM, its surface mount counterpart, are level 17 (LO power) microwave mixers intended for PCS, PCN, cellular, and airphone applications in the broad 100 to 1800MHz band. Typically, both feature low 7.3dB conversion loss, excellent 41dB L-R isolation, and 27dBm IP3 at center band. These mixers are built tough to operate within a maximum -55°C to +100°C temperature range and come with a 5 year Ultra-Rel<sup>®</sup> guarantee.

### 180° VOLTAGE VARIABLE PHASE SHIFTER FOR 100 TO 150MHz

The JSPHS-150 from Mini-Circuits is a 180° (min.) voltage variable phase shifter used in aircraft communications and delay for feed-forward amplifiers covering the 100 to 150MHz VHF band. Important characteristics of this surface mount unit include 0 to 12V control voltage with a control bandwidth range from DC to 30kHz typical and low 1.2dB (typ) insertion loss. VSWR is good at 1.2:1 typical. Solder plated J leads provide superior mechanical integrity over temperature.



J-LEAD

FROM  
\$31.95



it<sup>TM</sup>

FROM  
\$6.95

### LOW PROFILE 75 OHM DIRECTIONAL COUPLERS FOR CATV

Mini-Circuits announces off-the-shelf availability of their new 5MHz to 1000MHz ADC-16-4-75 directional couplers. These wide band 1W (max.) units free engineers from the expensive task of compensating by providing a nominal 16.2dB $\pm 0.5$ dB coupling value and excellent  $\pm 0.1$ dB (typ) flatness for CATV applications. Water washable and only 0.108" tall, these 75 ohm couplers typically exhibit low 0.7dB insertion loss and high 30dB midband directivity. Patent pending.

# Mini-Circuits<sup>®</sup>

US 36 INT'L 37  
CIRCLE READER SERVICE CARD

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 INTERNET <http://www.minicircuits.com>

For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE • EEM • MICROWAVE PRODUCT DATA DIRECTORY • [WWW.RFGLOBALNET.COM](http://WWW.RFGLOBALNET.COM)

ISO 9001 CERTIFIED

F 301 Rev Org

WRH



## TEST EQUIPMENT

### Spectrum analyzer for wireless testing

The V9054 programmable spectrum analyzer is designed for use in VXI cellular production test systems. The 0.5 ppm frequency accuracy is accomplished by digital tuning that locks the synthesizer to the reference oscillator at each point in a sweep. Independent point markers simultaneously provide the absolute amplitude and frequency value of two points. A constant display of the delta values of these two points provides the user with an easy method of measuring power amplifier intermodulation distortion (IMD) and other in-band and out-of-band characteristics of miscellaneous cellular RF components and assemblies. The synthesizer's step time of less than 120  $\mu$ s results in a fast measurement speed that has a direct effect on pro-

duction throughput. The 1.6 GHz analyzer has an amplitude range of -120 dBm to +20 dBm with an absolute level accuracy of  $\pm 0.5$  dB. The unit also offers a complete overlay drawing capability so that the user can set up limits for any of the cellular protocol spectral standards such as code-division, multiple access (CDMA), time-division, multiple access (TDMA) or global system for mobile communications (GSM).

**Morrow Technologies**  
INFO/CARD 155

### Sockets feature extended temperature range

The elevator Vertisockets for elevating displays and switch devices are available with bifurcated or collet contacts. The bifurcated elevator sockets are available in pin counts of 14-16 pins on 0.3" centers, and with 18 pins on 0.6" centers. The bifurcated contact material is Grade A spring-tempered phosphor bronze per QQ-B-750 and is

offered in either 90/10 tin/lead (200m) or gold (10m) plating over nickel (50m). The body material is UL-94V-0 glass-filled 4/6 nylon. The collet elevator Vertisockets are available in pin counts of 6-10 pins on 0.2" centers, 6-40 pins on 0.3" centers and 6-48 pins on 0.6" centers. The collet contact material is beryllium copper alloy per UNS C17200 and is offered in gold (30m) over nickel (50m) plating. The body is UL 94V-0 glass-filled 4/6 nylon.

**Aries Electronics**  
INFO/CARD 156

## SEMICONDUCTORS

### Silicon IQ demodulator IC supports digital receivers

The UPC3205GR silicon radio frequency integrated circuit (RFIC) in-phase and quadrature (IQ) demodulator from NEC is designed for digital communications systems. It features an on-chip quadrature (90°) phase shifter



**Telecommunications Synchronization**

Ultra-precise frequency outputs start with ultra-precise GPS disciplined clocks—from TrueTime. Anything else just isn't.

**TrueTime**  
707-528-1230  
fax 707-527-6640  
e-mail [truetime@truetime.com](mailto:truetime@truetime.com)  
[www.truetime.com](http://www.truetime.com)

INFO/CARD 81



**Monitor Products' SO-1300**  
TIGHT STABILITY OCXO

Monitor Products' new SO-1300 OCXO combines high stability with a small package, providing the frequency tolerances normally associated with larger OCXOs. With long term stabilities as low as  $\pm 0.075$  ppm per year (SC option), and frequency output ranges from 5.0 MHz to 66.66 MHz, the SO-1300 is designed for use in base stations, frequency counters, and switching applications.

- Small package size
- Low phase noise (-110 dBc @ 10 Hz)
- High stability
  - SC and AT crystal options
- Extremely low aging rate
- Square wave HCMOS output
- Surface mountable option
- Mechanical trim option
- Electronic frequency control standard
- Low power consumption (5W max)

Monitor Products has a proven 70-year track record as a manufacturer in the frequency control market. If our extensive selection of standard and engineered crystals and oscillators does not meet your spec, we will work with you towards a customized solution.

**MONITOR PRODUCTS**  
PC COMPANY INC  
A BOWTHORPE company

**CORP OFFICE / FACTORY**  
502 Via del Monte  
Oceanside, CA 92054  
Tel : 760 433-4510  
Fax : 760 434-0255

**REGIONAL SALES OFFICE**  
3415 Custer Rd, Ste 117  
Plano, TX 75023  
Tel : 972 758-8687  
Fax : 972 758-7574  
[www.monitor-products.com](http://www.monitor-products.com)

Designers and manufacturers of quality frequency control devices since 1927

INFO/CARD 78



# Only Raltron has it all...



## CLOCKS

Frequency Range to 160 MHz  
Tolerance and Stability to  $\pm 10$  PPM  
Temperature Range  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$   
+3.3 Volt Option (HCMOS)  
Enable / Disable Option  
Through Hole and SMD Configurations

## TCXO'S

Frequency Range to 160 MHz and Higher  
Stability to  $\pm 0.3$  PPM  
Wide Temperature Range  
Low Phase Noise  
Through Hole and SMD Configurations

# **RALTRON**

10651 NW 19<sup>th</sup> Avenue  
Miami, Florida 33172 U.S.A  
Tel: 305-593-6033  
Fax: 305-594-3973  
e-mail: [sales@raltron.com](mailto:sales@raltron.com)  
Internet: <http://www.raltron.com>

## VCXO'S

Frequency Range to 2.48 GHz  
Tolerance and Stability to  $\pm 10$  PPM  
Temperature Range  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$   
+3.3 Volt Option (HCMOS)  
Enable / Disable Option  
Through Hole and SMD Configurations

## OCXO'S

Frequency Range to 100 MHz  
Frequency Stability to  $\pm 1.0$  PPB  
Temperature Range  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$   
Excellent Short and Long Term Stability  
Enable / Disable Option  
Through Hole and Surface Mount

**A Worldwide Manufacturer of:**

- ✓ Microprocessor Crystals
- ✓ Oscillators
- ✓ Crystal Filters
- ✓ Ceramic Resonator
- ✓ Saw Devices
- ✓ VCO Products



and can achieve  $\pm 2^\circ$  phase balance at an input frequency of 479.5 MHz. Suitable for high-density surface-mount designs, the demodulator also integrates an automatic gain control (AGC) amplifier, double balanced mixers, oscillator, plus I and Q output buffer amps—all in a miniature 20-pin SSOP package. Performance features include an RF input bandwidth of 440–520 MHz and an IF output bandwidth of 0.3–30 MHz. The IM3 distortion is a typical 56 dBc and the supply voltage is 5 V.

**California Eastern Laboratories**  
INFO/CARD 157

### Receiver offers low-power consumption

The AWR8004 is an 800–1,000 MHz receiver for use in cellular telephones, cordless telephones and wireless local area networks (WLANs). Designed for 3 V operation, the gallium arsenide (GaAs) receiver features low-power consumption, a small foot-

print and is integrated, allowing wireless systems manufacturers to lower component counts. The receiver features typical conversion gain of 17 dB. This wireless receiver is able to detect low-power signals because it is sensitive, featuring a maximum noise figure of 3.5 dB.

**Anadigics**  
INFO/CARD 158

## AMPLIFIERS

### Amplifiers drive large output swings

The KH560 and KH561 wideband hybrid driver amplifiers are designed specifically for output/drive amplifier applications. The amplifiers drive large output swings and capacitive loads. They provide low distortion at high drive levels and high frequencies and maintain high bandwidths at large gain settings. They offer user-definable output impedances (50  $\Omega$ ,

125  $\Omega$ ) and provide short-circuit protection. The amplifiers offer customizable frequency response characteristics. The amplifiers are protected against shorts to ground and can be configured to withstand shorts to the supplies with the addition of one external resistor. Their outputs are internally limited to 250 mA, so driving high capacitive loads is simple. Their output impedance is set using a two-resistor external feedback network, so no backmatching resistor is needed. Both amplifiers are constructed using in-house thin-film resistor/bipolar transistor technology.  
**Kota Microcircuits**  
INFO/CARD 159

### High-power amplifier for large object testing

The 2000W1000A amplifier offers 2,000 W CW from 80–1,000 MHz. It is designed for applications requiring the high power and broad bandwidth needed to generate fields at a distance. Pop-

## CABLE ASSEMBLIES FOR MICROWAVE & ELECTRONICS INDUSTRIES



- RF/microwave and phase matched assemblies.
- DC wiring & cable assemblies.
- Cost effective solutions from prototype to production.
- Military & commercial.
- Serving industry since 1955.

Call us with your inquiries  
**520.281.1141**



**CHARLES E. GILLMAN CO.**

907 E. FRONTAGE RD., RIO RICO, AZ 85648  
FAX (520) 281-1372  
[WWW.GILLMAN.COM](http://WWW.GILLMAN.COM)

INFO/CARD 99

## Custom Crystal Oscillators Custom Thick Film Hybrids

Committed to manufacturing high quality, technologically advanced TCXOs, VCXOs, high frequency clock oscillators, and thick film hybrids for a whole new world of products. Call us today or visit our website to request a quote or brochure.

**SunriseTek**

1308 Adams Street  
Kansas City, KS 66103  
(913) 371-7755  
Fax: (913) 371-2994  
[www.sunrisetek.com](http://www.sunrisetek.com)

INFO/CARD 95



# The **POWER** of **INFORMATION**

## VIDEO COURSES

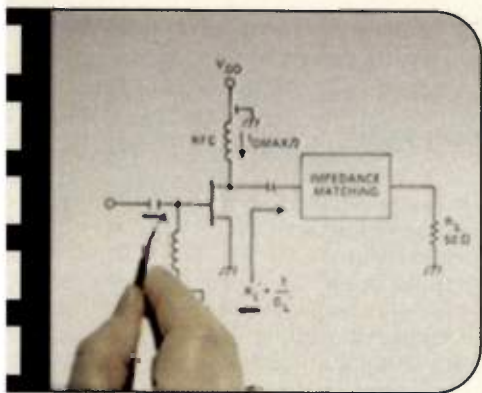


### RF Circuit Fundamentals

*Instructor: Les Besser*

This is the first part of the best one-two punch in basic RF circuit design instruction. It's an ideal introduction to high-frequency analog design for new engineers, or for engineers from digital or low-frequency specialties. Topics covered include — RF Concepts, Lumped-Element Component Methods • Resonant Circuit and Filters • Transmission Line Fundamentals • The Smith Chart and its Applications • Small-Signal Amplifier Design with S-Parameters. The course includes six one-hour tapes, class notes, and the book *RF Circuit Design* by Chris Bowick. This class offers thorough coverage of all the essential basic concepts specific to RF engineering.

**NP-16. . . . . \$595.00**



### RF/Microwave Transistor Amplifier Design

*Instructor: Les Besser*

Amplifier matching, stability and noise techniques are a cornerstone of RF and microwave engineering. This course is an outstanding way to learn classical amplifier techniques — Review of Circuit Fundamentals • Introduction to CAD • Amplifier Design Methods and Comparisons • Impedance Matching • Lossless Transformations • Applying Negative Feedback. Amplifier design is covered completely, including CAD and Smith Chart methods, gain and stability analysis, low noise techniques and layout. Real-life examples are used throughout the course. Six two-hour tapes (12 hours total) and the book *Microwave Transistor Amplifiers* by G. Gonzales.

**NP-14. . . . . \$1195.00**

### Discounts

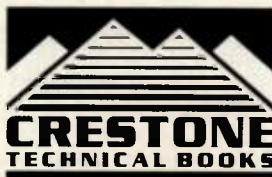
- For any **TWO** video courses, take **5% off**
- For any **FOUR** video courses, take **10% off**
- For any **SIX** video courses, take **15% off**
- For any **EIGHT** video courses, take **25% off**
- Save \$1441 - Get the complete set of EIGHT for just \$4323

**www.noblepub.com**

### Crestone Technical Books

A Division of Noble Publishing Corporation

4772 Stone Drive  
Tucker, GA 30084  
Tel: 770-908-2320  
Fax: 770-939-0157



Order today by phone, fax or on the web, using your VISA, Mastercard or American Express.

### RF Circuit Fundamentals II

*Instructor: Les Besser*

Instruction continues from the above course, adding the topics — Microstrip Transmission Lines • Power Combiners and Dividers • Broadband Matching Networks • PIN Diode Circuits • Broadband Amplifiers • Large-Signal Amplifiers. The course includes six one-hour tapes, notes, and the book *Transmission Line Transformers* by Jerry Sevick.

**NP-17. . . . . \$595.00**

### Filter and Matching Networks

*Instructor: Randall W. Rhea*

Complete, well-presented information on practical filters and matching networks that you will actually build, not just theory and equations with no application. Topics — Fundamentals • CAE Techniques • Real-World Effects • Matching • Bandpass Filter Symmetry • Group Delay • Direct-Coupled Microwave Filters • Field-Coupled Microwave Filters. Nine one-hour tapes and complete notes.

**NP-12. . . . . \$895.00**

### Microwave Filters, Couplers and Matching Networks

*Instructor: Robert Wenzel*

Detailed instruction on distributed structures — Filter Responses and Basic Calculations • Realization of Practical Filters • Filter Design • Directional Couplers • Distributed Element Matching Networks. Six two-hour tapes plus complete class notes.

**NP-15. . . . . \$1195.00**

### Oscillator Design Principles

*Instructor: Randall W. Rhea*

No other course gives you as much insight into oscillator design. All common resonator types are discussed — LC, coaxial, microstrip, crystal, SAW; and many active devices — bipolar, FET, MMIC amplifier. Noise performance, oscillator starting, VCOs and more. Six-hours with extensive notes.

**NP-13. . . . . \$595.00**

### Microwave Transmission Lines and Their Physical Realization

*Instructor: Steven L. March*

Six hours of transmission line education on striplines, microstrip, coupled lines, suspended substrates, coplanar waveguide, and more.

**NP-18. . . . . \$595.00**

### Introduction to the Smith Chart

*Instructor: Glenn Parker*

Learn the Smith Chart in 50 minutes. This tape shows you how to navigate around the chart, use various lumped and transmission line elements. A great teaching tool for new engineers.

**NP-19. . . . . \$99.00**



ular applications include the radiation of large objects and whole vehicles.

**Amplifier Research**  
INFO/CARD 160

### Amplifier offers 21 dBm output power

The JCA218-407 2–18 GHz amplifiers can provide +21 dBm output power while accommodating wideband needs. Gain is 30 dB minimum, with a noise figure of 5.0 maximum. The current is 500 mA nominal. The amplifiers incorporate reliability and performance. All units are tested and guaranteed.

**JCA Technology**  
INFO/CARD 162

### Amplifiers feature GaAs technology

The RF2333, RF2334, RF2335, RF2336, RF2337 and RF2338 amplifiers are general-purpose broadband amplifiers that combine low cost, small size and gallium arsenide heterojunction bipolar transistor (GaAs HBT) process technology for use in intermediate frequency (IF) and RF wireless voice and data communications. Typical applications for the amplifiers include use as broadband, low-noise gain blocks, as IF or RF buffer amplifiers, as a driver stage for power amplifiers

and as the final power amplifier (PA) for low-power products. The RF2333, for example, is designed as an easily cascaded 50  $\Omega$  gain block with an operating range of DC to 6,000 MHz. The component is offered in a small industry-standard SOT-23 five-lead surface-mount package.

**RF Micro Devices**  
INFO/CARD 161

## SUBSYSTEMS

### Desktop power supply for portable equipment

The DT series of lightweight, low-profile external power supplies includes a large range of adapter-style power supplies, offering three-wire or Class II (with two-pin wall plug) double insulated inputs and is available with a variety of output cables and connectors, making it suitable for powering most lightweight, portable equipment. Available in 10 package sizes starting from 1" in height, the power supplies offer output voltages from 5–24 V, including dual and triple outputs. All models are protected against accidental short circuit, and most are in compliance with EN61000-4 specifications for lightning, surge and electrical static discharge (ESD) protection.

**Lambda Electronics**  
INFO/CARD 163

### Portable antenna shorter than standard

The SX antenna can be as much as 20% shorter at the same frequency as industry-standard injection molded antennas. The industry-standard antennas with a frequency bandwidth of 150–161 MHz measures 6.5" long. The SXB 155 MX, in the same bandwidth, is an inch shorter at 5.5". The antenna features capless sheath construction, which enhances ruggedness while retaining flexibility. The patented sheath design also features a dimple at the tip of the antenna, a sleek finish and a profile that matches newer radio designs. Industry performance standards are exceeded in the SX series, with a voltage standing wave ratio (VSWR) rating at less than 1.5:1 at resonance frequency.

**Centurion International**  
INFO/CARD 164

### RFID tagging ICs feature advanced anticollision circuitry

The MCRF355 and MCRF360 13.56 MHz radio frequency identification (RFID) tagging devices have advanced anticollision circuitry for reading multiple tags in the same reader field, a "cloaking" feature that minimizes the detuning effect of adjacent tags, low-power consumption for extended read range and 154 bits of user memory. Both devices are contact-programmable and are designed for write once read many (WORM) applications. The MCRF355 allows the user to externally tune a resonance capacitor, while the MCRF360 contains an on-chip 100 pF resonance capacitor. The RFID tags can read through objects, such as parcels or inventory items, and can eliminate inaccurate or missed reads from damaged, dirty or obstructed barcodes. These tags can be



**PORTABLE TELECOM DEVICES**

**PLL APPLICATIONS**

**WIRELESS**

**MVS series  
SURFACE MOUNT  
VCXO  
with trisate**

actual size

**M-tron  
INDUSTRIES, INC.**

PO Box 630, Yankton, SD 57078-0630  
1-800-762-8800 • FAX 605-665-1709  
www.mtron.com

**ISO 9001**

**SPECIFICATIONS**

- Package: 14.0 x 9.0 x 4.7mm J-leaded ceramic package utilizes a standard footprint
- Frequency: 3.00 to 50.00MHz
- Stability:  $\pm 25$ ppm over a temperature range -40° to 85°C
- Trisate output is an option in a 6-lead package
- Pullability:  $\pm 100$ ppm is achievable with a 0.5V to 4.5V control voltage
- Grounded lid provides for reduced EMI emissions
- Well suited for PLL applications in telecommunications/wireless equipment

INFO/CARD 21



used in harsh environments and remain resistant to heat, moisture, abrasion, dirt and paint.

**Microchip Technology**  
INFO/CARD 165

## Modem, amplifier for license-free operation

The model 2400 frequency hopping spread-spectrum radio modem and the model AMP2440 pole-mounted bi-directional amplifier for license-free operation in the 2.4 GHz band feature ranges of more than 50 miles line-of-sight when used with 24 dB gain grid dish antennas. The radio modem has an RS-232 interface and operates point-to-point or point-to-multipoint at speeds as high as 115.2 kbps asynchronous. It can also be configured to operate at 64 kbps synchronous for point-to-point wireless data links. The modem can be used without the amplifier for short-range links (of several hundred feet or less) using small whip antennas and several miles using outdoor gain antennas. The amplifier consists of a low-noise receiver pre-amplifier and a transmit power amplifier. The remote mounting feature allows the amplifier to be mounted next to the antenna, which places the full transmit power where it is most effective.

**Young Design**  
INFO/CARD 166

## Transmitter shielded in protective enclosure

The Stingray transmitter is a self-contained laboratory instrument housed in an electromagnetic/radio frequency interference (EMI/RFI) protective enclosure. The components of this stimulus transmitter are a built-in frequency synthesizer, dynamically controlled power amplifier and the ability to remotely control all of the transmitters' parameters via a PC. Remote adjustments include the power level, channel and frequency assignment and transmit on and off.

**Berkeley Varitronics Systems**  
INFO/CARD 167

## SIGNAL PROCESSING COMPONENTS

### High bandwidth and high frequency switch

The 50S-1035 single-pole, quadruple

throw (1P4T) switch covers all cellular and some satellite bands. The switch features a 20–4,000 MHz frequency band with insertion loss of 2.0 dB maximum at 20–1,000 MHz and 4.0 dB maximum at 1,000–4,000 MHz. The isolation is 80 dB minimum at 20–1,000 MHz, 70 dB minimum at 1,000–2,000 MHz and 60 dB minimum at 2,000–4,000 MHz. The switch is available with a sub-miniature A (SMA) female connector and an N female connector.

**JFW Industries**  
INFO/CARD 168

### Diplexer screens PCS signals

The model W1805D intermodulation distortion (IMD)-free diplexer screens personal communications service (PCS) signals. A low-cost miniature cavity diplexer, it features two standard +40 dBm signals that produce less than –30 dBm of IMD. The diplexer covers full PCS bands with less than 1.2 dB of insertion loss. The Rx/Tx isolation is greater than 90 dB. The Rloss is greater than –16 dB, and power capability is greater than 50 W. It takes SMA connectors or type N. The device measures 2" × 2" × 9".

**Wireless Technologies**  
INFO/CARD 169

### Isohybrid provides 52 dB of interchannel isolation

The 0184IMN4 isohybrids are designed to provide 52 dB interchannel isolation with a low insertion loss of 3.4 dB, including the loss caused by the 3 dB hybrid coupler. These isohybrids provide 23 dB of isolation from output to input at 1,805–1,880 MHz frequency bandwidth and can process several 100 W of power with RF leakage less than –50 dBc. These units have a voltage standing wave ratio (VSWR) match of 1.2:1 on all ports over the specified frequency bandwidth and temperature range of –10°C to +85°C. Isohybrids at other frequency bandwidths are available in a similar package.

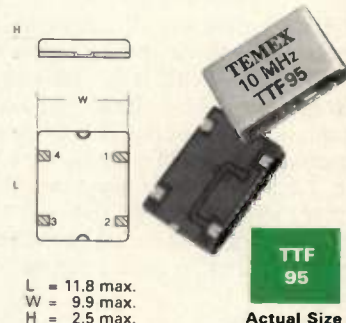
**Nova Microwave**  
INFO/CARD 170

### Splitter/combiner offers low insertion loss

Tuned to cover the wide 1.7–9 GHz frequency range, the two-way 0°

## LOW COST SURFACE MOUNT TCXO

### TTF 95



L = 11.8 max.  
W = 9.9 max.  
H = 2.5 max.

**TTF 95**  
Actual Size

The Temex Time & Frequency TTF 95 is a low cost TCXO or VCTCXO available in many standard frequencies from 10 MHz to 26 MHz. Parts are available on Tape and Reel and may be reflow soldered, using no clean processing.

#### Applications:

Wireless Communications  
Test & Measurement  
GPS receivers

#### Specifications at 10 MHz

Stability Options  
± 2.5 ppm –30° to +75°C  
± 1.5 ppm –20° to +70°C  
± 1.0 ppm 0° to +50°C  
Input ..... +3.3 or +5.0 Vdc  
Clipped Sinewave or TTL output  
Phase Noise ..... –125 dBc at 100 Hz

Custom specifications welcomed



**Crystals, Filters,  
Oscillators, VCXO's,  
TCXO's, OCXO's &  
Rubidium Atomic Clocks**

PH: 602-780-1995

FAX: 602-780-9622

e-mail: sales@temex-az.com

www.temex-az.com

TEMEX ELECTRONICS, INC.  
3030 W. Deer Valley Rd. Phoenix, AZ 85027

INFO/CARD 72



**ZN2PD-9G** power splitter/combiner offers low 0.5 dB typical insertion loss, good 22 dB (typical) isolation and 0.6 dB amplitude, 4.0° phase unbalance (maximum) bandwidth. This 50  $\Omega$  unit is equipped with SMA connectors and has a maximum power input of 1 W (as splitter) when used in the -55°C to +100°C temperature range (maximum). Uses include radar and satellite communication.

**Mini-Circuits**  
INFO/CARD 171

### CDMA combiner can be mechanically tuned

The model WSC2-00011 is a personal communications service (PCS) band, mechanically tunable code-division, multiple access (CDMA) transmit combiner. It offers 1.5 dB maximum (1.0 dB typical) passband insertion loss and 30-dB minimum (greater than 40 dB typical) passband-to-passband isolation with a 1 CDMA carrier to carrier separation. The combiner can be tuned to any CDMA carrier assignment within the PCS base station transceiver (BTS) transmit frequency range of 1,930–1,990 MHz. The combiner also provide 23 dB minimum antenna to transmit input isolation, 20 dB minimum transmit input port return loss, 14 dB minimum port return loss, 100 ns maximum channel group delay, and is

specified to -75 dBm maximum intermodulation products with two +44 dBm transmit carriers applied. The combiner measures 9.5" x 6.0" x 2.7", excluding type N-F connectors. Operating temperature range is 0 to 55°C.

**K&L Microwave**  
INFO/CARD 174

### Circulator for HDTV, digital applications

The low-loss 1 kW UHF circulator, CT-1510-S, operates over channels 26–44 for use in digital and high-definition TV applications. Typical loss is 0.12 dB over the operating band. Three units span the domestic channels 14–69. Another covers the channel 69–78 range. Isolation is greater than 20 dB and 1.20 maximum voltage standing wave ratio (VSWR). Connectors are 7/8 EIA with a type N load port. DIN 7/16 or N connector models are also available.

**Ute Microwave**  
INFO/CARD 173

### Fractional-N synthesizers lead to 3.7 GHz device

The next generation 7-family of fractional-N synthesizers builds on the new 6-family of the synthesizers (SA8026, SA8016, SA7026, SA7016). They are manufactured with QUBiC3 BiCMOS

process technology and support applications as high as 3.7 GHz. The fractional-N synthesizers provide low close-in phase noise, fast switching and high comparison frequencies without decreased resolution. By simultaneously delivering low phase noise and fast acquisition time, the 6-family meets the requirement for services like high-speed circuit-switched data (HCS) and general packet radio service (GPRS) of the global system for mobile communications (GSM) standard.

**Philips Semiconductors**  
INFO/CARD 172

### Balun eliminates custom fitting task

The Xinger balun is designed to be surface-mounted by automatic assembly equipment onto a printed circuit board (PCB), eliminating the task of custom fitting coaxial baluns. The balun is smaller than a conventional printed microstrip balun. The balun takes an unbalanced input signal and splits it into a balanced output signal that is then fed into a push-pull transistor pair. This allows the transistors to work in parallel, efficiently and with low impedance. The balun can be attached to the same ground plane for both input and output, ensuring common ground. This design allows for the dissipation of heat, making the balun

## The world's most innovative source of crystals

Our website puts you the customer in the driver's seat. Now you can simply enter the parameters you require –such as frequency stability, operating temperature ranges, calibration tolerances and so on. Immediately you will be presented with all the Rakon models that meet your requirements, along with price indicators and lead times.

Once a product is selected, a fully customised specification complete with engineering drawings is displayed, you can then request a quote. Approved users will be automatically emailed a quote with the customised specification attached, in PDF form.

The site also enables you to browse through the Rakon product range and manufacturing process. And you'll discover an invaluable independent tutorial on the fundamentals and properties of quartz crystal devices.





suitable for high-power applications.  
**Anaren Microwave**  
**INFO/CARD 175**

## SIGNAL SOURCES

### Surface mount VCXO has high-frequency capabilities

The VSM series surface-mount voltage-controlled crystal oscillator (VCXO) has high-frequency capabilities as high as 100 MHz. Available in four- and six-pin models, the VSM series operates at 5 Vdc or 3.3 V with frequency stabilities of 620, 625 and 650 ppm over a temperature range as wide as -40°C to 85°C and deviations as high as 6,100 ppm over a control voltage range of 0.5–4.5 VDC. All models are hermetically sealed in a compact 9 × 14 mm ceramic package with a grounded metal case in LCC or solder-dipped J-leaded designs. The VSM series also features low-jitter as well as low-phase noise performance caused by the use of fundamental mode crystals in the design.

**Connor-Winfield**  
**INFO/CARD 178**

### VCXOs feature wide frequency range

The K1528C series of voltage-controlled crystal oscillators (VCXOs) offers

a tri-state disable option in frequency stabilities as low as  $\pm 25$  ppm (typical) over an operating temperature range of 0–70°C. The VCXOs feature a wide frequency range of 35–125 MHz in TTL/CMOS compatible output. An optional temperature range of -40°C to +85°C is available. The device provides a variety of deviation sensitivities and a control voltage range of 0.5–4.5 V. Using a sealed crystal resonator package will also provide optional tight aging characteristics for this K1528C series, making it suitable for telecom infrastructure and data networking apparatus.

**Champion Technologies**  
**INFO/CARD 179**

## CABLES & CONNECTORS

### RF coaxial cable assemblies

A line of custom cable assemblies feature flexible and semi-rigid RF coaxial cables in lengths as long as 150 feet, which can be equipped with a wide variety of connectors to eliminate the need for adapters. Manufactured to specification, the cables can range from 0.11–1.20" O.D. and include 7/16, C, ELA, HN, LC/LT, QDL, QDS, SC and other types of connectors. The assemblies allow customers to solve equipment com-

patibility problems, smooth out cable runs and deal with space constraints by incorporating straight-thru or right-angle cable designs. The assemblies can be rated at 50–75 V from 0–18 GHz. Connectors can be made from brass, bronze alloys, BeCu and other materials with insulations, gaskets and finishes to military and commercial specifications.

**Tru-Connector**  
**INFO/CARD 177**

### Fire-retardant coaxial cable rated CATVR

The LMR-FR line of low-loss coaxial cable for in-building fire retardant applications is rated CATVR by Underwriters Laboratories. In accordance with the National Electric Code, LMR-FR can be run anywhere within a building, except in return air handling plenums (e.g. suspended ceilings). LMR-FR can be considered for all indoor applications where fire retardancy, low-smoke generation and zero-halogen is required. Unlike PVC jacketed cables, LMR-FR does not generate lethal toxic fumes when exposed to fire. The coax is available in all standard LMR sizes from 0.2–1.67" in diameter. It is size compatible with standard LMR and accepts all LMR connectors and hardware accessories.

**Times Microwave Systems**  
**INFO/CARD 176**

**& oscillator products is now just a click away!**

# www.rakon.com



The easiest and most accurate way to get the product info you need — when you need it.

*More innovation from Rakon.*

Actual website screens showing how you can browse, specify and customise input to meet your exact needs.

It's all right here.

**RAKON**  
 PRECISION QUARTZ CRYSTALS



# RF design

*online!*

**RF Design**

**Online**

**now has**

**three ways**

**to link**

**to companies**

**mentioned**

**in this issue:**

**Advertiser links,**

**product directory**

**links**

**and editorial links.**

**Check out**

**our website at**

**[www.rfdesign.com](http://www.rfdesign.com)**

## RF software

### First substrate modeling, noise analysis solution

Snaketech's Layin 2.0 is the first substrate modeling and noise analysis solution targeted at RF, analog and mixed-signal integrated circuit (IC) design. The software allows designers to model and analyze substrate noise coupling effect in ICs before fabrication. Layin takes its information from process doping profiles and builds a three-dimensional model of the substrate. It also concentrates on modeling local effects.

**Snaketech**  
**INFO/CARD 115**

### Test software improved with VRM capability

Powerwin, from Eltest, has been updated to include voltage-regulated module (VRM) and AC/DC power supply testing. Previous versions supported testing of DC/DC power supplies. The software controls Eltest's EL-467 power supply measurement boards that contain a 14-bit, 1 MSPS sampling A/D.

**Eltest**  
**INFO/CARD 116**

### Design software adds EDIT/SDF support

Tanner EDA's L-Edit-Pro integrated circuit (IC) design software has been upgraded with the ability to read electronic design interchange format (EDIT) 2000 netlist files and write standard delay format (SDF) files. The standard cell place and route module in L-Edit-Pro, L-Edit/SPR, translates graphical and electrical information from EDIF netlist created in S-Edit.

**Tanner EDA**  
**INFO/CARD 117**

### Circuit analysis program offers RF design tools

The Linc2 RF and microwave circuit analysis program, from Applied Computational Sciences, now includes integrated schematic capture and a suite of RF design tools. The software combines an RF/MW simulation engine with a set of design tools that are task oriented. Circuit development can proceed from automated synthesis to performance analysis rather than the reverse process of design by repeated cut and try simulation. Interactive tuning provides immediate insight into circuit behavior while any one of 18 circuit

responses are updated in real time as component values are adjusted.

**Applied Computational Sciences**  
**INFO/CARD 118**

### Load pull data module for HP software

Maury Microwave offers a load pull data module (model MT993Q1) software that allows device characterization data from Maury's automated tuner system to be imported into Hewlett-Packard (HP) EEsof advanced design system (ADS). The data can be used for design simulation and analysis of circuits and systems. The module automatically translates ATS data files into ADS data sets.

**Maury Microwave**  
**INFO/CARD 119**

### Schematic software offers new functions

WinDraft Schematics, Version 3.0, by Ivex Design International, has been updated with 20 major user suggestions. Improvements include a module footprint browser to allow designers to scan WinBoard PCB software for the desired footprint packages and assign it to the selected schematic part. Part editing has been expanded to use all the edit characteristics of a part on a schematic, such as pin type and pin shape.

**Ivex Design International**  
**INFO/CARD 120**

## Software on the Web

### Web site offers drivers and tools

Anritsu offers Labview and Lab windows drivers to support automated test equipment (ATE) as well as downloadable tools for its Sitemaster and Powermeter product lines. The downloads are executable zip files.

**Anritsu Company**  
**INFO/CARD 121**

To access this Web site and other Web sites offering downloadable software or online programs, check out **RF Design Online** for direct links. You can also access any company whose product release is mentioned in this month's Software section.



# RF literature

## Products for RF distribution systems

Renaissance Electronics offers a four-page product catalog of customized base station products for multichannel multi-point distribution service (MMDS), specialized mobile radio (SMR), cellular, personal communications service (PCS) and other markets. Included are receiver multicouplers with eight primary and two expansion outputs, duplexers and multichannel transmitter combiners that combine in nine different configurations.

**Renaissance Electronics**  
INFO/CARD 122

## Data book details frequency products

The 1999 *Crystal Product Data Book*, from C-MAC Frequency Products (CFP), provides detailed specifications on standard frequency products, plus information on a range of custom design services available from CFP. The 344-page catalog includes products from IQD (UK), C-

MAC quartz crystals, CEPE (France) and Greenray.

**C-MAC Frequency Products**  
INFO/CARD 123

## Data sheets detail tunable bandpass, band reject filters

K&L's full color data sheets describe the company's tunable bandpass and band reject filters. The filters include octave range tuning designed to replace the need for several fixed tuned filters. The data sheets include product description, performance data and product photos.

**K&L**  
INFO/CARD 124

## MMIC die products featured in new catalog

Hittite Microwave's latest catalog features as many as 75 monolithic microwave integrated circuit (MMIC) die, ceramic packaged die and plastic packaged die covering DC to 40 GHz.

ten new products are featured including 5 mm wave MMIC up/downconverter and amplifier die as well as attenuators, mixers and modulators for wireless applications.

**Hittite Microwave**  
INFO/CARD 125

## Catalog describes EMI/RFI shielding tapes

Venture Tape offers a new catalog for design engineers requiring electromagnetic interference (EMI) or radio frequency interference (RFI) shielding tapes. The catalog features super conductive foils, fabrics and adhesive tapes, each categorized by their specific EMI/RFI application.

**Venture Tape**  
INFO/CARD 126

## Catalog offers test and measurement products

IFR's 312-page 1999/2000 test and measurement catalog features detailed

## Online

**Goodfellow offers online metals and materials catalog**—Goodfellow's catalog of up to 48,000 metal and material products is available on the company's Web site. Products include metals and materials for research or prototype development and feature pure metals, alloys, polymers, ceramics and composites. Goodfellow's Web can be found at [www.goodfellow.com](http://www.goodfellow.com)  
**Goodfellow**  
INFO/CARD 133

**MMC develops new Web site**—Microelectronic Modules Corporation (MMC) offers a new Web site detailing the company's microelectronic packaging capabilities, as well as its lines of standard and custom components and subsystems. The site offers users online review and downloadable product data sheets and applications notes for MMC's DC/DC converters and other products. Access the site at [www.mmccorp.com](http://www.mmccorp.com).  
**MMC**  
INFO/CARD 134

**Interconnect Devices offers online ordering**—Interconnect Devices introduces its new online ordering system for spring contact probes. The new capability allows users to manually key in the part number, or the part number can be built by selecting the links for the desired tip style, spring force or placing. The contact probes are designed for use in automated test equipment. Interconnect Devices' Web site is at <http://ecom.idinet.com>.

**Interconnect Devices**  
INFO/CARD 135

**National Instruments offers e-mail newsletter**—National Instruments, "NI news," is a free e-mail publication providing computer-based measurement and automation news, tips and techniques. Subscribers can get information about the company's LabView, data acquisition, test and measurement and other information. National Instruments' Web site is at [www.natinst.com/news](http://www.natinst.com/news).  
**National Instruments**  
INFO/CARD 136

**Trompeter adds E-commerce capability**—Trompeter Electronics has upgraded its Web site to include electronic commerce (E-commerce) capabilities such as online quotations and direct order placement. Trompeter manufactures RF coaxial, triaxial and twinaxial interconnects and other products. Trompeter's Web site is at [www.trompeter.com](http://www.trompeter.com)  
**Trompeter Electronics**  
INFO/CARD 137

**AVX offers online capacitor purchasing**—AVX's new capacitor part number generator and parser allows engineers to enter the description of the capacitors they need and arrive at AVX capacitor part numbers that correspond with their specifications. The Web address is [www.avxcorp.com](http://www.avxcorp.com)  
**AVX**  
INFO/CARD 138

## RF Design Online

For direct access to those companies offering information through their Web sites, go to [www.rfdesign.com](http://www.rfdesign.com).

RF DESIGN (ISSN 0163-321X USPS: 453-490) is published monthly, May 1999, Vol. 22, No. 5. RF Design is a registered trademark of Intertec Publishing, A PRIMEDIA Company. Copyright 1999 by Intertec Publishing, 9800 Metcalf Ave., Overland Park, KS 66212-2218. Editorial and advertising offices at 5880 Greenwood Plaza Blvd., Suite 100, Englewood, CO 80111, 303-741-2901. Printed in USA. Periodicals postage paid at Overland Park, KS, and at additional mailing offices. Canada Post Publications Mail (Canadian Distribution) Sales Agreement No. 1071211. Subscription office: RF Design, P.O. Box 12907, Overland Park, KS 66282-2907. Subscriptions are \$48 per year (\$82 for two years) in the United States; \$68 (surface mail) or \$108 (air mail) per year for countries outside the U.S. Payment must be made in U.S. funds and accompany request. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Intertec Publishing, provided the base fee of U.S. \$2.25 per copy, plus U.S. \$0.00 per page is paid directly to Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923 USA. The fee code for users of this Transactional Reporting Service is ISSN 0163-321X/1999 \$2.25 + \$0.00. For those organizations that have been granted a photocopying license by CCC, a separate system of payment has been arranged. Prior to photocopying items for educational classroom use, please contact the CCC at 508-750-8400. Organizations or individuals with large quantity photocopy or reprint requirements should contact Jenny Eisele at 913-967-1986. SUBSCRIPTION INQUIRIES: 800-441-0294. POSTMASTER & SUBSCRIBERS: Please send address changes to RF Design, P.O. Box 12907, Overland Park, KS 66282-2907.



descriptions of the company's expanded product line. Products include commercial and wireless test sets, signal sources and analyzers, counters and power meters, avionics, spectrum analyzers, microwave, telecommunications, automated test equipment (ATE) and other capabilities.

**IFR Systems**  
INFO/CARD 127

## Sourcebook details crystals and oscillators

Ecliptek's 1999 International Sourcebook features the company's frequency control devices. The 64-page catalog includes a product selection guide and detailed technical specifications. Also included are as many as 40 surface-mount and through-hole quartz crystals, crystal oscillators, voltage controlled crystal oscillators (VCXOs) and temperature compensated crystal oscillators (TCXOs). Each product data sheet contains a part numbering guide and mechanical dimensions.

**Ecliptek**  
INFO/CARD 128

## Selection guide features single processing products

Signal Processing Technologies (SPT) offers its 1999 product selection guide for data conversion and signal processing integrated circuits (ICs). The catalog features an overview of SPT's analog-to-digital converters (ADCs), digital-to-analog converters (DACs), video DACs, comparators and track-and-hold amplifiers.

**Signal Processing Technologies**  
INFO/CARD 129

## Catalog details passive components

Venkel has updated its catalog of passive components. The catalog features information on ceramic and tantalum chip capacitors, thick and thin film chip resistors, melt chip resistors, high meg chip resistors (as high as 1000 G  $\Omega$ ), chip inductors, chip resistor arrays, thick and thin surface mount device (SMD) resistor networks and engineering kits.

**Venkel**  
INFO/CARD 130

## Guide offers insight into phase noise

Connor-Winfield offers a phase noise guide to assist designers in understanding the problem of phase noise when selecting oscillator designs for timing circuits. The guide includes a technical explanation of phase noise along with the random processes in electronic systems that contribute to phase noise occurrence.

**Connor-Winfield**  
INFO/CARD 131

## Catalog features microwave cable assemblies

Micro-Coax's 24-page catalog describes its Utiflex flexible microwave cable assemblies that are constructed using a low or ultra-low density PTFE dielectric. The catalog includes a selection guide for cables, connectors and armors, as well as a description of a typical cable construction. Charts detail the mechanical, electrical and environmental attributes of the cables.

**Micro-Coax**  
INFO/CARD 132

ICM's TO-5...  
the right product  
for your  
microwave, radar,  
telecommunications,  
or satellite  
communications  
application.



## CUTTING EDGE

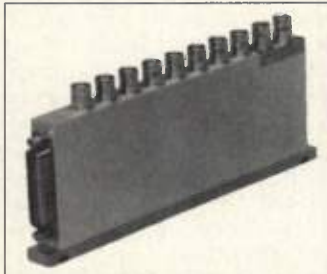
- High Stability
- Low Phase Noise
- Superior Shock Vibration
- Smaller Mass for Faster Warm-up in Oven Use
- Small Quantities Available

Contact ICM at 800-725-1426 or  
visit our website at [www.icmfg.com](http://www.icmfg.com).



PO Box 26330  
10 North Lee  
Oklahoma City, OK 73126-0330

## FOR IMMEDIATE RELEASE



Contact: Matrix Systems, 5177 Douglas Fir Road,  
Calabasas, CA. 91302  
(818) 222-2301 FAX (818) 222-2304  
E-mail [tech@matrixsystems.com](mailto:tech@matrixsystems.com)  
[www.matrixsystems.com](http://www.matrixsystems.com)

### Coaxial Relay Incorporates A Built-In R.F. or Video Amplifier

Matrix Systems Model 76A00 Coaxial Relay incorporates a built-in R.F. or Video Amplifier which is convenient when assembling Non-blocking Matrices or when simply a Gain Block is needed in conjunction with a Coaxial Relay.

The module is Self-Terminating, allowing it to mate with Power Splitters which always need to be terminated. The unit can be used independently or can be incorporated in Matrix Systems' Model 11600 Controller Chassis which provides RS-232, RS-422, IEEE-488 and Keypad Control.

The module's frequency response of DC to 800 MHz makes it ideal for Switching Wideband R.F./I.F. or Fast Rise Video/Pulse Signals.

# 800-522-2253

## This Number May Not Save Your Life...

But it could make it a lot easier!  
Especially when it comes to  
ordering non-standard connectors.

### RF/MICROWAVE CONNECTORS

- Specials our specialty virtually any SMA, N, TNC, BNC, SMB, or SMC delivered in 2-4 weeks
- Cross reference library to all major manufacturers.
- Large inventory of piece parts for all types of coaxial connectors.
- Experts in supplying "hard to get" RF connectors.
- Connectors supplied to your drawings and specs.
- Our 56 Standard adapters can satisfy virtually any combination of requirements, between SMA, TNC, N, 7mm, BNC and others.
- Extensive inventory of passive RF/Microwave components including attenuators, terminations and dividers.

# NEMAL

Cable & Connectors  
for the Electronics Industry

NEMAL ELECTRONICS INTERNATIONAL, INC.

12240 N.E. 14TH AVENUE  
NORTH MIAMI, FL 33161  
TEL: 305-899-0900 • FAX: 305-895-8178  
E-MAIL: [INFO@NEMAL.COM](mailto:INFO@NEMAL.COM)  
URL: [WWW.NEMAL.COM](http://WWW.NEMAL.COM)

INFO/CARD 29

INFO/CARD 34

INFO/CARD 54 - Send literature only  
INFO/CARD 57 - Call me, I'm interested

WRH



# RF LITERATURE/PRODUCT SHOWCASE

## SysCalc 4 for Windows 95/NT

### HIGH LEVEL SYSTEM DESIGN

- New AGC block provides dynamic power control capability.
- New Component parameters include 1 dB Compression Point, 2nd Order Intercept Point, tolerance and temperature coefficients.
- Specialized reports (standard, linearity, graph, yield and link-budget) can be attached to any system page.
- SNR/BER support added for PAM/QAM signaling.
- User interface can be customized on any system page.
- Build library models for frequently used components.



\$495

## Eclipse 4 for Windows

### CIRCUIT LEVEL DESIGN

- Comprehensive element library
- User-defined equations
- Flexible sweep capability
- Multiple graph sheets
- Manual element/variable tuning
- Optimization
- Customizable graphs
- Network analyzer style markers



\$495



**Arden Technologies, Inc.**

PO Box 286 • Forest, VA 24551  
Sales: 804/525-6837 or 888/535-6837 (US only)  
Fax: 804/525-5376 • E-mail: sales@ardentech.com  
http://www.ardentech.com for a fully functional demo

SAVE! RF Design Suite  
includes both tools for only

\$945

INFO/CARD 200



### 0.1MHz to 3.1GHz Portable Spectrum Analyzers

- PS-550 0.1 - 550MHz PS-5A 0.1 - 1100MHz (1300MHz optional)
- PS-5B 0.1 - 2050MHz (2 bands) PS-5C 0.1 - 3100MHz (3 bands)
- Center/Marker frequency display with on screen marker cursor
- Measurement Range: -108 to +20 dBm
- Five Resolution Bandwidths: 10KHz, 30KHz, 100KHz, 300KHz, 1MHz
- 50 dB Input Attenuator in 10 dB steps
- 2 / 10 dB/Div vertical display with Base Line Clipper
- Built-in AM/FM demodulation with monitoring speaker
- Optional built-in Tracking Generator
- AC / DC / Battery powered (optional internal +12V battery pack)
- Lightweight - Portable operating Size: 11.5" x 6.4" x 12.9"
- Price: PS-550 \$1675 PS-5A \$2275 PS-5B \$2875 PS-5C \$3175

V.Tech Instruments, Inc.  
171 Burns Ave, Lodi, NJ 07844

Tel: 973-546-7635  
Fax: 973-546-7681  
E-mail: vtechinst@aol.com

INFO/CARD 201

## Pin-Diode Switches



- All Frequencies from 100 Mhz to 18 Ghz
- Reflective or Absorptive Types
- TTL, CMOS, ECL, Control Logic families
- Switching speed as fast as 10ns (Rise/Fall)
- Miniature Outlines with Removable Connectors
- Numerous factory options for any applications

### Universal Microwave Components Corp.

5702-D General Washington Drive  
Alexandria, Virginia 22312  
Tel: (703) 642-6332  
Fax: (703) 642-2568  
E-Mail: UMCC111@AOL.Com



INFO/CARD 202

## QUALITY PRODUCT DESIGN



### RF POWER GENERATORS

- RF Excited Plasma for Deposition, Sputtering, Etching, & Ion Implant
- Induction Heating

### AMPLIFIERS / XMITT'S

- Commercial
- Industrial
- HF / VHF Bands
- Mobile / Base Station

IF YOU CAN'T FIND IT, WE'LL DESIGN IT!

**T&C Power Conversion, Inc.**  
110 Main Street E-Mail: TPOWER@AOL.COM  
Rochester, New York 14610, USA Phone: 716-453-8851  
http://www.tci.net/~tci/power1 Fax: 716-453-4487

INFO/CARD 203

## CUSTOM & STANDARD FILTERS



- Bandpass
- Lowpass
- Highpass
- Linear Phase
- Phase Matched
- Anti-Aliasing Filters
- Video Filters
- Group Delay Equalized
- Sin(x)/x Compensated
- Cosine (Nyquist) Filters

Send for a free catalog or fax your filter specifications for a prompt technical review and quotation.

### KR ELECTRONICS

91 Avenel Street • Avenel, NJ 07001  
Phone: (732) 636-1900 • Fax: (732) 636-1982  
www.krfilters.com

INFO/CARD 204

## Wireless Simulation



TESOFT, Inc.

http://www.tesoft.com

INFO/CARD 205

## Spectrum Analyzers

New! \$6495! 2.7 GHz!

- 2.7 GHz bandwidth
- synthesized RF
- lightweight 18 pounds
- 2 simultaneous spectrums
- Powerful marker functions
- Built-in AM / FM receiver
- or 1.15 GHz, \$1495!



### LPT-1250 Spectrum Analyzer Adapter

- Fully Synthesized RF
- 2 kHz thru 100 MHz / div
- Adjustable reference level
- Markers with level display
- Easy to use, accurate
- Uses any scope, no flicker
- Optional Track Gen 2.6 GHz Freq Ext

### SA-7270 Spectrum Analyzer

- Options include Tracking Generator, GPIB, PCMCIA card, Quasi-peak, High-stability frequency reference

Power Meter, \$495!

- 2 GHz+ range
- 2 Power scales
- Internal battery
- Hand-held
- Rugged
- Easy to use
- Easy to read

### LPT-2010A

Ask about our other high performance instruments!

**LP Technologies, Inc**  
1919 N Amidon Ste 216 Wichita KS 67203  
Call 316-831-9696 for info, Fax 316-831-9692  
sales@lptech.com http://www.lptech.com

INFO/CARD 206

## MINIATURE CRYSTAL CONTROLLED BLOCK DOWN CONVERTER



- ✓ HEATER STABILIZED L.O.
- ✓ THICK FILM HYBRID CONSTRUCTION
- ✓ MACHINED ALUMINUM HOUSING
- ✓ RF INPUT: 50 MHz TO 2.5 GHz
- ✓ IF OUTPUT: 0.1 TO 500 MHz
- ✓ RF TO IF GAIN: -7dB TO +40dB, CUSTOMER SPECIFIED

**Wilmanco**

5350 Kazuko Court, Moorpark, CA 93021  
(805) 523-2390 FAX (805) 523-0065

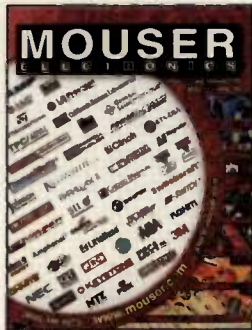
INFO/CARD 207



# RF LITERATURE/PRODUCT SHOWCASE

## ELECTRONICS PURCHASING MANUAL

Mouser Electronics presents its electronics purchasing manual featuring more than 87,000 components from 145+ leading suppliers such as 3M, Alpha Wire, Amp, Amphenol, General Semiconductor, NEC, STMicroelectronics, Spectrol, Vishay Dale, Vishay Sprague, and more. Also view our catalog at [www.mouser.com](http://www.mouser.com).



The website features: Secure Online Ordering; Product Search; Complete Line Card; Spec Sheets; Search by part number, keyword, cross-reference, or manufacturer.

**Mouser Electronics**

958 N. Main St.; Mansfield, TX 76063.  
(800) 992-9943; FAX: (817) 483-6899;  
E-mail: [catalog@mouser.com](mailto:catalog@mouser.com).

INFO/CARD 208

## Rubidium Frequency Standard



**Novatech 2950AR \$3950**

- Atomic Resonance Rubidium Standard
  - < 5 x 10<sup>-10</sup> per year
  - 10 MHz, 1MHz and 100kHz Buffered
  - Small Size: 2.5" H x 7.3" W x 9.5" L
- Low Cost..... just \$3950**

**Novatech Instruments, Inc.**

(206) 301-8986 FAX (206) 363-4387

<http://www.eskimo.com/~sales>

INFO/CARD 209

## RF Signal Generator



**\$1495**

**100 KHz  
to  
1000 MHz**

- Calibrated AM/FM Modulation
- Synthesized, 10 Hz step size
- Max 0 dbm output, +13 dbm optional
- 130 db solid state attenuator
- Reverse power protection
- 1 ppm Time Base, 0.1 ppm optional
- Level flatness of  $\pm 0.5$  db
- RS-232 interface option

**RAMSEY**

**Ramsey Electronics, Inc.**  
793 Canning Parkway Victor, NY 14564  
Tel: 716-924-4560 Fax: 716-924-4886  
email: [RFTest@Ramseyelectronics.com](mailto:RFTest@Ramseyelectronics.com)  
[www.RamseyElectronics.com](http://www.RamseyElectronics.com)



INFO/CARD 210

## MICROWAVE ISOLATORS/CIRCULATORS



Freq. 0.45 to 26.5 GHz  
Insertion loss <0.3 dB  
Isolation >23 dB  
VSWR 1.25:1

### Low Cost/High Volume Production Capability

- Drop-in Packages • High Power Coaxial packages
- Surface Mount Packages • Multiple connector options
- High Isolation/Multijunction • MIL-I-45208 Qualified
- Four port custom designs • Just in Time delivery
- Reflection sensing tabs • Custom design capability

**NOVA  
MICROWAVE**

380 Tennant Ave., Morgan Hill, CA 95037  
<http://www.novamicro.com>  
Tel: 408-778-2746 • Fax: 779-5967  
email: [novamic@msn.com](mailto:novamic@msn.com)

INFO/CARD 213

## HIGH PERFORMANCE HIGH TECHNOLOGY



**RF POWER AMPLIFIERS**  
1MHz - 2 GHz • 1W - 2 KW

**LCF  
ENTERPRISES**  
RF POWER AMPLIFIERS

- Small, Ultra High Efficiency Modules
- Low Cost Amplifier Systems
- T/R Subsystems

651 Via Alondra, Bldg. 712 • Camarillo, CA 93012 USA  
805-388-8454 • Fax 805-389-5393  
[www.lcfamps.com](http://www.lcfamps.com) • E-mail: [info@lcfamps.com](mailto:info@lcfamps.com)

INFO/CARD 212

## NEW SAW DESIGN IN HALF THE TIME

New developer and supplier of  
SAW components - AEC Ltd.

Why should AEC be the one to choose?

- we deliver your custom designed SAW samples in just a couple of weeks
- we have minimum or no design charges
- we offer extremely competitive prices
- we provide excellent quality and minimum lead-time
- we have talented designers, who can create even the most sophisticated SAW filters

Please contact our expert service at SES  
(SAW Electronic Solutions)

Tel./Fax 770-360-8292 E-mail [ses@avana.net](mailto:ses@avana.net),  
or visit us at [aec@mail.wplu.net](mailto:aec@mail.wplu.net)



**ADVANCED SAW  
FILTERS**

INFO/CARD 214



The A4-2 solid dielectric multiturn trimmer capacitors tune from 0.6—2 pF and is usable to more than 4.2 GHz. It is a surface-mount device and priced at \$1.69 in 10,000-piece quantities.

**Voltronics**

(973) 586-8585 • FAX (973) 586-3404

INFO/CARD 215

## ICAP/4WINDOWS RF DELUXE

Intusoft's powerful suite of SPICE tools for RF Engineers includes ICAP/4

Windows and the RF Deluxe package, with vendor-

supplied IC libraries, SPICE Reference books, the SpiceMod modeling tool and the RF library, all in a cost-saving bundle. More info at: [www.intusoft.com/rfdesign.htm](http://www.intusoft.com/rfdesign.htm)



INFO/CARD 216



# RF marketplace

## CLASSIFIEDS

### Fax

Jody Schrader  
Classified Ad Manager  
1-720-489-3253

### Phone

Jody Schrader  
Classified Ad Manager  
1-888-234-0448  
or 1-720-489-3290

### Mail

ad materials to:  
Annette Hulsey  
9800 Metcalf  
Overland Park, KS  
66212

E-mail: jody\_schrader@intertec.com



Jody Schrader

### At a glance...

	Page
Buyers' Source .....	92-93
Career Opportunities .....	89-91
Literature/ Product Showcase .....	87-88
Products & Services .....	92

## RF design

Toll-Free: **1-888-234-0448**

## CAREER OPPORTUNITIES

### RF/WIRELESS/PCS

Leading designer and integrator for the CATV/Telecommunications industry is seeking EE's to be involved in spec. design, implementation of wireless and PCS systems and devices. Also seeking Analog/RF Engineers with knowledge of modulation, amplification, filtering, mixing and noise. Please contact:

Todd Fischer

Technical Employment Consultants

(P) 215-396-4975

(F) 215-396-1501

tectodd@aol.com

### CDI

CDI Telecommunications is part of a large public corporation (NYSE) serving customers nationwide.

We are seeking experienced personnel for the following positions:

#### CELLULAR & PCS

Program Managers  
Network Engineers  
RF Engineers  
Installers

Construction Managers  
Real Estate Specialists  
Salespersons - Testers  
Technicians

Fax resume to:

**CDI Telecommunications, Inc.**

800-669-1890, Ext 798

Fax: 800-875-1904

2800 N. 44th Street, Suite 800,  
Dept. RFD, Phoenix, AZ 85008-1500  
E.O.E.

Phone: 800-527-0373

Fax: 800-784-0499

2425 N. Central Expressway, #101  
Richardson, TX 75080  
E.O.E.



...your connection to the best opportunities nationwide!

**National Engineering Search®** is the leading search firm placing Engineers nationwide. Contact Us for immediate access to today's most exceptional career opportunities! Our clients range from the Fortune 500 to the most successful emerging technology companies.

800/248-7020

FAX: 800/838-8789

email: nes@nesnet.com

3700 East Avenue • Rochester, NY 14618  
1235-E East Blvd. 145 • Charlotte, NC 28227

See many of our current opportunities on-line at:

[www.nesnet.com](http://www.nesnet.com)

#### DESIGN/DEVELOPMENT ENGINEERS:

##### IMMEDIATE OPPORTUNITIES IN:

Communications (Data, PCS, Cellular, Networks, Satcom, GPS), CATV, Computers, Medical, Security, Defense, Semiconductors, Software, Consumer Electronics

##### Skills in any of the following:

Wireless Design, Digital & Analog Design, ASIC, FPGA, SiBipolar/BiCMOS/GaAs, Mixed Signal, MMIC, Spread Spectrum, DSP, Antennas, Passive Components, PLL, Synthesizers, Simulation, Verification, Embedded SW

**What are you worth?**  
See our on-line Salary Survey!

### CAREER OPPORTUNITIES NATIONWIDE Engineers & Tech's

Systems and Components, RF, PCS, Microwave, Antenna, Network, Software, Sales, Dig. & Analog, Mixed Signals, many more. Resume to: Peter Ansara, c/o ABF, P.O. Box 239, W. Springfield, MA 01090. Tel: (413) 733-0791, Fax: (413) 731-1486 or pa@ansara.com.

See our web site: <http://www.ansara.com>

[www.rfdesign.com](http://www.rfdesign.com)

### R.F. ENGINEERS: NATIONWIDE

R.F./WIRELESS/RECEIVERS/AMPS  
CDMA/TDMA/SPREAD SPECTRUM  
SATELLITE & ANTENNA DESIGN

Respond to: CTH Corporation  
2204 Bahia Vista #D7, Sarasota, FL 34239  
Phone: 941/362-2773 • Fax: 941/362-0217  
E-mail: [cth@mindspring.com](mailto:cth@mindspring.com)

We can create a custom reprint for any marketing effort without breaking your budget.

For a quote call: **Jenny Eisele**  
Phone: 913-967-1966 • Fax: 913-967-1898



**MANAGEMENT  
RECRUITERS®  
OF BOULDER, INC.**

The search and recruiting specialists

### WINDY BRADFELD

RF / MICROWAVE SPECIALIST

CONTINENTAL BLDG., SUITE 301  
1401 WALNUT STREET, P.O. BOX 4657  
BOULDER, COLORADO 80306  
(303) 447-9900  
FAX(303) 447-9536



www.conexant.com

## RF SYSTEMS ENGINEERS

### Positions in Newport Beach, CA

Conexant Systems, Inc., formerly Rockwell Semiconductor Systems, is the world's largest semiconductor company totally dedicated to communications technologies. We are a driving force in 60% of all Internet connections, 70% of the world's fax machines, and 80% of CDMA cell phones. For decades, our mixed signal computing solutions have been inside faxes, computer modems, cellular and cordless phones, PC multimedia peripherals, digital infotainment appliances and network access equipment.

We have exceptional opportunities for RF Systems Engineers to provide support in specification, design and simulation of complex digital cellular and cordless communication systems. You will perform trade-off studies to provide specification subsystems. Requires MSEE or equivalent and 10 years hands-on experience. Experience in systems design, including receivers, transmitters, and synthesizers essential. Must be able to apply system work toward implementation of RF ASIC devices. Strong background in communication theory and knowledge of system simulation using state-of-the-art CAD tools necessary. Familiarity with digital RF modem design a plus.

We offer highly competitive salaries and a comprehensive benefits package including stock options. Please send resume to: **Conexant Systems, Inc., Professional Staffing, Dept. Code RFD0599-CW, 4311 Jamboree Road, Newport Beach, CA 92660;** Fax: 888-815-1923; or Email: [connie.williams@conexant.com](mailto:connie.williams@conexant.com) Website: [www.conexant.com](http://www.conexant.com)  
We are an equal opportunity employer supporting diversity in the workplace.



### ...YOUR CAREER

**Wireless IC Design Centers:** Major corporations select several key Sr. Technologists to staff wireless design centers located throughout the US. Technical expertise in the area of Si RF IC's for wireless communication applications (AMPS, DAMPS, GSM, DECT, PCS). Si RF IC design experience in the 400-2400 MHz. Past RF PLL synthesizer design experience. BS/MS/PhD.

**Sr. Systems Architecture, Wireless Handsets & Base Stations:** Define RF system architectures in low-cost receiver-transmitter design on discrete circuit level. Knowledge of integrated circuit architecture, modulation theory and digital signal processing.

**Director of Operations:** Responsible for existing operation and growth of division into new business opportunities.

**Process Manager/Staff Engineers:** Responsible for technical support in wafer fabrication, process development and sustaining engineering in device manufacturing. Directs the development and implementation of new wafer fabrication process formulas and establishes operating equipment specifications.

**CATV Design:** RF Design experience should include LC filter, microstrip, amplifier, circuit modeling and system analysis in the 5-1000MHz range. BS/MSEE filter optics a plus.

**RF Test Engineer:** You will develop automated test software and procedures for RF/analog circuits. Experience using cellular test equipment. GPIB (HP VEE/LabVIEW) programming and CDMA/AMPS knowledge a plus. Will consider highly motivated entry-level RF Engineers with BSCE.

**Regional Field Sales:** Aggressive individuals to create and serve new accounts. Positions are located throughout the U.S.A. An engineer who wants to enter sales world is acceptable. Base salary, commission and car. BSEE.

**Applications Engineers:** Responsible for providing customers with RF technical product development, developing application notes and data sheets. Requires BSEE/MSEE with minimum 3 years RF design/product experience, strong RF/microwave measurement skills; design experience with analog and digital modulation schemes (AMPS, GSM, TDMA, CDMA); and strong communication and customer relation skills.

**RF Engineer:** RF circuit design and development for wireless phones. Develop radio architectures and RF circuit design for systems operating in the 800-900MHz and the 1800-2000MHz regions.

**Sr. Project Antenna Design:** Lead the conception, design and development of a wide variety of antennas and antenna systems, including both reflector and array systems using microstrip, stripline and waveguide technologies. BS/MS with 5 years experience.

**RF Design Manager:** Lead a team of RF engineers from initial design and implementation through product incorporation and testing into high volume production. 8+ years of RF design with emphasis on low cost radio design. BS/MS.

**Sr. MMIC Design:** Design highly integrated GaAs MMICs for advanced cellular products. Circuits to be designed include: power amplifiers, LNAs, mixers, IF amplifiers, buffer amplifiers. RF frequencies are 900 and 1800 MHz.

**Product Line Manager Wireless:** Specific responsibilities include product line strategic planning, establishing revenue and price objectives, setting internal cost targets and oversight of internal product realization schedules.

**RF PA Engineers:** Requires 4+ years experience in design, test and manufacturing of high efficiency GaAs MESFET and HBT class A and C power Amplifiers (2+ watts) in the frequency range (2-20GHz). Experience in both discrete and MMIC design a plus.

**Sr. Analog IC Designers:** Responsible for conceptual circuit design and developing new analog/mixed signal IC's. BS/MS experience in A/D D/A, ASIC's bipolar and BiMOS.

**Filter Design Engineer:** Development of microwave high "Q" coaxial cavity and machine filter designs for PCS base stations. BS/MS familiar with simulation and modeling tools, three plus years filter design experience with direct "Q" designs (6-8000 Q's).

**RF Systems Engineers:** You will analyze, design, develop and simulate RF systems architecture (DC to 2 GHz) for next generation of cellular phones, working in a multi-disciplinary team environment using integrated product development approach. Requires a minimum of seven years' experience in RF communication systems. BSEE or MSEE preferred.

**Senior RF Engineer:** Design RF and Microwave components for microwave digital communication links. Develop RF hardware block diagrams and perform analysis for communication systems. BSEE or MSEE with 5+ years experience in Microwave circuit design such as microstrip, low noise amplifiers, power amplifiers, mixers, oscillators and RF circuits.



**MICRO COMMUNICATIONS**  
EXECUTIVE SEARCH

We specialize in the placement of wireless, RF, microwave communications nationally.

FOR THESE AND OTHER OPENINGS  
CALL COLLECT: TEL: 978-685-2272

800 Turnpike St. • North Andover, MA 01845  
E-mail: [micsrch@aol.com](mailto:micsrch@aol.com) FAX: 978-794-5627



Powerwave Technologies is a leader in the design and manufacture of superior quality RF high power amplifiers for wireless communications. We are seeking talented and motivated individuals to join us in our **Irvine or Folsom, CA** facilities.

### Digital Design Engineer

Responsible for designing the digital hardware/firmware that controls the operation and interfaces of Power Amplifiers. Will identify innovative processes to ensure optimum performance and cost effective products via intelligent digital control circuitry. Requires a BSEE or equivalent and 5+ years digital design experience. Knowledge of DSP and RF components including Power Amplifier design is a plus.

### RF Design Engineer

Responsible for design of high linearity RF/Microwave Power Amplifiers for cellular and PCS infrastructure applications. Design experience with feed-forward or predistortion is desirable. Requires a BSEE or equivalent and 5+ years of design experience in the RF/Microwave industry.

### Mechanical Design Engineers

Responsible for mechanical design of RF Power Amplifiers including tolerances, thermal analysis, and design for manufacturing. Requires a BSME or equivalent and 5+ years experience in an RF mechanical design role. Must be fluent in mechanical design software and thermal modeling programs.

We offer an excellent compensation package including bonus, profit sharing, 401(k) and stock purchase plan. Send your resume to: **Powerwave Technologies, Attn: HR, 2026 McGaw Avenue, Irvine, CA 92614.** FAX: (949) 757-6672. Email: [hr@pwav.com](mailto:hr@pwav.com). Please visit our website at [www.powerwave.com](http://www.powerwave.com). EOE/MF/DV



## MOVING? TAKE US WITH YOU.

Just peel off your subscription mailing label and attach it to the reader service/subscription card inside this issue. Please allow 6-8 weeks to process your address change.



Place your business on **top** of the world with 40,000+ worldwide circulation! Advertise in *RF Design*!



## **TAD** *Telecom, Inc.*

Whenever, Wherever, TAD Telecom provides premier personnel and project services worldwide.

### **ENGINEERING OPPORTUNITIES AVAILABLE**

- Sr. Project Engineers
- RF Engineers
- Project Engineers
- RF Design Engineers
- Field Engineers
- RCDD & Project Engineers
- LAN/WAN Network Engineers
- Switch Engineers/Technicians

Retiree's Welcome!  
Health Insurance,  
401 (k), Holiday/Vacation  
Call or fax resume to:



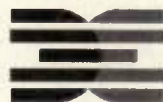
National Recruiting Office  
4405 International Blvd., Suite B-102  
Norcross, GA 30093  
Ph: 800-843-6910  
Fax: 800-545-1988  
Email: [tadtelecom@adeco.com](mailto:tadtelecom@adeco.com)  
(rtf or txt format preference)  
Web site at  
<http://www.tadtelecom.com>

## **PROJECT MANAGERS RF CIRCUIT DESIGNERS**

Elektrobit is an engineering company with offices in USA, Finland, Switzerland and Japan. We have extensive experience in commercial wireless product development working with the latest technologies (e.g. GSM, CDMA, etc.) We develop our own products and also serve as an OEM to the industry. We are growing rapidly and looking for engineers with wireless background to join our team in Redmond, WA or Dallas, TX. We are interested in team players with M.Sc. or B.Sc. in electrical engineering and excellent communications skills. Furthermore design and/or project management experience in the following areas is required:

- Wireless product development (infrastructure and/or handsets)
- Design for low cost and high yield manufacturing
- RF design up to 2-3 GHz
- Concurrent engineering

We offer casual, open work environment, international setting, plenty of responsibility and opportunity for growth in start up environment.



### **ELEKTROBIT INC.**

11241 Willows Rd. NE, Suite 320  
Redmond, WA 98052  
Fax: 425-376-0235  
e-mail: [Vesa.Raudaskoski@elektrobit.com](mailto:Vesa.Raudaskoski@elektrobit.com)  
[www.elektrobit.fi](http://www.elektrobit.fi)

# Has the job search got you in a maze?

## Let RF Design help.



Whether you are looking for a job or looking to fill a job, let RF Design help!

Call Jody at 1-888-234-0488  
for more information.

# Because it works.

The *RF Design* direct mail maintains a clean, qualified subscriber list.

*RF Design* magazine meets the tough audit standards of BPA International. So when we say you'll reach over 40,000\* professionals in radio frequency design — we mean it.

When you're ready to reach this qualified group of professionals call Lori Christie and let our names work for you!



**phone** 913-967-1875

**fax** 913-967-1897

**e-mail** [lori\\_christie@intertec.com](mailto:lori_christie@intertec.com)

**website** [www.interteclists.com](http://www.interteclists.com)

\*Based on the June 1998 BPA International Circulation Statement



• SWITCHES



- **MODEL MSN-10DR/DT-05**  
FREQUENCY: 0.5 to 18.0 GHz  
INSERTION LOSS: -4.5 dB  
ISOLATION: 70 dB  
VSWR: 2.0:1  
SPEED DELAY ON: 75 nS Typ.  
DELAY OFF: 75 nS Typ.  
SIZE: 5.00" x 1.50" x 0.40"

• ATTENUATORS (Multioctave & Octave Bands / Digital, Analog, or Current Controlled)



- **MODEL DVAN-2040-60-8.1**  
FREQUENCY: 2.0 to 4.0 GHz  
ATTENUATION RANGE: 60 dB  
INSERTION LOSS: -2.0 dB  
VSWR: 2.0:1  
FLATNESS: @ 10 dB  $\pm 0.4$  dB  
@ 20 dB  $\pm 0.8$  dB  
@ 40 dB  $\pm 1.5$  dB  
@ 60 dB  $\pm 1.6$  dB  
ACCURACY: 0 to 30 dB  $\pm 0.5$  dB  
30 to 50 dB  $\pm 1.0$  dB  
50 to 60 dB  $\pm 1.5$  dB  
SWITCHING SPEED: < 500 nS  
SIZE: 2.00" x 1.80" x 0.50"

• DETECTOR LOG VIDEO AMPS



- **MODEL LVD-218-50**  
FREQUENCY: 2 to 18 GHz  
FREQUENCY FLATNESS  $\pm 1.0$  dB  
DYNAMIC RANGE: -40 to +5 dBm  
LOG LINEARITY ERROR:  $\pm 0.5$  dB  
PULSE RESPONSE: 50 nS to CW  
RISE TIME: 20 nS  
SETTLING TIME: 45 nS  
RECOVERY TIME: 150 nS TYP.  
TSS: -42 dBm  
VSWR: 3.0:1  
MAXIMUM RF INPUT: +15 dBm  
SIZE: 2.20" x 1.50" x 0.40"



AMERICAN  
MICROWAVE  
CORPORATION

"IN PURSUIT OF EXCELLENCE THROUGH  
ENGINEERING"

7311-G Grove Road, Frederick, MD 21704  
Tel (301) 662-4700, Fax (301) 662-4938  
WEB PAGE: [HTTP://WWW.AMWAVE.COM](http://www.amwave.com)  
E-MAIL ADDRESS: [AMCPMT@AOL.COM](mailto:AMCPMT@AOL.COM)

# Filters to 50 GHz

- Waveguide
- Stripline/Microstrip
- Transmission Line
- Miniature/Subminiature
- Lumped Constant.

For more information, ask for  
our RF Catalog.



**MICROWAVE FILTER COMPANY**

6743 KINNE STREET, E. SYRACUSE, NY 13057  
315-438-4700 • 800-448-1666 • FAX: 315-463-1467  
E-MAIL: [mfcsales@microwavefilter.com](mailto:mfcsales@microwavefilter.com)  
<http://www.microwavefilter.com>



## Analog & RF Models

SPICE Models, full non-linear  
models including class C, opto  
and logic. NEC antenna models.  
Measurements. Consulting.

Phone: (520) 575-5323  
[www.users.uswest.net/~bsands](http://www.users.uswest.net/~bsands)

[www.rfdesign.com](http://www.rfdesign.com)

**RFdesign**

## BUYERS' SOURCE

### ANTENNAS



**M<sup>2</sup> ANTENNAS** 1.6 - 3000 MHz  
Positioners & Pedastals

We Specialize in High Gain Arrays  
Standard & Custom Designs

7560 N. DEL MAR AVE., FRESNO, CA 93711  
Ph: (209) 432-8873 Fax: (209) 432-3059 Website: [m2inc.com](http://m2inc.com)

### DISCRETE COMPONENTS

#### CAPACITORS

Vacuum

**SURCOM ASSOCIATES, INC.**

2215 Faraday Avenue, Suite A, Carlsbad, CA 92008  
Phone: (760) 438-4420 Fax: (760) 438-4759  
E-mail: [link@surcom.com](mailto:link@surcom.com) Web: [www.surcom.com](http://www.surcom.com)

### DISCRETE COMPONENTS

#### CRYSTALS/RESONATORS

Varactor

Knox Semiconductor, Inc.  
13 Quarry Rd., P.O. Box 609, Rockport, ME 04856

Phone: (207) 236-6076  
Fax: (207) 236-9558

### DISCRETE COMPONENTS

#### CAPACITORS

Mica High Power

**SURCOM ASSOCIATES, INC.**

2215 Faraday Avenue, Suite A, Carlsbad, CA 92008  
Phone: (760) 438-4420 Fax: (760) 438-4759  
E-mail: [link@surcom.com](mailto:link@surcom.com) Web: [www.surcom.com](http://www.surcom.com)

Variable

**SURCOM ASSOCIATES, INC.**

2215 Faraday Avenue, Suite A, Carlsbad, CA 92008  
Phone: (760) 438-4420 Fax: (760) 438-4759  
E-mail: [link@surcom.com](mailto:link@surcom.com) Web: [www.surcom.com](http://www.surcom.com)

### Crystals • Oscillators • VCXOs • TCXOs

**SaRonix**

141 Jefferson Dr • Menlo Park • CA 94025  
650-470-7700 • 800-327-4032

[saronix@saronix.com](mailto:saronix@saronix.com)

[www.saronix.com](http://www.saronix.com)

Need to sell surplus equipment  
or overstock?

Call 888-234-0448.  
The call is free.

**RFdesign**

Jody Schrader  
1-888-234-0448  
Classified Advertising Manager



Take note:

RF Design  
Classifieds Work!



## DISCRETE COMPONENTS

### CRYSTALS/RESONATORS

#### West Crystal Company Ltd

Since 1980

- 1 to 200 MHz custom crystals
  - Tight spec. quic, turn
  - Lifetime warranty
  - ISO 9002 certified
- www.westcrystal.com  
250-765-4833 Fax: 250-765-3308  
Email: wcrystal@home.com  
10 - 2550 Acland Rd, Kelowna, BC  
V1X 7L4 Canada

## ELECTRONIC COMPONENTS/EQUIPMENT

### TRANSFORMERS

- RF TRANSFORMERS UP TO 300 MHZ
- POWER SPLITTERS & COMBINERS 2-30 MHZ AND 88-108 MHZ
- TRANSFORMER DESIGN CONSULTATION



17827 N. 26th. Street  
Phoenix, AZ 85032

Ph:(602)867-0389•Fax:(602)971-9295•www.rfpowersystems.com

### EMI SUPPRESSION COMPONENTS



#### Fair-Rite Products Corp. Your Signal Solution™

P.O. Box J 1 Commercial Row,  
Wallkill, NY 12589

Phone (914) 895-2055 • FAX (914) 895-2629  
E-Mail ferrites@fair-rite.com

Fair-Rite Products Corp., a QS9000 registered company, is a leading full-line ferrite component manufacturer offering a wide variety of components for EMI suppression and power applications utilizing innovative processes and materials.

## MATERIALS/HARDWARE/PACKAGING

### SHIELDING MATERIALS

#### EMI/RFI Shielding Tapes

Conductive Adhesives & Tapes  
Foils/Fiber/Fabric/Gasketing/Laminating

#### Venture Tape Corp.

30 Commerce Road, Rockland, MA 02370  
Tel: (800) 343-1076 Fax: (781) 871-0065  
Visit us at: www.venturetape.com

## WANT A BRIGHT IDEA?

Advertise in RF Design  
Classifieds!



## MODULAR COMPONENTS

### OSCILLATORS



#### Wenzel Associates

"Quietly the Best"

- Standard and Ultra Low Noise Crystal Oscillators
- New Low Noise RF Modules
- Ultra Low Noise Frequency Standards

PH 512-450-1400 Fax 512-450-1490 www.wenzel.com

## PRODUCT DEVELOPMENT

### CUSTOM OEM PRODUCT DEVELOPMENT/SUPPLY

Locus, Inc.  
1842 Hoffman St., Madison, WI 53704

Phone: (608) 244-0500  
E-mail: www.locusinc.com

## RF TRANSMISSION COMPONENTS

### INDUCTORS AND CHOKES



- Lightning Suppressors
- D.C.-26GHz Coaxial
- Powerline • Digital

FISCHER CUSTOM COMMUNICATIONS, INC.  
2917 W. Lomita Blvd., Torrance, CA 90505

Phone: (310) 891-0635  
Fax: (310) 891-0644  
E-mail: sales@fischercc.com

Custom Inductors and Chokes For  
VLF, LF, MF and HF Applications

Kintronic Labs  
144 Pleasant Grove Rd., Bluff City, TN 37618  
Phone: (423) 878-3141 • Fax: (423) 878-4224  
Email: ktl@kintronic.com  
Web Site: www.kintronic.com



25-27 August 1999  
Washington Convention Center  
Washington, D.C. USA  
www.scec.com

Intelligent  
satellite  
network  
solutions for  
your business.

For more information,  
call 1-800-288-8606  
or +1-303-741-2901.

## SOFTWARE & SYSTEMS, CAD/CAE

### SYSTEM SIMULATION

**Rf Intercept.** Increase your design confidence by simulating and optimizing entire systems: IM, noise, S/N, BER, eye pattern, spectral occupancy.

**RHR Laboratories, 207 Harding Blvd. W.  
Richmond Hill, ON, L4C 8X6, Canada**

Tel.: (905) 884-2392 • Fax: (905) 884-6843  
104673-3110@compuserve.com  
http://lypn.com/rhrlaboratories

Tesoft, Inc.  
205 Crossing Creek Ct., Roswell, GA 30076  
Makers of TESLA for Windows Simulator

Phone: (800) 631-1113  
Fax: (770) 664-5817  
Intl: (770) 751-9785

## TEST EQUIPMENT

### RF TEST & MEASUREMENT EQUIPMENT

Coaxial Dynamics, Inc.  
15210 Industrial Pkwy., Cleveland, OH 44135

Phone: (216) 267-2233  
Fax: (216) 267-3142



17-19 November 1999  
Miami Beach Convention Center  
Miami Beach, Florida U.S.A.

**Globalization. Innovation.  
Convergence.**

Telecom Latina'99 delivers the  
information and technology that  
communications professionals in  
Latin America need to prosper in this  
new marketplace.

For more information on attending or  
exhibiting, call 1-800-288-8606 or  
+1-303-741-2901.  
Or visit our Web site: www.telecomlatina.com





by Ernest Worthman

# Platform independence...maybe, but RF sure looks like a major player

OK, I've been saying it for years. And I have been hearing from futurists for years as well. Pretty soon, they say, it won't make any difference whether or not we have to understand how it's done. End-to-end connectivity is the "pièce de résistance"—the final frontier of communications. It won't matter if it's a computer, mobile phone, a locator device (such as global positioning system (GPS) or automatic vehicle location (AVL)), a pager, an office, a home, a person, a vehicle...or even the microwave!

There will be that "magic channel" that will connect everything, whether it's wireline, wireless, telepathic, interdimensional, intuitive or artificially intelligent. Well, that's nice for that "end user" but for those of us that have to make this "channel" technology work, it will be a challenge. Especially with so many platforms needing integration.

Knowing what I know about technology, I have this funny feeling that much of this "channel" will be wireless-based. Simply because it may be practical to build the copper, fiber, infrared (IR), ultrasonic, or other cheaper communications ability into future devices and buildings, it generally isn't cost-effective to retrofit the existing infrastructure.

We pretty much have the installations and the RF technology part down pat. Therefore, I believe one of the biggest challenges the RF industry will face, in the next few years, will be the interface.

Because I'm limited to how many words this column can contain, I chose to take a look at one of the hotter topics in intelligent communications—the smart house—and see what some of these challenges might be.

We have to assume a couple of

things. First, each device has some sort of intelligent interface. On one end may be a computer, or at least a full-blown central processing unit (CPU), much like today's X86-based technology, or more likely a reduced instruction set computer (RISC).

The second assumption is the opposite end will contain a simple RF identification (RFID) code that is merely unidirectional (off or on state). One alternative is that others may contain an application specific integrated circuit (ASIC) that is distinctly designed for the device. Depending on the level of intelligence, the device could be capable of remotely setting multiple on-times, off-times and cycle-times, as well as status, feedback and real time on-the-fly instructions.

Within this home, I see a low-power RF-based network. Every device on the system would have an RF interface. The transmission system would be digital spread spectrum, probably at GHz frequencies. Even as it connects to the outside world, it could also be low-power RF with a transceiver and a tiny antenna in the attic or on the roof. On every block there is a central controller with solar power and battery backup. This central controller connects to the "worldwide network" (WWN), to which all controllers are linked via, most likely, a fiber cable or perhaps a microwave link. Or it could talk to the low earth orbit satellites (LEOs) and bypass terrestrial communication links altogether.

There wouldn't be much of a problem within the house. Since it would be a local "cell." The major issue here is between the digital mode of the devices and the RF transmitter (or transceiver, in the more sophisticated devices). As the RF and digital world are already

finding each other, this should be relatively easy to implement.

The more complex issues will be the interface between the RF devices and those that use other communications mediums (those mentioned earlier). There might also be some issues with the premise exit interface as well. Does it connect to fiber, copper, satellite, microwave, etc.? Although these technologies have been pretty well integrated with RF already, it may be that a ubiquitous interface is needed—remember platform independence.

So, now it seems a matter of getting the related industries together to power up before, as other industries have proven, it turns into a free-for-all. There is a tremendous opportunity for all these industries (as well as many others too numerous to mention) to form partnerships, share technology, and develop devices, interfaces and a channel that is reliable, dependable and...works (which is more than I can say for today's cellular infrastructure).

OK, I'm going to take a break now and interconnect my TTIM (Transcendental Telepathic Interbrain RF Modulator), and will my microwave to heat up the bagels.



**Ernest Worthman is RF Design's contributing editor. He is a fellow of the Radio Club of America and a member of the IEEE. He holds a B.S. in electronics engineering technology and teaches college courses in electronics and computers. Ernest is easily recognizable at conferences by the coffee cup surgically attached to his hand. You can contact Ernest by e-mail at [ernest\\_worthman@ieee.org](mailto:ernest_worthman@ieee.org).**



# NEW ERA AMPLIFIERS

**WOW!** DC to 8GHz **\$1<sup>19</sup>**  
(up to +18.5dBm output) From (1000 qty.)

Mini-Circuits ushers-in a new era of technology and economy with ERA monolithic GaAs amplifiers. Just check the specs! These surface mount and drop-in amplifiers cover your applications to 8GHz with higher gain, more output, and flatter response. Characterized with S-parameter data, these amplifiers are very easy to use. Simply sketch an interconnect layout, and the design is done. And ERA's are engineered with wider bandwidths to eliminate your need for costly compensation networks and extra gain stages. So, review your present design and replace with Mini-Circuits new ERA technology. Lower overall cost, wide bandwidth, and lots to...gain!

**Mini-Circuits...we're redefining what VALUE is all about!**

Model	*Freq. (MHz)	Gain (dB)	Max Power Out (dBm, @ 1dB Comp)	Dynamic Range NF(dB) IP3(dBm)	@Device Current(mA)	@Price \$ ea. (10 Qty.)
ERA-1	DC-8000	11.8	11.7	5.3 26.0	40	1.80
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.

#### DESIGNER'S AMPLIFIER KITS:

K1-ERA: 10 of each ERA-1, -2, -3 (30 pieces) only \$49.95

K1-ERASM: 10 of each ERA-1SM, -2SM, -3SM (30 pieces) only \$49.95

K2-ERA: 10 of each ERA-4, -5 (20 pieces) only \$69.95

K2-ERASM: 10 each ERA-4SM, -5SM (20 pieces) only \$69.95

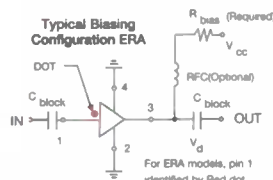
K3-ERASM: 10 each ERA-4SM, -5SM, -6SM (30 pieces) only \$99.95

#### Chip Coupling Capacitors at 12¢ each (50 min.)

Size (mils)	Value
80x50	10, 22, 47, 68, 100, 220, 470, 680, 1000, 2200, 4700, 6800, 10,000 pF
120x60	.002, .047, .068, .1 µF



ERA-1 ERA-1SM  
ACTUAL  
SIZE



**Free User Guide!**  
Packed with comprehensive technical support. Shipped with order, or call for your free copy today.

## Mini-Circuits®

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 INTERNET <http://www.minicircuits.com>

For detailed specs on all Mini-Circuits products refer to • 760- pg. HANDBOOK • INTERNET • THOMAS REGISTER • MICROWAVE PRODUCT DATA DIRECTORY • EEM

ISO 9001 CERTIFIED

US 65 INT'L

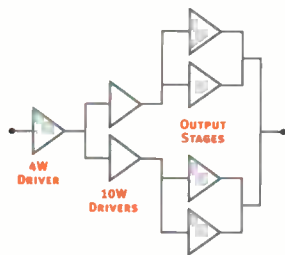
CIRCLE READER SERVICE CARD

F 214 Rev F



# www.here do you find L&S Band Power?

Need power for your MMDS transmitter? NEC's NES2527B-30 Class A MESFETs deliver, with high efficiency and low distortion. For PCS, our NES1821B-30 delivers the power and linearity



your new designs demand, with Class A or AB operation.

Combine them with our NE650 Series drivers and the benefits of our

low-distortion devices really begin to multiply.

Best of all, we design these devices right here at CEL.

So if you ever have a question, the guys you'll really want to talk to are just a phone call away.

Want data sheets? That's easy too. Download them directly from our website. Or we'll fax them to you right now. Just dial **800-390-3232**.

#### NE6500496

##### 4W DRIVER

11.5 dB Gain, 45% Efficiency  
Fax Document # 205



#### NE6501077

##### 10W DRIVER

10.5 dB Gain, 40% Efficiency  
Fax Document # 207



#### NES1821B-30

##### 30W MESFET

45 dBm @ 1.9 GHz, 13.0 dB Gain  
Class A or AB Operation  
Fax Document # 227



#### NES2527B-30

##### 30W MESFET

45 dBm P<sub>1dB</sub>, 13.0 dB Gain  
40% Efficiency  
Fax Document # 231

Visit us at MTT-s Anaheim  
**BOOTH 657**  
June 15 - 17

[www.cel.com](http://www.cel.com)

**CEL** California Eastern Laboratories

**NEC**

4590 Patrick Henry Drive ■ Santa Clara, CA 95054 ■ 408 988-3500

DISTRIBUTORS: Arrow/Bell (800) 525-6666 Repron Electronics (888) REPRON

Mouser Electronics (800) 346-6873 Electro Sonic (800) 567-6642 (CANADA)

INFOCARD 55

W21