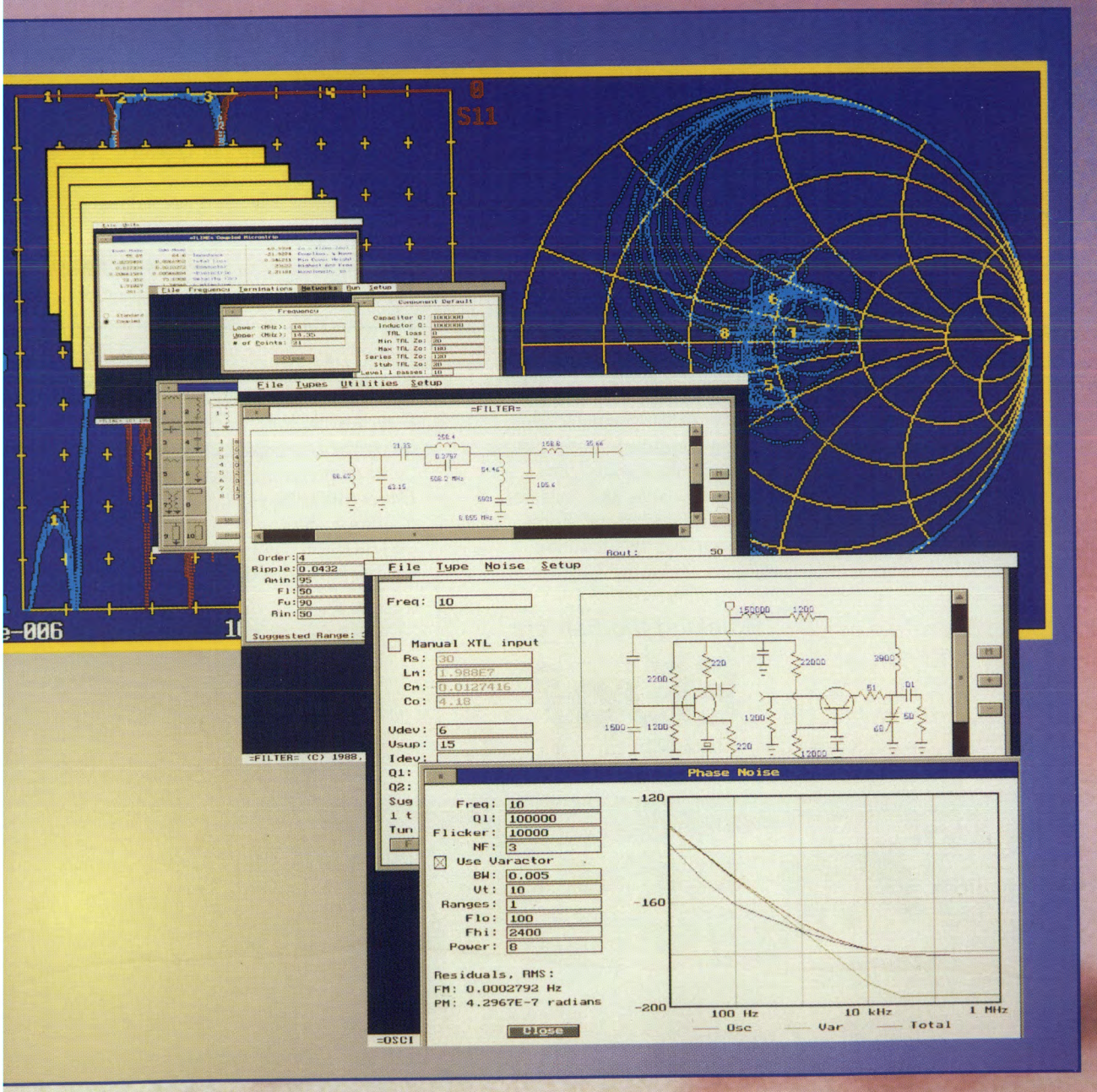
RF design

engineering principles and practices

December 1991



Cover Story
Software for Synthesis and Simulation

Featured Technology
Techniques for RF Power

1990-1991 Article Index

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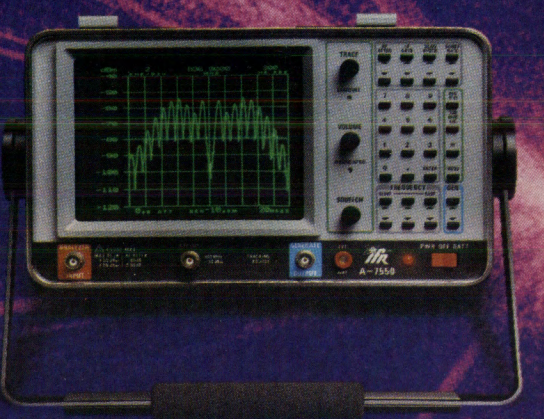

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DSO990	SPST	10-2000	1.5	62	25.0	14 Pin DIP	TTL
DSO850	SP2T	DC-2000	0.4	47	3.0	TO-5	0/-7
DSO813	SP2T	DC-2000	0.7	39	130	TO-5	TTL
DSO812	SP2T	10-1000	0.5	53	50.0	TO-8	TTL
DSO860	SP2T	10-1000	0.7	47	40.0	.380 sq	TTL
DSO602	SP2T	5-2000	1.3	65	26.0	14 Pin DIP	TTL
DSO842	SP2T	5-1500	1.0	75	50.0	14 Pin DIP	TTL
DSO864	SP4T	5-2000	1.3	49	28.0	16 Pin DIP	TTL
DSO874	SP4T	DC-2000	2.2	60	52.0	14 Pin DIP	TTL
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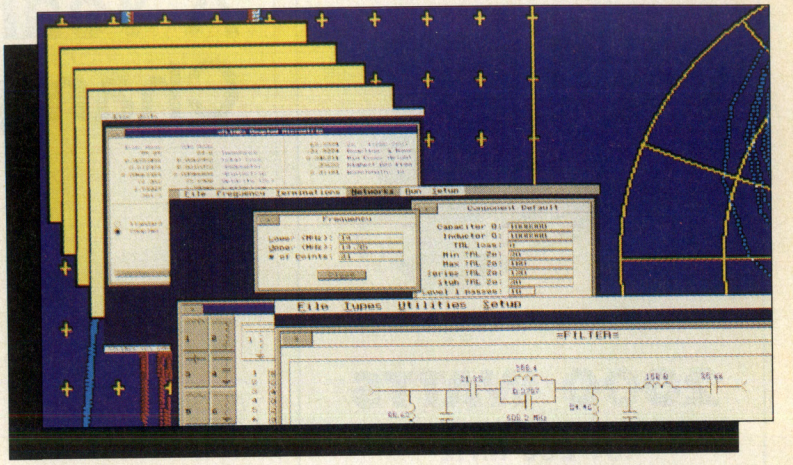

featured technology

27 Platinum-Clad Wire Improves Power Tube Performance

General Electric has developed a platinum clad molybdenum wire for vacuum tube filaments and power grids. The material improves performance and saves money over conventional platinum plated wire. — *Edward F. Kelly*

30 A Modular Two-Band Diplexer

A diplexer was developed to connect two transceivers to a single multi-band antenna, permitting simultaneous operation. The design is based on two independent modular isolating sections and lends itself to expansion. — *J. Robert Witmer*

cover story

37 Software Family Integrates Synthesis and Simulation

Computers have gradually become a major tool in the RF engineer's tool kit. New products include necessary synthesis and analysis functions, along with optimization, graphical interface, and convenient operation. — *Randall W. Rhea*

design awards

49 An Improved Tau-Dither Technique for Spread Spectrum Code Tracking

One of the most exciting trends in modern communication technology is spread spectrum techniques for commercial systems. Until now, however, basic signal processing functions have been relatively complex. This note covers traditional data recovery techniques, including a revised method of implementation. — *Harry B. Brown III*

58 Analysis Program for Coaxial Cable

This program from the 1991 RF Design Awards contest was developed for analysis and synthesis of round conductor coaxial transmission lines. Electrical and mechanical parameters are determined from the user's data. — *Eric L. Stasik*

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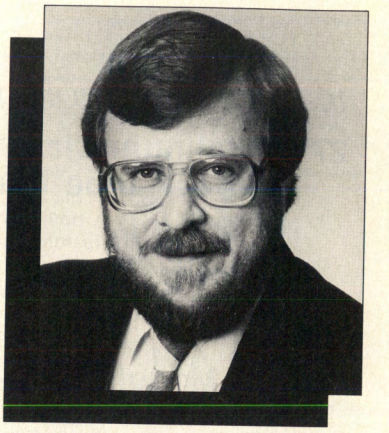
A Year of Change



By Gary A. Breed
Editor

The past year will be noted in history for many significant events. World politics dominates the news with the final collapse of the Communist Party as the dictatorial head of Eastern Europe. The ensuing chaos will be with us for many months or years, but the seeds of self-determination and open economic principles have been sown and are beginning to grow.

A few countries, notably Poland, Czechoslovakia, Hungary and the Baltic republics, have managed to escape much of the disruption. Although these nations are far from stable, they give us hope for a peaceful resolution of a difficult transition. Engineers and educators from these countries, and from Romania and Yugoslavia have shown great interest in sharing ideas with their Western counterparts.

The Gulf War with Iraq was a showcase for high-tech weaponry and communications. But it also continues to be a reminder that there will always be efforts for domination and conquest. The extremely difficult process of negotiating for peace between Israel and its Arab neighbors is ample reason to remain cautious about the future.

The slowdown of the U.S. economy has certainly been big news in 1991. The sluggishness continues, with most analysts predicting a slow recovery. U.S. automobile makers are having their worst year in a long time. The electronics business has slowed as well, but with extreme variations between many successful markets and others which are suffering.

This might also be considered a year in which the U.S. lost its leadership role in some key areas. The European Community will implement its unified economic system in 1992, with a number of regulatory standards that will establish worldwide criteria for electronics products. Japan and Europe established themselves as undisputed leaders in direct broadcast satellite (DBS) technology. A number of RF companies attribute their current success to sales into foreign markets, with DBS being just one of many active application areas. Maybe it's a coincidence, but this year was the first time in many years that an American did not win or share a Nobel Prize.

Fortunately, there has been much good news in technology during 1991. The Hubble Space Telescope, despite its optical flaws, is revealing secrets about the universe. At least three major theories have been disproved and new phenomena discovered. Venus is being mapped with high resolution radar for the first time. Intense solar activity has provided unprecedented opportunities for research. Knowledge gained from these endeavors will help us understand our own planet and the fundamental nature of matter.

The technology represented in these scientific studies is just one bright spot. Communications technology is bringing the world together, whether it is by satellite telephone from a hotel in Baghdad, live broadcast of an attempted coup in Moscow, encrypted financial data transmitted from Tokyo to New York, or just checking on dinner plans using a cellular phone in Denver. RF technology is as big a part of globalization as any other factor, and we can take pride in our own personal contributions.

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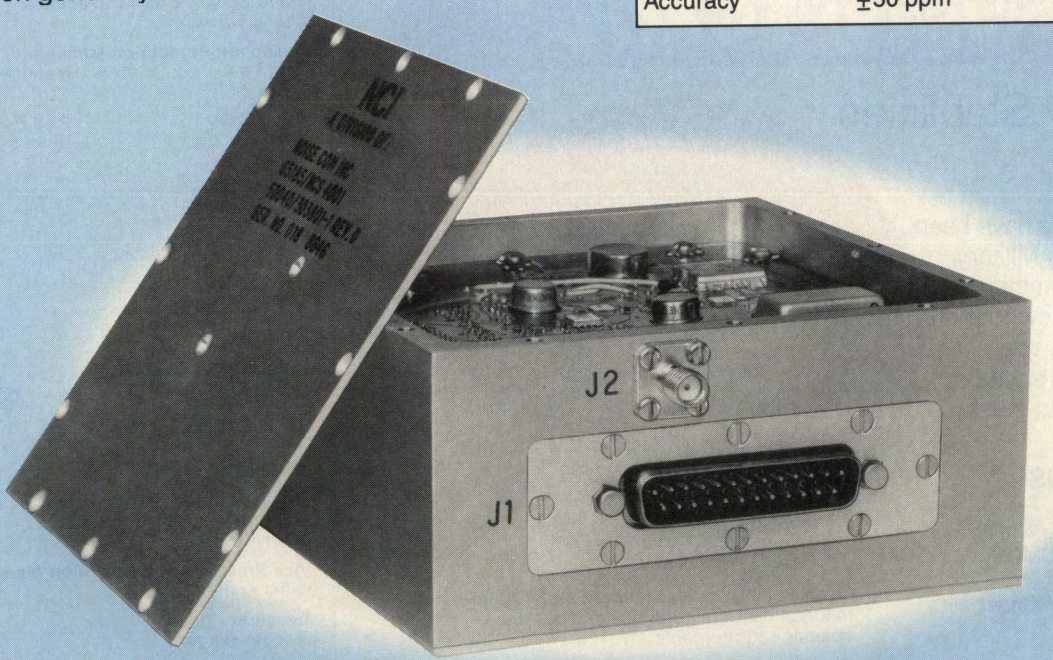
SYNTHESIZER 1 MHz resolution, 10 Hz to 1 MHz modulation		
Stability	±0.03%	50 ppm
Accuracy	±50 ppm	±10 ppm



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RF letters

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More Notes on RF Education

Editor:

Thank you for the "PR" you gave me and Bradley University in the Industry Insight column of the August 1991 issue. Fortunately, I am no longer the lone RF/Microwave professor in the department as was the case when you were last here. Since 1986, we have hired two new faculty members with interests in RF and microwave. We also have acquired additional RF/microwave instrumentation, as well as workstations and CAD packages. As a consequence, Bradley continues to offer high quality courses and design experiences for those electrical engineering students interested in a career in RF or microwaves.

Once again, thanks for mentioning us, and feel free to visit the department whenever you are in the Peoria area.

Brian D. Huggins
Bradley University

Editor:

I would like to take issue with a recent editorial in *RF Design*. While it may be true that RF engineering receives little attention when recruiting EE students, it gets more attention as they go along. At least it does here at South Dakota State. RF is, after all, only one specialty in a discipline of specialties too numerous to mention here. I think the problem that employers claim to have recruiting RF engineers stems from two related causes.

First, it is apparent from reading many job ads that the person being sought is the competitor's top engineer, a specialist with many years of experience, most recently working on exactly the problems of the would-be employer.

Second, there has been intense pressure from industry through the Accrediting Board for Engineering and Technology (ABET) to include more design in the engineering curriculum. Design means anything from choosing a blocking capacitor to laying out a transmitter circuit board. We have included project design courses in our curriculum, but I feel that this is a distortion of our purpose. The

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Liane Pomfret

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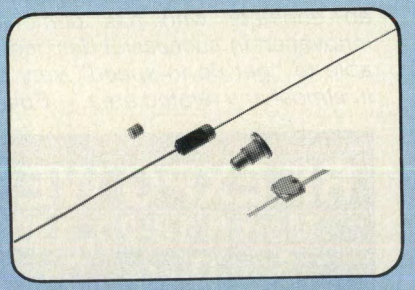

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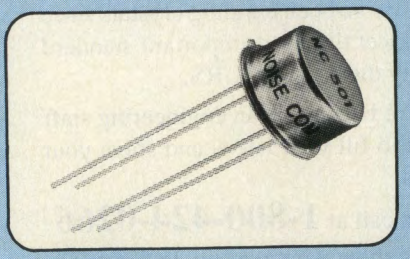

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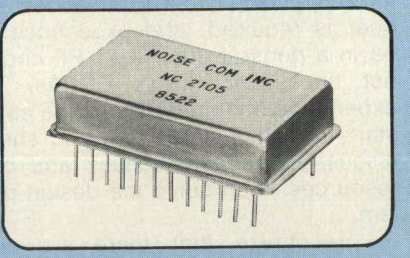

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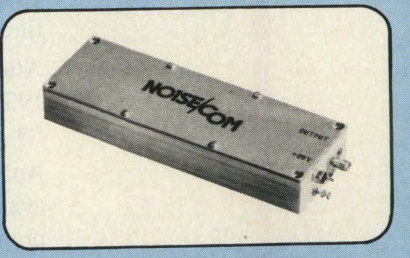

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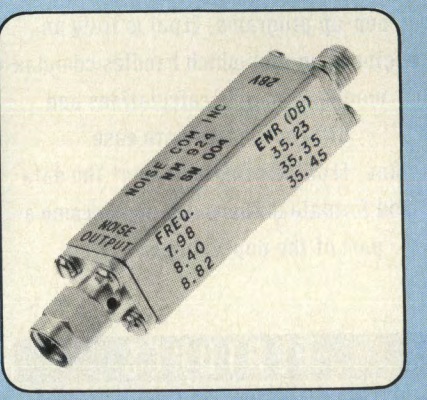

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industry is shirking its responsibility to train the apprentice engineer. Design at the subsystem or project level is not something to be learned in a few months in an academic environment. It should be learned on real projects under close supervision by an experienced engineer with a personal stake in the success of the projects and the apprentice.

The connection between these two attitudes is short-term self-interest. Employers need to understand that a beginning engineer has been academically trained to learn, and has been given a bag of mathematical and scientific techniques which will stay useful for 20-40 years. If an experienced engineer is required, that experience can be in a general area (e.g., RF circuits, not necessarily Class D PAs). The experienced engineer should be able to start from the literature, spec sheets, discussion with colleagues and other resources, then solve the design problem.

I recognize that there are costs involved and the employer must survive the short term in order to have a long term, but we must remember the proper roles of education and industry.

Douglas B. Miron
South Dakota State University

Dr. Miron also noted that he has recently been trying to find a job in industry, with no success. A major part of his problem is that employers are too narrow in their requirements. He is not alone in his frustration; many other engineers are eliminated from consideration because they don't have experience in a specific area. Employers need to remember that an engineer who has demonstrated innovation in successful designs will be able to "get up to speed" very quickly in almost any related area. —Editor

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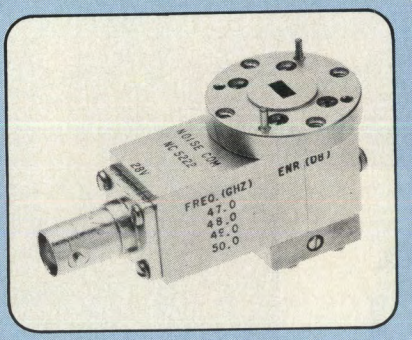

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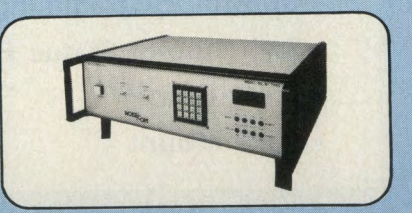

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NC 7109	up to 1 GHz
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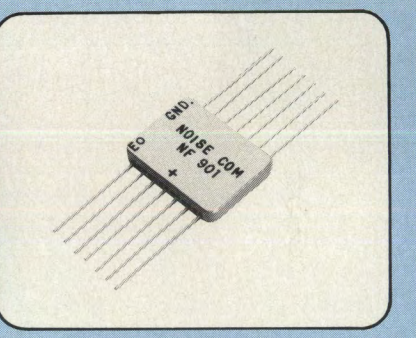

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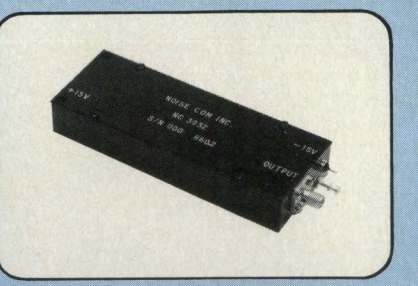

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8-11 **IEEE Ultrasonics Symposium**
Orlando, FL
Information: LRW Associates, 1218 Balfour Drive, Arnold, MD 21012. Tel: (301) 647-1591.

9-12 **Sixth International Conference on Mobile Radio and Personal Communications**
University of Warwick, United Kingdom
Information: MRPC 91 Secretariat, IEE Conference Services, Savoy Place, London WC2R 0BL, UK. Tel: (44) 071-240-1871 ext. 222. Fax: (44) 071-240-7735.

January

13-16 **ATE & Instrumentation Conference**
Anaheim, CA
Information: Miller Freeman Expositions, 1050 Commonwealth Ave., Boston, MA 02215-1135. Tel: (800) 223-7126. Fax: (617) 232-0854

27-31 **Communications Networks '92**
Washington, DC
Information: World Expo Corp., Barbara Inglese, PO Box 9107, 111 Speen Street, Framingham, MA 01701-9107. Tel: (800) 545-EXPO. Fax: (508) 872-8237.

February

24-27 **NEPCON West '92**
Anaheim Convention Center, Anaheim, CA
Information: Michael Critser, Conference Manager, Cahner's Exposition Group, 1350 East Touhy Ave., PO Box 5060, Des Plaines, IL 60019-9593. Tel: (708) 299-9311. Fax: (708) 635-1571.

March

3-5 **RF/Microwave Applications Conference**
Santa Clara Convention Center, Santa Clara, CA
Information: PO Box 1603, Los Altos,, CA 94023. Tel: (415) 691-9423. Fax: (415) 969-0222.

18-20 **RF Expo West 1992**
San Diego, CA
Information: Kristin Hohn, Cardiff Publishing Company, 6300 S. Syracuse Way, Suite 650, Englewood, CO 80111. Tel: (303) 220-0600, (800) 525-9154. Fax: (303) 773 -9716.

30-1 **Software Engineering for Telecommunication Systems and Services**
Congress Centre, Florence, Italy
Information: Conference Services, IEE, Savoy Place, London WC2R 0BL, United Kingdom. Tel: (44) 071-240-1871 ext. 222. Fax: (44) 071-240-7735.

Data, Speech, Image, and Video Compression: Principles, Applications and Standards
January 6-10, 1992, Los Angeles, CA
RF/Microwave Circuit Design: Linear/Nonlinear Theory and Applications
January 27-31, 1992, Los Angeles, CA
Information: UCLA Short Course Program Office. Tel: (213) 825-3344. Fax: (213) 206-2815.

Radar Signal Processing: Theory, Technology and Applications
January 7-10, 1992, Atlanta, GA
Coherent Radar Performance Estimation
January 14-16, 1992, Atlanta, GA
Antenna Engineering
February 4-7, 1992, Atlanta, GA
Information: Education Extension, Georgia Institute of Technology. Tel: (404) 894-2547.

Advanced Tracking Radar: Monopulse Methods and Applications
January 7-10, 1992, Washington, DC
Electronic Warfare Systems: Technical and Operational Aspects
January 13-17, 1992, Washington, DC
Introduction to Modern Radar Technology
January 22-24, 1992, Washington, DC
Modern Digital Modulation Techniques
January 27-30, 1992, Washington, DC
Digital Telephony
February 3-7, 1992, Washington, DC
Digital Cellular Telephony for Mobile Applications
February 10-14, 1992, Washington, DC
Global Positioning System: Principles and Practice
February 19-21, 1992, Washington, DC
Microwave High Power Tubes and Transmitters
February 24-28, 1992, San Diego, CA
VSAT Design, Analysis, and Applications for Data, Voice, and Video Environments
March 2-4, 1992, Washington, DC
Mobile Cellular Telecommunications Systems
March 9-11, 1992, Washington, DC
Information: The George Washington University, Continuing Engineering Education, Merril A. Ferber. Tel: (202) 994-8522 or (800) 424-9773.

Digital Signal Processing
January 8-10, 1992, Tempe, AZ
Information: Center for Professional Development, Arizona State University. Tel: (602) 965-1740.

Modern Microwave Techniques
December 10-13, 1991, Bethesda, MD
Radar Cross-Section Measurement Techniques
December 10-13, 1991, Scottsdale, AZ
Information: Technology Service Corporation. Tel: (800) 638-2628, (301) 565-2970. Fax: (301) 565-0673.

How to Meet EMI/TEMPEST Shielding Requirements for Rooms & Facilities (Includes an Intro to Theory and a Review of the New NSA 89-02 and NTISSI 7000)
February 3-6, 1992, San Diego, CA
Physical Security Standards for Sensitive Compartmented Information Facilities (SCIF)
February 7, 1992, San Diego, CA
Information: Praxis International. Tel: (215) 524-0304.

EC 92, Its Effect on the American Electronics Industry
December 12, 1991, San Jose, CA
Information: Rockford Engineering Services, Julia Gbadebo. Tel: (800) 848-3781. Fax: (510) 862-9013.

ESD Design and Testing
January 23, 1992, Novi, MI
Information: S.E. Michigan IEEE EMC Society. Tel: (313) 597-3950 or Jastech. Tel: (313) 553-4734.

Improving the Software Testing Process
December 16-17, 1991, Boston, MA
December 19-20, 1991, Detroit, MI
Information: Data-Tech Institute. Tel: (201) 478-5400. Fax: (201) 478-4418.

DSP Without Tears
December 16-18, 1991, San Jose, CA
February 12-14, 1992, Scottsdale, AZ
Information: Right Brain Technologies. Tel: (404) 420-3834. Fax: (404) 967-1672.

Introduction to Telecommunications
January 21-24, 1992, San Diego, CA
January 28-31, 1992, Vancouver, BC
Introduction to Datacomm and Networks
January 7-10, 1992, Washington, DC
January 14-17, 1992, Los Angeles, CA
Hands-On Datacomm Troubleshooting
December 17-20, 1991, San Diego, CA
January 21-24, 1992, Los Angeles, CA
Introduction to Fiber Optic Communications
January 7-10, 1992, Los Angeles, CA
January 21-24, 1992, Washington, DC
Digital Signal Processing: Techniques & Applications
January 21-24, 1992, Washington, DC
January 28-31, 1992, Ottawa, Canada
Information: Learning Tree International. Tel: (800) 421-8166, (703) 893-3555, (203) 417-8888.

Practical EMI Fixes
January 13-17, 1992, San Francisco, CA
Introduction to EMI/RFI/EMC
January 28-31, 1992, Orlando, FL
March 10-13, 1992, Las Vegas, NV
Computer Room Design for Interference Control
February 4-6, 1992, Orlando, FL
Grounding and Shielding
February 11-14, 1992, Orlando, FL
EMC Design and Test
February 24-28, 1992, San Francisco, CA
Cable Design and Installation
March 24-26, 1992, San Diego, CA
HIRF and the Control of Electromagnetic Terrorism
March 31-April 3, 1992, Washington, DC
Information: Interference Control Technologies, Registrar. Tel: (703) 347-0030.

Antennas: Principles, Design and Measurement
March 11-14, 1992, St. Cloud, FL
Information: Kelly Brown, SCEEE. Tel: (407) 892-6146.

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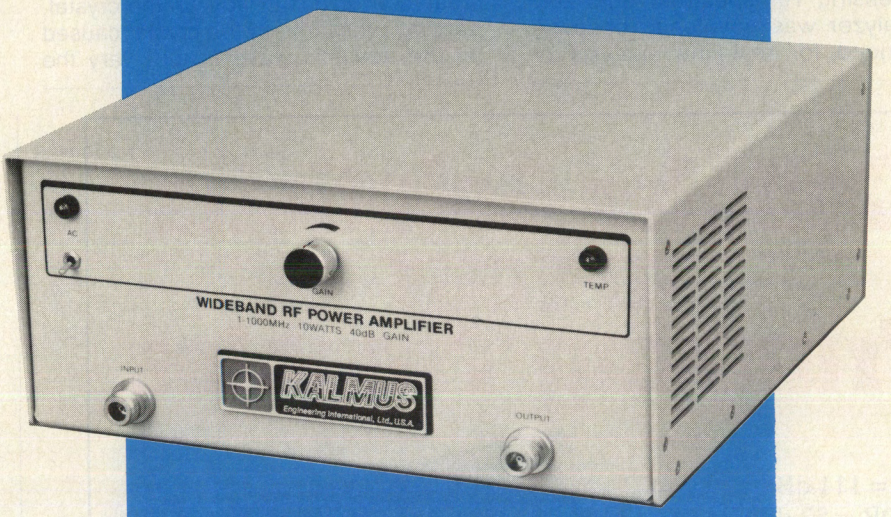
Model 710FC

- ★ 10 Watts Output
- ★ 1-1000 MHz Broadband
- ★ 40 dB Gain
- ★ 10 dB Gain Adjust
- ★ Only 16 Pounds
- ★ MOS-FET Efficiency
- ★ 19'' Rack Adapters Included



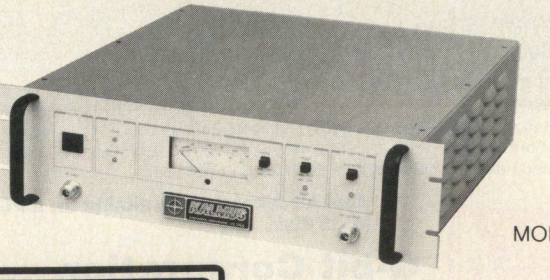
UP TO

200W/1000MHz LINEAR RF AMPLIFIER SYSTEMS

MODEL	POWER OUT	FREQUENCY RANGE	GAIN	SIZE (CM)	WEIGHT	AC LINE	U.S. PRICE $
700LC	1.5W CW	.003-1000 MHz	33dB	25x28x13	3.3kg	100-240V	$ 1,695
704FC	4W CW	.5-1000 MHz	33dB	23x18x09	2.8kg	100-240V	$ 2,195
706FC	6W CW	.5-1000 MHz	36dB	25x28x13	3.3kg	100-240V	$ 3,195
410LC	10W CW	.006-400 MHz	43dB	30x35x13	4.5kg	100-240V	$ 4,600
710FC	10W CW	1-1000 MHz	40dB	30x35x13	7.3kg	100-240V	$ 6,695
727LC	10W CW	.006-1000 MHz	43dB	48x46x13	8.5kg	100-240V	$ 7,750
711FC	15W CW	400-1000 MHz	40dB	30x35x13	5.5kg	100-240V	$ 3,620
720FC	25W CW	400-1000 MHz	40dB	48x46x13	8.6kg	100-240V	$ 5,995
712FC	25W CW	200-1000 MHz	40dB	48x46x13	8.8kg	100-240V	$ 7,350
737LC	25W CW	.01-1000 MHz	45dB	48x46x13	10.5kg	100-240V	$ 9,995
747LC	50W CW	.01-1000 MHz	47dB	48x46x26	26.5kg	100-240V	$22,500
707FC	50W CW	450-1000 MHz	47dB	48x46x13	13.0kg	100-240V	$ 9,995
709FC	100W CW	500-1000 MHz	48dB	44x48x18	22.5kg	100-240V	$19,990
722FC	200W CW	500-1000 MHz	50dB	44x18x31	41.5kg	100-240V	$31,900

Note: Models 727LC, 737LC and 747LC consist of two bands with one common input and output connector, switched with coaxial transfer relay, manually, or by remote. Switching speed 5 milliseconds.

MODEL 704FC



MODEL 707FC

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Engineering International, Ltd., U.S.A.

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FAX: (206) 486-9657

INFO/CARD 14

NIST Researchers Win Awards

Researchers at NIST were recently awarded two 1991 R&D 100 awards for new products. The two products are an optical fiber current sensor and a parallel processing RF spectrum analyzer. The analyzer was developed because of the need for real-time analysis of signals so weak that conventional spectrum analyzers would lose them in the background noise. Steven Rolston, Chris Westbrook and Poul Jessen used optics and acoustics to develop the analyzer. The RF signal is fed to an acousto-optic crystal of tellurium dioxide, where it creates an acoustic wave in the crystal. Varying pressures in the crystal caused by the acoustic wave in turn vary the local index of refraction, which effectively creates a diffraction grating that at any instant is a snapshot of the power spectrum of the RF signal. Light from a helium-neon laser is diffracted through the crystal and gathered by a linear photodiode array, and the output of the array provides an instantaneous reading of the entire power spectrum.

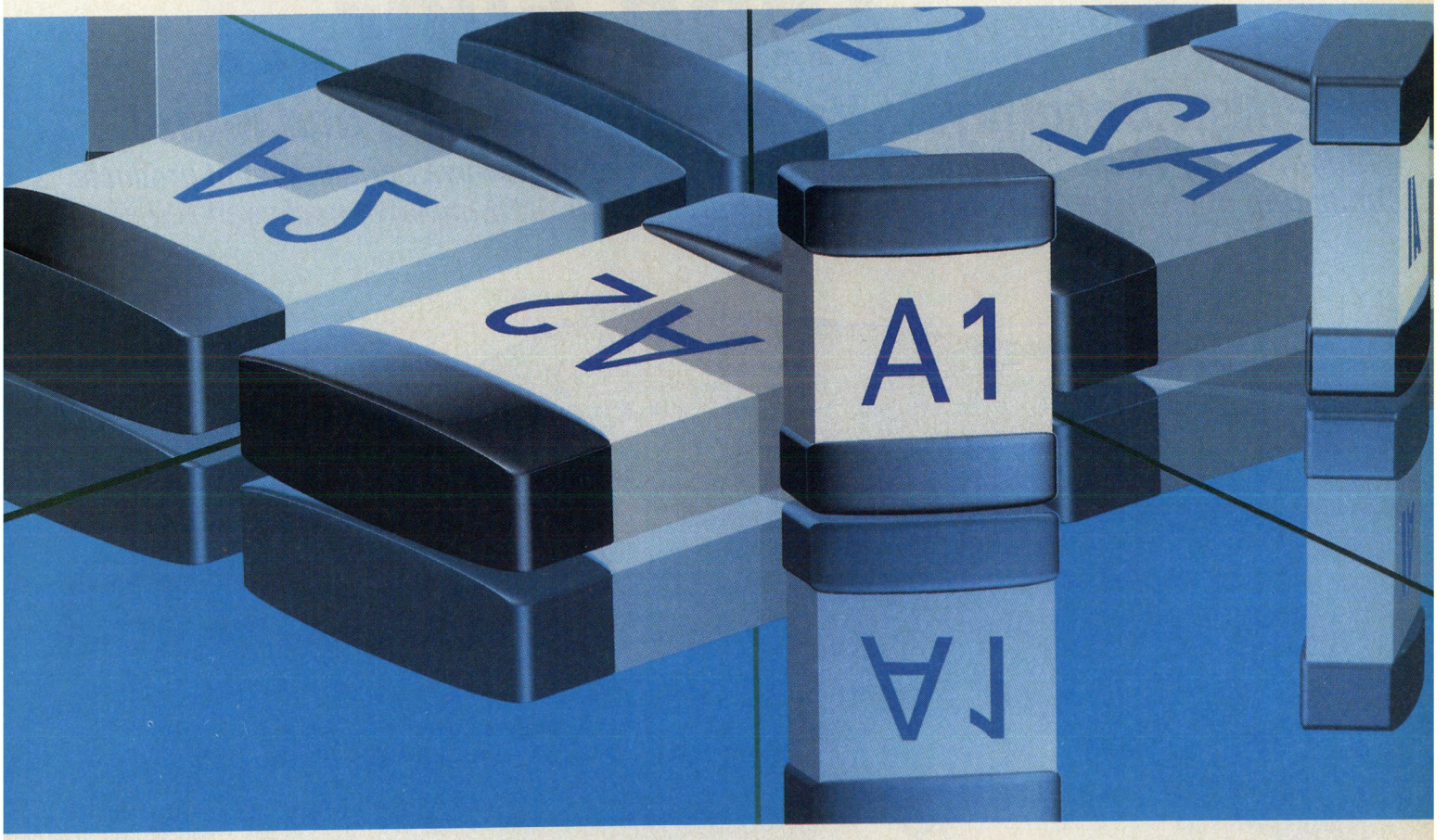
Malcolm Baldrige Winners Announced — President Bush recently announced the winners of the 1991 Malcolm Baldrige National Quality Award for excellence in quality management. The winners are Solectron Corporation — a manufacturer and assembler of electronic equipment and systems, Zytec Corporation — manufacturer of computers and electronic office, medical and testing equipment and Marlow Industries — a manufacturer of small solid-state electronic devices that cool, heat or stabilize the temperature of electronic components.

Window of Opportunity for Telecommunications — A new report recently issued by Frost & Sullivan International indicates that the 1990s will be a decade for expanded growth and competition in the European telecommunications markets. As trade barriers fall, demand for services and equipment will rise rapidly. The highest growth areas will be in the less developed economies such as Greece and Portugal where EC grants are currently being used to build a telecommunications infrastructure.

NIST Users' Guide Available — NIST has issued a new, comprehensive guide to the institute's many research opportunities, facilities and services. The guide summarizes major NIST research programs that could be the basis for cooperative research and development agreements with industry; describes the major specialized research facilities at NIST available for industrial use and lists services to industry offered by the institute. Copies of *Research, Services, Facilities* are available with a self-addressed mailing label from the NIST Public Affairs Division, A903 Administration Bldg., NIST, Gaithersburg, MD 20899.

HP and Flam & Russell Exchange Antenna Measurement Products — Hewlett Packard and Flam & Russell recently announced that they have agreed to exchange marketing and manufacturing rights to certain key prod-

An Unbeatable Combination... Low ESR and Low Cost!



Murata Erie's New GRH700 Series of MLC Chip Capacitors for High Frequency Applications.

If you design or work with high frequency circuits for cellular, GPS, DBS, VSAT, or RFLAN, our new GRH708 and GRH710 MLC chip capacitors provide a ready solution with a guaranteed low ESR and high Q through 1 Gigahertz and beyond. And, they offer the manufacturing economies realized through the use of standard E.I.A. 0805 and 1210 packages.

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Want to find out how to keep your costs and ESR's down and your Q's up? Just write to Murata Erie North America, 2200 Lake Park Drive, Smyrna, GA 30080 or call 1-800-831-9172. For application assistance, call Hi-Q Product Engineering at 814-237-1431.

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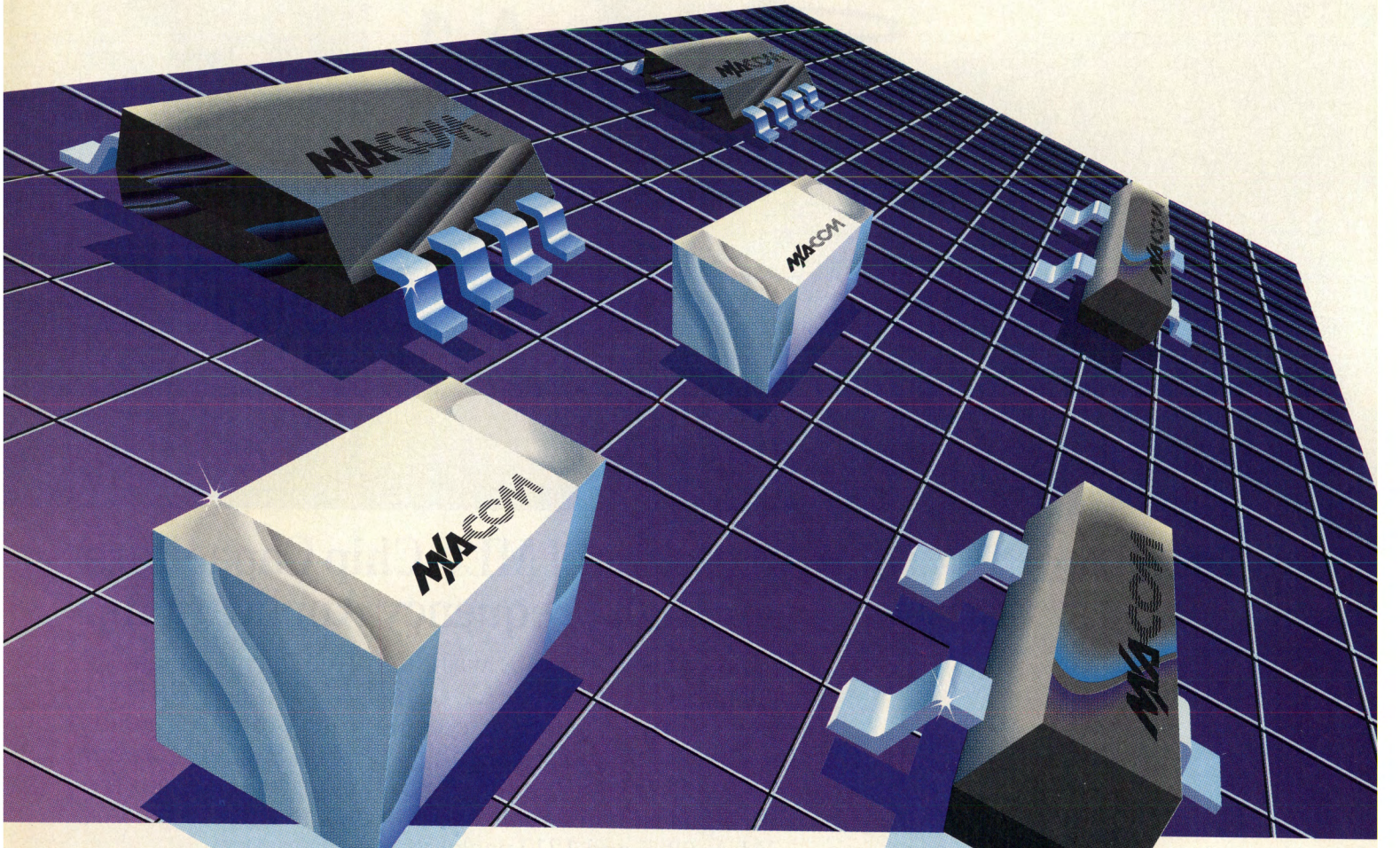

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INFO/CARD 17

ucts. Flam & Russell has acquired the rights to the HP 85360A and HP 85361A Antenna Test Software from Hewlett Packard. In exchange, HP will receive the rights to Flam & Russell's entire product line of frequency conversion hardware.

U.S. Crystal Oscillator Markets — The communications markets for quartz crystal oscillators are expected to grow 9.3 percent annually in value from 1990 to 1996. A new report covers demand, distribution channels, technological trends, quartz crystal consumption and the competitive environment in the crystal oscillator industry. The report predicts that industries such as LAN, FDDI, SONET, cellular, microwave and satellite transmission are going to be the growth areas for the oscillator industry. Information is available from World Information Technologies, 24 Woodbine Avenue, Northport, NY 11768.

Japanese Technology Bulletin Available — The Japan Technology Program is administered by the U.S. Department of Commerce and is available to provide U.S. business and industry with information on scientific and technical developments in Japan. This office works closely with the National Technical Information Service which provides a selection of Japanese technical literature and a program to assist U.S. Government agencies and non-profit organizations in obtaining permission to translate Japanese scientific and technical publications. Information can be obtained from: JTP, Room 4817 HCHB, 14th & Constitution Ave., Washington, DC 20230. Tel: (202) 377-1288. Fax: (202) 377-4826.

Wireless Communications to Expand — Revenue generated by wireless communications is expected to jump tenfold by the year 2000 says a recently issued report from ElectroniCast, with the most impressive growth in wireless communications service charges. Europe will undergo the greatest rise in consumption share due in part to the upgrading of the Eastern Europe communication infrastructure. The report covers cellular, PCN/PCS, satellite PCN and wireless in-building

Wavecom SP2T coaxial switches

The most choices. The largest line.

Wavecom offers the largest line of SP2T switches in the business. What's more you can get exactly the specs you want – at commercial prices and with products that are manufactured to Wavecom standards of space age reliability.

That's because we designed our basic switches to accommodate an almost infinite variety of spec combinations.

Frequency range: DC through 26.5 GHz.

RF connectors can be SMA, TNC, N, BNC, SC or PC board mount.

Actuation can be failsafe, latching, or normally open. Make-before-break available for hot switching applications.

Options can include 50 ohm terminations, indicator circuitry, TTL logic, BCD TTL decoder, self de-energizing circuitry, and manual operation.

We also offer a complete line of multi-position (SP3T to SP12T) and transfer switches – all available with the same variety of spec combinations as SP2T switches.

All switches can be manufactured to meet any spec requirements, whether commercial, mil-spec or deep space probes.

For more information or a free catalog, call or write Loral Microwave-Wavecom, 9036 Winnetka Avenue, Northridge, CA 91324. Tel: (818) 882-3010. Fax: (818) 709-8204.

Specifications – Wavecom SP2T coaxial switches

Frequency Range (GHz)	DC - 3	3 - 8	8 - 12.4	12.4 - 18	18 - 26.5
VSWR (Max)	1.2:1	1.3:1	1.4:1	1.5:1	1.6:1
Insertion Loss (Max dB)	0.2	0.3	0.4	0.5	0.6
Isolation (Min dB)	80	70	60	60	50

LORAL
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INFO/CARD 20

networks. The report also states that the demand for wireless LANs will eventually expand to 4 percent of the growing LAN market.

EIA Ten Year Forecast — The most recent EIA Ten Year Forecast for FYs 1992-2001 identifies challenges and opportunities that exist both domestically and internationally for electronic defense contractors. The EIA forecasts that about $370 billion will be spent over the next ten years by the DoD on electronics. According to the report there will be three periods for the defense budget over the next ten years. Through 1993, the budget will hold steady, then from 1994 to 1995 the budget is expected to decline because of chronic deficit problems and budget resource allocation problems. The final period, 1996-2001 will see a slowdown in the decline and an eventual leveling out period. Despite the predicted declining budget, there will be certain areas of opportunity such as embedded and stand-alone electronics.

New Instrument Company Enters North American Market — Tesla, a major supplier of high technology equipment, based in Czechoslovakia, has signed a contract with Gemtek Tesla Instruments Inc. for the distribution rights in North America for their products. The products to be marketed include voltmeters, frequency and universal counters, generators, RLC and Z meters, component measuring devices and general purpose test equipment. For more information contact: GTI Inc., 3 Beaverbrook Road, Kanata, Ontario K2K 1L2, Canada.

Transworld Receives VHF Manpack Contract — Transworld has received a multimillion dollar contract from the Ministry of Defense and Security of the Republic of Indonesia for several thousand additional PRC1077 tactical VHF manpacks. The package includes the basic radio, accessories, spares, services and training. The new contract is the second signed by Indonesia for the system. The initial procurement was signed in early 1990.

Microwave Power Devices Acquired — Charterhouse, an investment group has acquired Microwave Power Devices. MPD designs and manufactures high-power, solid-state RF/microwave amplifiers for communication, radar, EW/ECM, navigation and guidance, and general instrumentation systems. Terms of the acquisition were not announced.

Collins and Ball to Provide Satellite Communication Systems — Collins Air Transport Division and Ball Communication Systems Division have formed a business alliance to provide satellite communication systems to the air transport industry. Customers will be able to purchase a complete aeronautical satellite communication system consisting of avionics, antennas and high power amplifiers through one source.

Slowdown in the Semiconductor Market — After high growth in 1987 and 1988 the semiconductor market was hit by weakening de-

mand for electronic equipment. Consequently the market increases have been small, 2.4 percent in 1990 and an expected 3.5 percent in 1991. However, the new report from Elsevier Advanced Technology notes, that a recovering world economy will push the semiconductor market to an approximate 10 percent growth for 1992 and 1993.

Andrew and Moscow Metro Sign Agreement — Andrew Corporation and the Moscow Metro have signed a joint venture to provide wide-band, high data rate telecommunications transmissions in a fiber optic network covering the metropolitan Moscow area. Moscow Metro will own 69 percent of the joint venture and Andrew Corporation, 31 percent. In addition to the fiber optic telecommunications network, the joint venture will install an Andrew distributed communications system for use in the Moscow Metro. The system will be capable of handling multi-band radio signals including cellular telephone, AM/FM radio, traffic control, fire, police and other emergency communications, as well as operational management of the Metro itself.

Transco Wins INMARSAT Contract — Transco Products has announced the signing of a contract with Marconi Space Systems, to supply coaxial switches for the INMARSAT satellite program through 1992. The contract exceeds $1 million.

Qualcomm Files for Proposed Initial Offering — Qualcomm announced that is has filed a registration statement with the Securities and Exchange Commission relating to a proposed initial public offering of 3,500,000 shares of common stock to be sold by the company. Proceeds of the offerings will be used for working capital, debt retirement and general corporate purposes.

TI Opens R&D Center in Japan — Texas Instruments recently opened a dedicated research and development center in Japan. The center will strengthen TI's technology base in semiconductors and systems worldwide. It will also give TI insights into next-generation technology and market requirements in Japan and the Asia-Pacific region. The 240,000 square foot facility is located at Tsukuba, Ibaraki Prefecture, 40 miles northeast of Tokyo.

Varian Reaches Agreement with U.S. Department of Justice — Varian Associates has reached an agreement with the U.S. Department of Justice to conclude the company's involvement in an investigation of practices in the power-grid tube industry dating back to 1989. Under the arrangements, the company has agreed to plead guilty to a single violation of federal antitrust laws in connection with the improper purchase of certain rebuildable spent, power-grid tube carcasses. Under the plea agreement, Varian will pay a fine of $500,000. The company will also pay $1.5 million to settle damage claims brought by the government. In the agreement covering the damage claims, Varian denied any wrongdoing regarding the government's claims.

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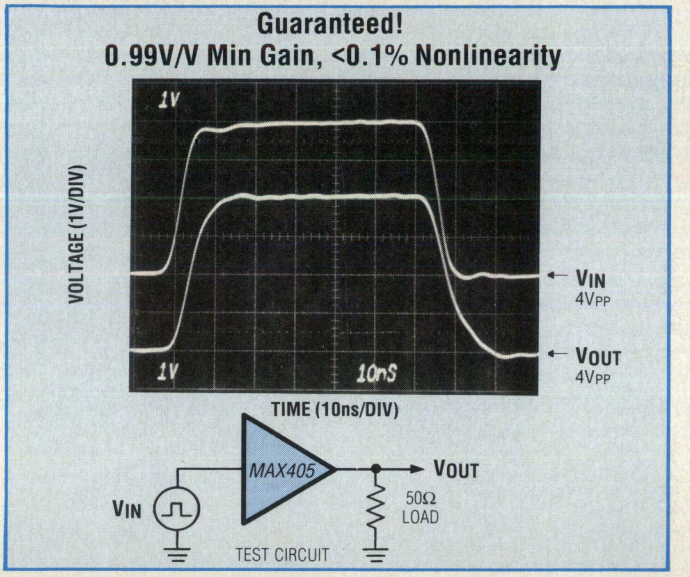
Maxim's new 180MHz MAX405 high-speed, precision buffer amplifier combines superior differential gain and phase with 650V/µs slew rate while operating from ±5V supplies. Gain is guaranteed to be greater than 0.99V/V over -40°C to +85°C, with loads as low as 50Ω. The MAX405 comes in compact 8-pin DIP or SOIC packages and, unlike existing buffers, access to the inverting input allows accurate gain adjustment from 0.99 to 1.1V/V.

Precision

- 0.01° Differential Phase
- 0.03% Differential Gain
- 0.1% Nonlinearity Over Temp
- 0.99V/V Min Gain Over Temp
- 0.01Ω ROUT
- Adjustable Gain

Speed

- 180MHz Bandwidth
- 650V/µs Slew Rate
- 35ns Settling to 0.1%



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The MAX405, with a guaranteed 60mA continuous output current, directly drives a 50Ω load to ±3V, or as many as four 150Ω loads (four 75Ω back-terminated loads) to ±2.25V. The MAX405 is ideal as a 50Ω and 75Ω coaxial cable driver for NTSC, PAL or SECAM color video signals.

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INFO/CARD 69

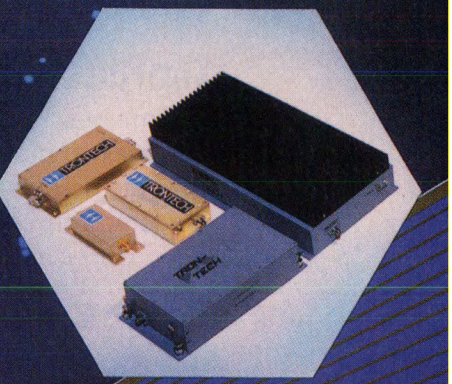
RF & MICROWAVE AMPLIFIERS FOR CELLULAR SYSTEMS

For over 10 years, Trontech has pioneered a variety of products for Cellular Systems, from engineering custom design through production. Today, our amplifiers can be found in nearly all of AT&T's Cellular Radio Cell Site Systems.

Trontech is recognized as an industry innovator and leading edge source in advanced amplifier design. We can offer you a wide range of capabilities and applications such as:

- Ultra low noise amplifiers.
- High dynamic range receive amplifiers.
- High power amplifiers for transmit applications.
- Custom designs for test systems.
- L & S band high power amplifiers for Cell Site Microwave Communications Links.

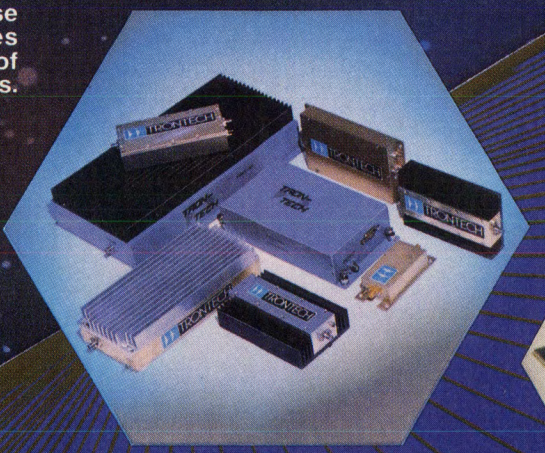
We have literally thousands of designs for production type amplifiers on file. They're available as is, or we can customize them by adjusting virtually any parameter. Now you can specify precisely to maximize system performance. From single units to high volume production, get it all at standard amplifier prices! The chart illustrates several existing product areas for both US and European standards.

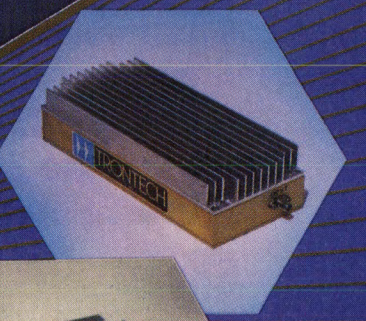


All Trontech products are manufactured to MIL-I-45208. In-house environmental testing capabilities offer rapid and economical testing of new designs to system requirements.

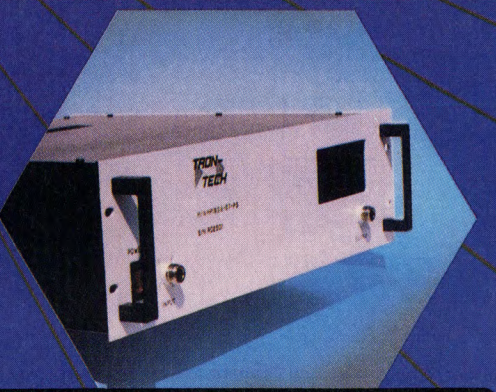
Specify the source that offers a real choice, field-proven designs and a successful track record in quality, performance, price and delivery — Trontech!

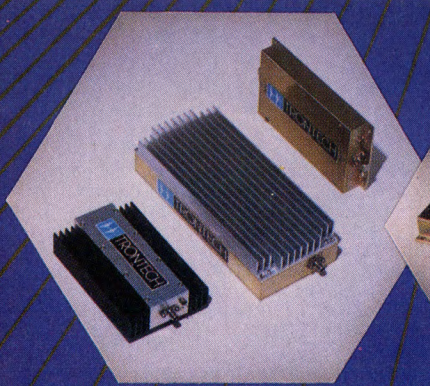
Call or write for more detailed information or applications assistance.

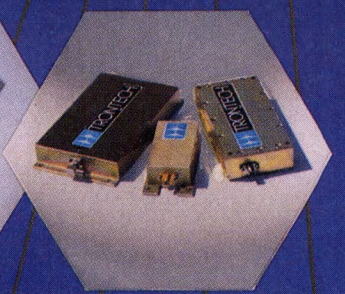




Product Area	Freq. Range	Description
Low noise	10 — 4200 MHz	Noise Figures under 1.2 dB for superior receiver sensitivity
Wide dynamic range amplifiers	400 — 1000 MHz	Low noise amplifiers with typical gain under 20 dB and 3rd order intercept points greater than +35 dBm
High power linear	400 — 1000 MHz	Amplifiers up to 80 Watts Linear for transmit applications
High power linear	1.7 — 2.3 GHz	GaAs Power Amplifiers for Cellular Radio Microwave Links







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Cellular Radio Drives the RF Market

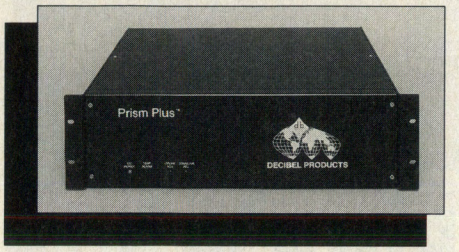
By Gary A. Breed
Editor

AMPS, TACS, GSM, NADC, JDC, CDMA, TDMA and $\pi/4$ DQPSK are familiar acronyms in the RF industry, as companies position themselves to serve the strong cellular market. As analog cellular growth eases, digital cellular and dual-mode equipment is beginning to take off. New products such as laptop computers and facsimile machines with built-in cellular telephones keep interest high among consumers.

How strong is the cellular market for RF component, module and test equipment companies? Many RF companies are investing heavily in products targeted directly at these applications. Some are betting their future on it. The results are still mixed. Firms with products that fit into 900 MHz applications several years ago have been the leading suppliers to the cellular equipment manufacturers. Others with access to key technologies, such as antennas, combiners, filters, low-cost components, and integrated RF functions have also seen success. Later entrants into the competition include some companies shifting from a military and space emphasis to a broader product line. In general, they are having a tougher time breaking into the cellular market.

The test equipment needs of the cellular industry were first met with standard signal generators, spectrum analyzers, and modulation analyzers. Analog cellular systems could utilize these instruments quite readily, but digital cellular systems have spawned a collection of unique products. Along with the needs for production and field test, a new family of cellular test gear from major manufacturers has been developed. Hewlett-Packard, Wavetek, IFR, Fluke, Marconi, Rohde & Schwarz, and others have products directed at cellular designers, manufacturers and service personnel.

Component manufacturers targeting these applications are too numerous to cover completely. Semiconductor makers strongly targeting cellular applications include Philips/Signetics, Motorola, Avantek, NEC, SGS-Thomson, Semetex and Microwave Technology. Michael Sera, RF Marketing Manager at Signetics, says his company is working on lower power consumption devices, and for the near future, "we're focusing on the digital side, producing an AMPS chip set."



Cellular equipment, like this new range extending repeater from Decibel Products, is providing a substantial market for RF components, modules and test equipment.

Modular components, such as base station amplifiers, combiners and antenna system components are being pursued by Trontech, Motorola, Semetex, Antenna Specialists, Mark Products, and others. Merrimac Industries notes significant business in their high power coupler and combiner products. Other product lines are seeing activity, as well: front-end helical filters from Toko, SAW and crystal IF filters from Sawtek, Thomson-ICS, RF Monolithics, Toyocomm and others, voltage-controlled oscillators from many companies, and synthesizers.

Digital cellular is bringing a new set of performance requirements to RF suppliers. Controlled group delay filters to pass the digital signals without distortion are required. Accurate quadrature modulators and demodulators are essential, and well-characterized amplifier chains are needed, as well. The increased complexity of digital and dual-mode systems will place even greater pressure on manufacturers to accomplish circuit functions with lower power consumption.

Spin-Off Applications

Cellular radio/telephone technology appears to be the trigger for many other RF applications. The wireless convenience of a cellular phone has made the public aware of the potential for "wireless anything." Proposed personal communications systems such as PCS, PCN, and CTII use many of the same techniques as cellular systems, providing additional markets for RF manufacturers.

Additional wireless applications include home and business security systems, factory communications and control systems, RF ID tags, local area networks, and computer-to-peripheral links. Gary Monetti, Vice President of Marketing at Sawtek, notes that there is already large scale activity in digital cellular manufacturing, and that a myriad of engineering development projects are underway in other wireless applications.

Many of the most promising new applications will be in the 800-1800 MHz range, allowing similar design techniques and component selection to that of cellular equipment. Most will be lower power than cellular base stations, but similar to handheld units. The basic modulation/demodulation functions will be similar, making RF circuitry very much like cellular phones. The main differences will be in the control, signal processing, and handling of the infomation transmitted through the system.

Is the cellular market enough to sustain RF manufacturers while they readjust to a flat or declining military market? The answer is a qualified "yes," if other new applications are included in the equation. Some companies will have to become smaller and more efficient to deal with the generally lower profit margins and higher risks that commercial sales have versus military systems. Others will find that their expertise fits well with the personal communications market and prosper. And, a few will fail as will inevitably happen when market demands and technology change.

There are many competitive marketing and technology ideas being explored to expand the cellular market and and develop other related ones. These will be the major factors driving RF business for the next couple of years. **RF**

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100-1500 MHz	45	35
1500-3000 MHz	35	30
1 dB Compression (dBm)	**TYP**	**MIN**
10-100 MHz	18	8
100-1500 MHz	27	20
1500-3000 MHz	30	29
VSWR (ON)	**TYP**	**MAX**
	1.3:1	1.6:1
Switching Time (μSec) (50% TTL to 90% RF)	**TYP** 2.0	**MAX** 3.0
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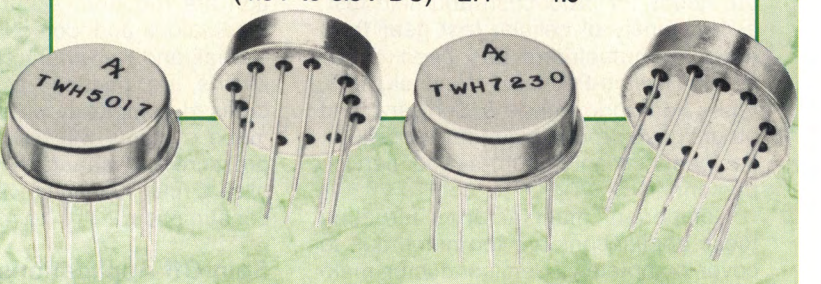

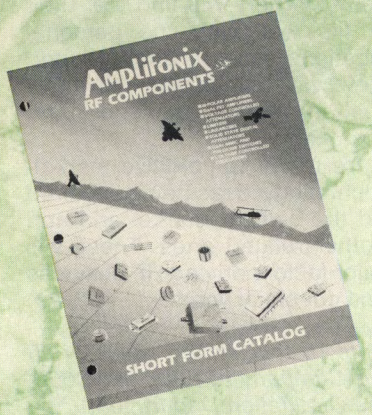

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Platinum Clad Wire Improves Power Tube Performance

By Edward F. Kelly
Technical Products Marketing

Platinum is an excellent material for controlling the electron emissions from high output power vacuum tubes. However, it is very expensive. At a price of $500 a troy ounce, even plating platinum over wire represents a significant cost factor for builders and rebuilders of these electron tubes.

Platinum clad molybdenum wire was developed by GE to solve a welding problem in making high performance lamps. It is used primarily as a welding flux for leads in quartz, high intensity, halogen and other hard glass lamps. This lower cost material is proving that it takes far less platinum weight than previously thought to achieve the desired results.

Vacuum tubes of this type are used for amplifying power for radio and television signals and industrial and military electronic hardware. They typically have power outputs between 5 and 250 kilowatts. Inside the tubes is a filament (or cathode) that emits the electrons, a wire grid which moderates their flow, and a plate (or anode) which collects the electrons and channels them into the output load of the tube.

Used as either the filament or the grid, GE's platinum clad moly wire is making an impact at both the high and low ends of the electron tube market. Producers and rebuilders of large powered tubes, rated up to 250 kilowatts, are enjoying a significant cost advantage compared to previously used molybdenum or tungsten wire that is plated with platinum. Makers of small tubes rated around five volts are obtaining longer filament life and better performance than they had with the bare molybdenum wire they used formerly.

According to Hansen Huang, vice president of New Product Engineering at Jolida, Inc. in Annapolis Junction, MD, the material gets the credit for upgrading their product line substantially. "By switching to a platinum clad from a bare moly wire for our filaments, we are providing power outputs that are up to four times greater than traditional electron tubes, in both temperature resistance and emission levels," he says.

The platinum clad moly wire provides enough thermal strength to handle higher power loads with longer life cycles, and generates lower noise/distortion levels, according to Huang.

Typical of Jolida products is a five volt power triode vacuum tube used for short wave, UHF and AM/FM radio amplification. When operated in a cathode drive circuit, it creates a power gain as much as 20 times the input. An even higher amplification factor is available in a

An example of a rebuilt power grid using the platinum clad wire.

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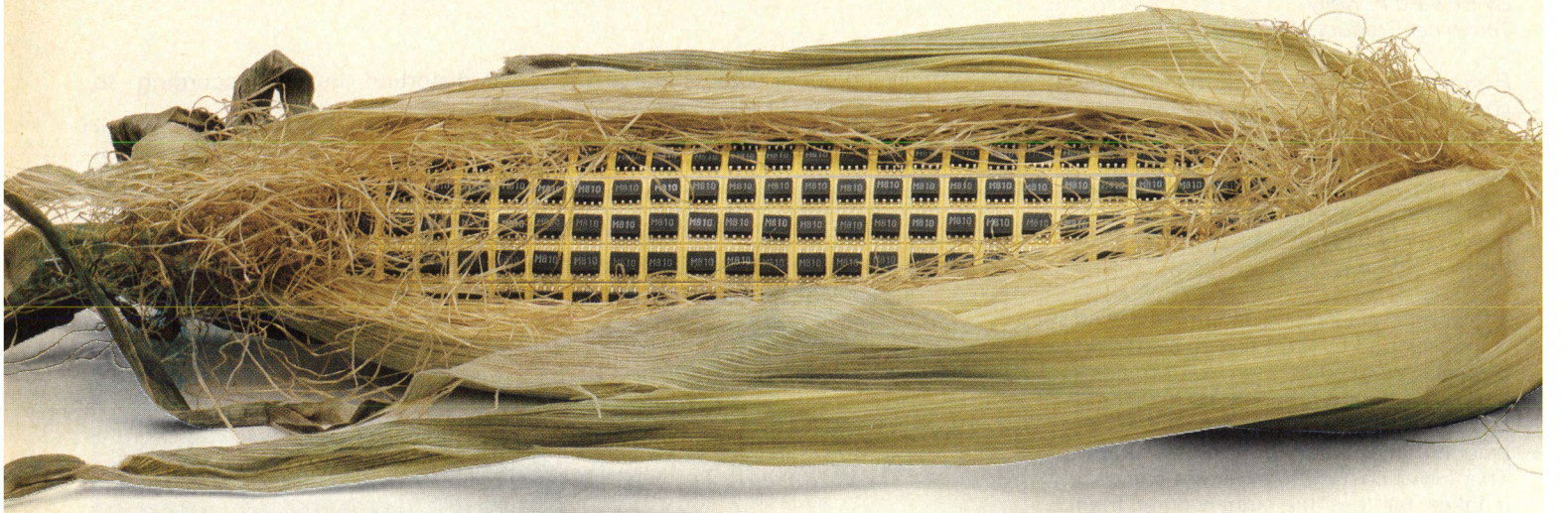

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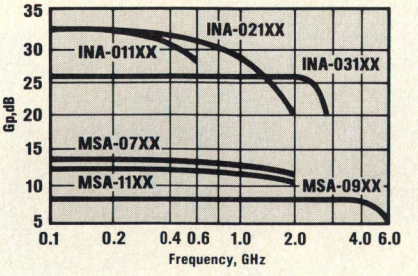

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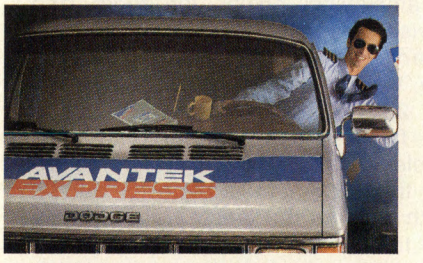

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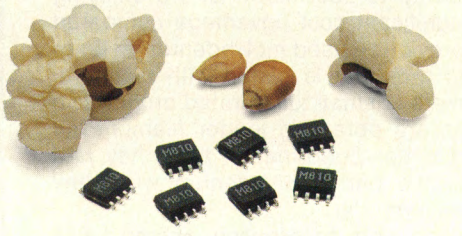

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Jolida tube used primarily for increasing the power of CAT scanners, plastic stamping presses, and other heavy duty equipment.

In higher output tubes, platinum clad moly wire is used for the grid that surrounds the filament. Designs differ, but the typical shape is a mesh cage made from wires that are crisscrossed and spot welded.

Molybdenum is needed as the core wires because the filament operates at temperatures up to 1800 degrees C. With a melting point of 2622 degrees C, molybdenum easily retains its shape in these temperatures.

Since platinum has very low electron emission, even at these temperatures, the cladding serves to reduce the work function of the grid, keeping it relatively passive. This enables electrons to flow directly between the cathode and the plate without interference. Grid emission causes high distortion and could result in a runaway tube.

GE's platinum clad molybdenum wire has only a thin sheath of the precious metal, 15 percent by weight and only 4 percent of the wire diameter. But it is demonstrating the same performance and service life as the plated materials.

"Apparently, it doesn't matter how heavy the cladding is, as long as the molybdenum surface is completely covered," says J.H. Freeland, President of Freeland Products of Covington, LA, a major rebuilder of radio and television transmitter tubes.

These tubes cost between $800 and $5000 when they are new. Because most of the tube can be salvaged after it burns out, rebuilding is a major business.

Freeland had developed its own facility for plating platinum on molybdenum wire, but found GE's mass produced wire more price attractive and switched a few years ago. "The performance and service life are the same," he says.

The benefits of the clad wire have also caught the attention of rebuilders of higher power grid tubes for TV broadcast and the military. These tubes cost up to $25,000 each and may have as many as three grids to control the flow of electrons.

Among the rebuilders in this market is Econco of Woodland, CA, which started using GE's platinum clad molybdenum wire two years ago. According to John Canevari of Customer Service, his company's rebuilt tubes will normally provide service life that is at least that of the original equipment at a lower cost. He says, "With platinum clad moly wire, we have replaced a more expensive core material (tungsten) and a more costly coating operation without giving up anything in performance."

The material consists of a core of 99.90 percent pure molybdenum and a coating of thermocouple quality 99.50 percent platinum. Special processing is used to create a platinum sheath around the wire that becomes mechanically/metallurgically bonded to the core. The wire is produced in diameters between 5 and 50 mils.

Platinum clad moly wire is still used for lamps. But since a single power grid tube may use 30 to 40 feet of the material, the vacuum tube application represents a highly promising market for the GE Components Marketing and Sales Operation.

For more information on this product, contact: GE Components Marketing and Sales Operation, 21800 Tungsten Road, Cleveland, OH 44117. ***RF***

A Modular Two Band Diplexer

By J. Robert Witmer
AEL Defense Corporation

Having completed the design, construction and installation of an antenna that provided acceptable simultaneous operation in segments of the high VHF and UHF FM bands, a technique was needed to permit connection of the antenna to the VHF and UHF transceivers. The objective was to connect both transceivers to the antenna at the same time to permit simultaneous operation.

The two band coupler or diplexer design presented in this article is based on two independent modular sections, one for each desired frequency band. Each section consists of an electrical 1/4-wave length section of coax and a discrete component series resonant tuned circuit. The modular nature of the design lends itself to expansion for additional isolation depth or bandwidth, with minimal additional insertion loss due to the extra section. This design has also applied to the 146 and 52 MHz frequency bands where two versions of the diplexer have been constructed and evaluated.

The application of 1/4-wavelength transmission line solutions to various antenna problems has interested me for some time and I found it provided what I feel is a unique solution to this problem. See Figure 1 for the schematic of the modular diplexer.

Each modular section, see Figure 2, consists of a 1/4-wavelength section of coax between the dedicated frequency band port and the common port with a series resonant circuit across the dedicated frequency band port. The 1/4-wavelength coax section and series tuned circuit are resonant at the center of the other selected frequency band. Coax 1/4-wavelength sections provide a relatively broad insertion loss bandwidth.

The heart of the design approach is the 1/4-wavelength transmission line T/R switch as shown in Figure 3. It depends on the unique impedance transforming capability of the 1/4-wavelength transmission line. A shorted 1/4-wavelength transmission line presents an open circuit at the end opposite of the line. The reverse is also true, an open 1/4-wavelength transmission line presents a short circuit at the opposite end (Both of course at the frequency at which the transmission line is an electrical 1/4-wave). In the classic design the short was typically provided by a diode.

In the modular diplexer design, the discrete component series tuned circuits provide frequency dependent shorts for the end of the 1/4-wave length coax sections which in turn provide the desired open circuit - disconnecting effect - at the common port end of the line. Because of their off resonance high impedance, the series tuned circuits have minimal effect on the desired frequency band. The series tuned circuits also provide rejection of the undesired frequency band.

This design's performance is relatively independent of the loads presented at the independent "band" ports. This permits operation with only one transceiver or antenna connected. The effect of a feedline break or short on the opposite port on the diplexer will be minimal.

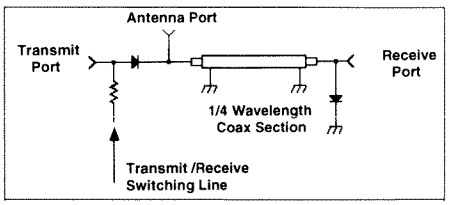


Figure 3. T/R switch schematic.

Performance

See Figure 4 for the measured performance of the 146/446 MHz diplexer and Figure 6 for performance of the 52/146 MHz diplexers. Measurements were made with a Hewlett Packard Model 8640B signal generator and a Hewlett Packard Model 8559A spectrum analyzer.

When you consider the insertion loss provided by the length of RG-58/U coax (approximately 15 feet) typically supplied with most commercial antennas -approximately 0.5 dB at 52 MHz, 0.8 dB at 146 MHz and 1.5 dB at 446 MHz -the diplexer insertion loss may not be a major factor in the total antenna system performance.

146/446 MHz Diplexer Description

The 146/446 MHz diplexer measured uses single isolation sections. RG-188/U TFE insulation coax 1/4-wavelength sections were used to reduce the size of the diplexer and minimize the possibility of solder shorts during the assembly. Air wound coils were used in both series resonant sections. The only significant requirements on the trimmer capacitors are mechanical stability and power handling capacity

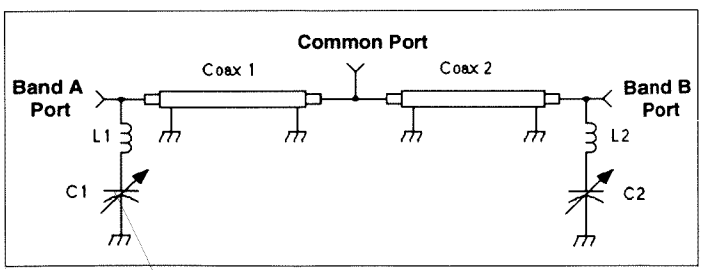


Figure 1. Modular diplexer schematic.

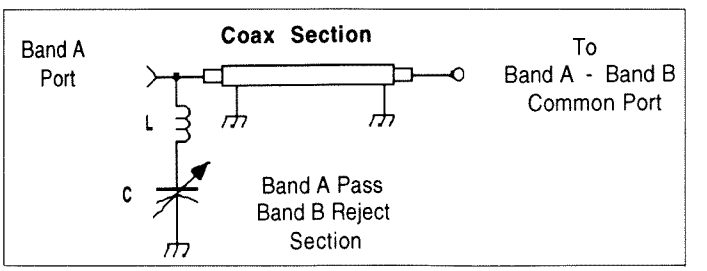
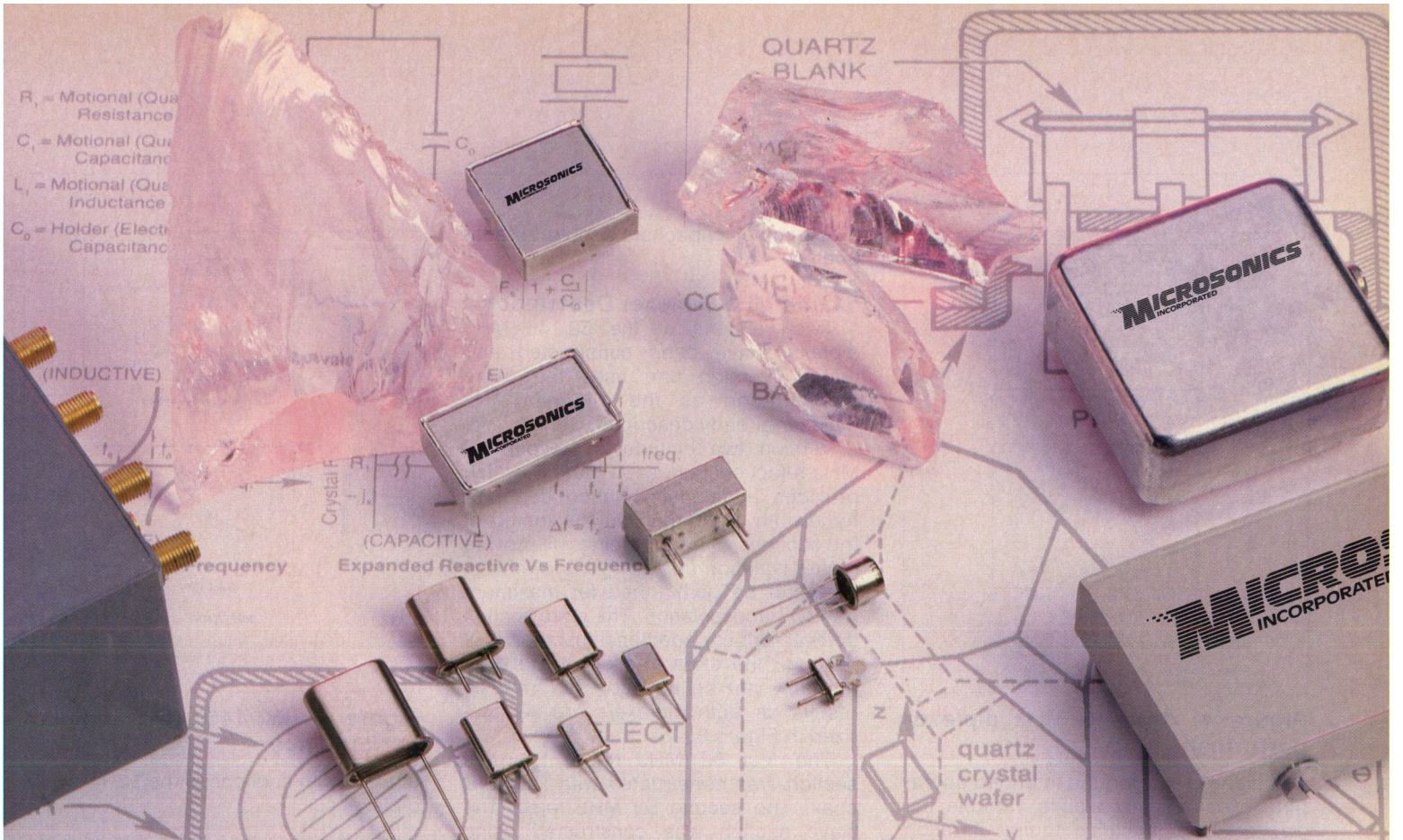


Figure 2. Modular section schematic.



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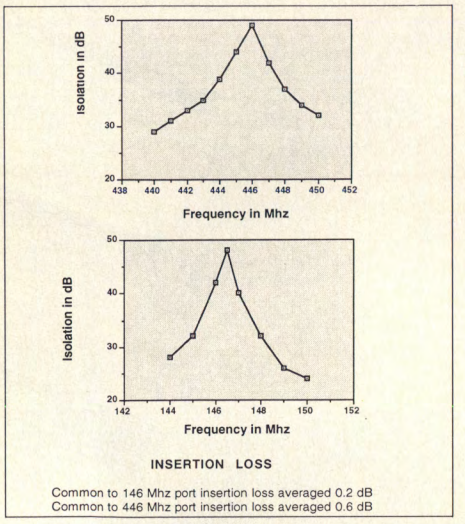


Figure 4. 146/446 MHz diplexer performance.

sufficient to support the intended operation. Mechanically stabile variable capacitors will minimize tuning iteration because the "rejection" notch tuning is very sharp. Air-dielectric trimmer capacitors were used in the unit tested. With low power levels (1- 5 watts), ceramic-disc trimmer capacitors should be adequate.

52/146 MHz Diplexer Description

Two versions of the 52/146 MHz diplexer have been constructed and tested. Version one uses the same configuration as the 146/446 MHz diplexer already described.

Version two includes a second 52 MHz reject section, see Figure 5, which provides additional isolation depth or bandwidth depending on the tuning of the sections. Stagger tuning will provide higher isolation frequency bandwidth or they can be both tuned for maximum narrow-band isolation. The extra section does contribute additional insertion loss - though the extra fraction of a dB will probably not be noticed. Performance results for both diplexers are summarized in Figure 6.

The first 52 MHz reject 1/4-wave section was constructed with RG-58/U coax. The second 52 MHz reject 1/4-wave section was constructed using RG-8X and the reduction in additional insertion loss is noticeable. Mica-metal plate compression type trimmer capacitors and air wound coils were

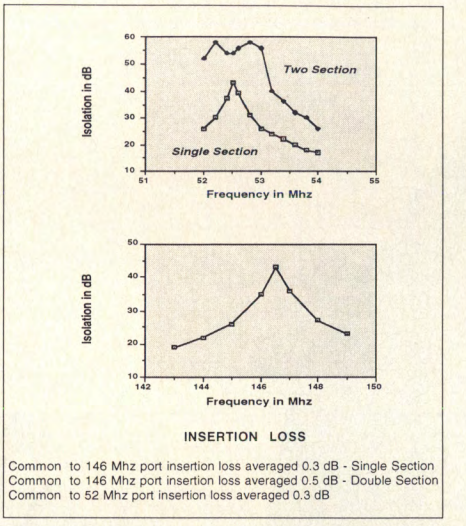
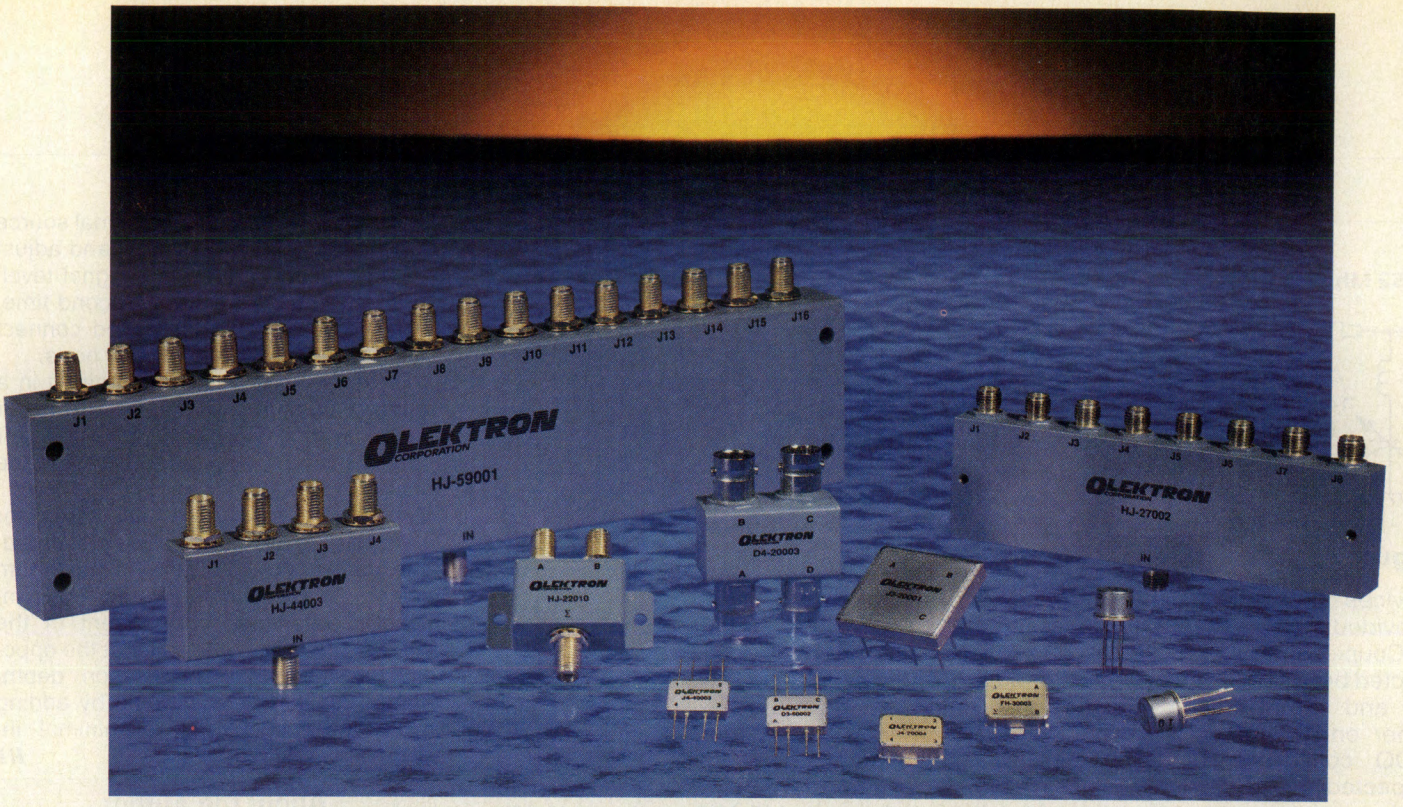


Figure 6. 52/146 MHz diplexer performance.

used in both sections of the 52/146 MHz diplexers.

1/4-wave Coax Section Tuning

A grid dip oscillator (GDO) was used to trim the 1/4-wave coax sections —Remember when most electronic



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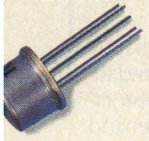

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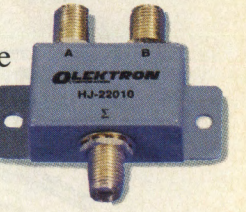

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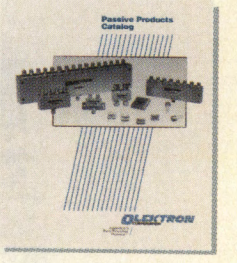

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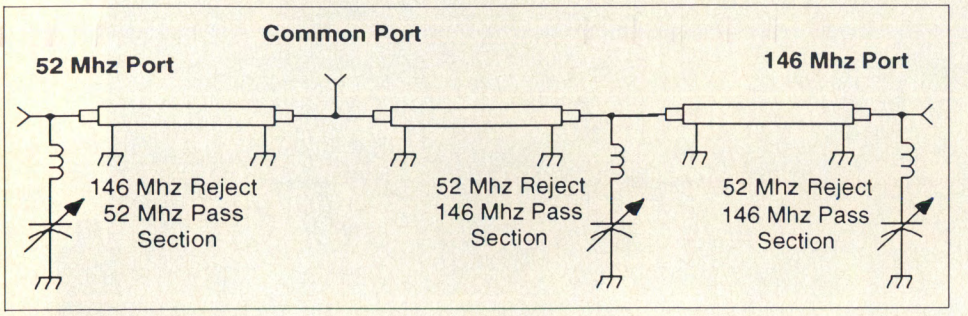


Figure 5. Dual section diplexer schematic.

devices had grids? The following is provided as a guide for this process:

Couple your GDO to a small loop connected between the coax center conductor and shield at one end. Leave the other end of the coax open. Select a GDO coil to cover lower than the expected frequency range and move higher in frequency until a dip is found. This is important in order to find the true resonant frequency and avoid false peaks. Tune the GDO for a dip to find the resonant frequency of the line. Trim the line to obtain the desired resonant frequency.

Alignment

Alignment of the diplexer is straightforward. The following procedure is provided specifically for alignment of the 146/446 MHz diplexer (Figure 1); alignment of other band combinations is comparable:

Connect a 146 MHz transceiver to the diplexers's 446 MHz port, a 446 MHz transceiver to the 146 MHz port and a signal source to the common port.

A spectrum analyzer can be substituted for the transceivers. Tune the signal source to provide a 146 MHz signal and adjust C1 for minimum 146 MHz signal level. Tune the signal source to provide a 446 MHz signal and adjust C2 for minimum 446 MHz signal level. Repeat the above steps a second time. After adjustment is completed connect the transceivers to the correct ports.

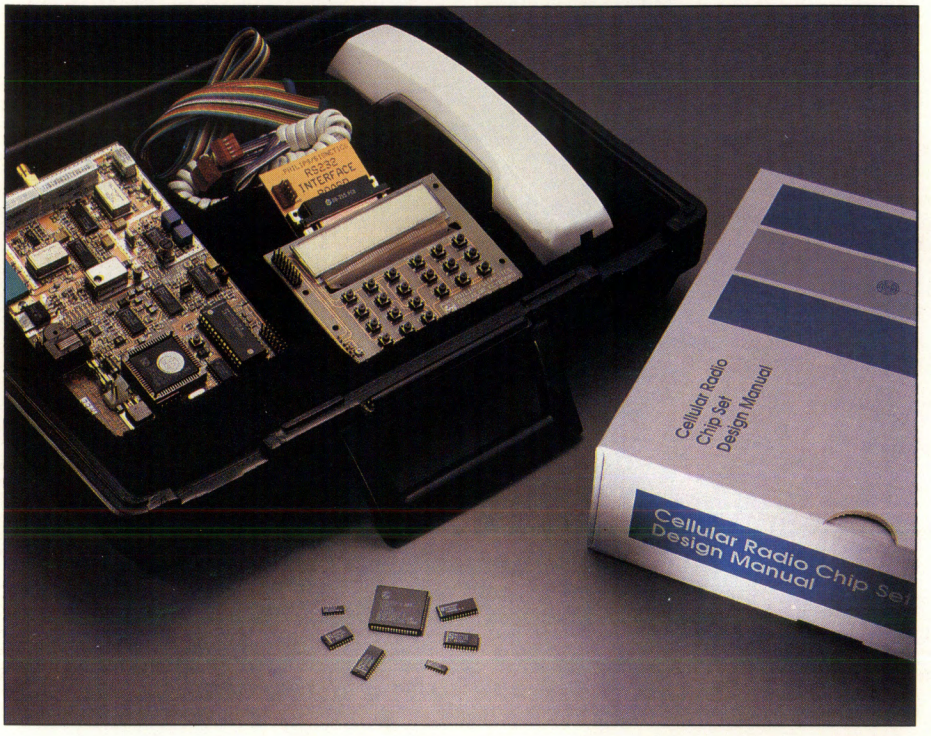
If the diplexer will be contained in a metal enclosure, make provision for tuning with the diplexer enclosed or "compensate" your alignment for the enclosed condition.

A straightforward modular design for a two band diplexer has been presented. The design provides a wide, minimum insertion loss, pass bandwidth. Performance is relatively independent of the impedance loads presented at the opposite band port. The isolation depth/bandwidth can be increased by adding modular sections with a minimal increase in insertion loss. ***RF***

About the Author

J. Robert Witmer is a Senior Program Manager at American Electronic Laboratories, 305 Richardson Road, Lansdale, PA 19446-1429. Telephone (215)-822-2929. He has a BSEE from Drexel University.

Cellular Chip Set Demo Kit



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DESCRIPTION	ORDER CODE
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The Signetics Cellular Chip Set is the world's first complete chip set commercially available. This complete system, in conjunction with your design, revolutionizes the cellular radio marketplace. The board can virtually be copied onto your system as a complete cellular solution. Whether your application is in portable RF Modems and FAX's or you need remote diagnostics capabilities this kit can help you design. It significantly reduces your design and development cycle and at a fraction of the cost.

The complete Cellular Demo Kit contains a chip set of 12 ICs, a tested demo board with all the hardware and firmware, documentation, schematics, RS-232 interface board, keyboard, handset and display. The chip set handles the processing of data, audio, the receiver, the switching of channels and the transmitter. The following is a list of the parts and the functions they perform:

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- **UMA1014DT Synthesizer** - Handles the channel selection on both the receiver and transmitter (Two per system, TX and RX)
- **NE605DK FM IF System** - Handles the receiver portion of the system
- **NE5750D APROC** - Handles audio processing
- **NE5751D APROC** - Handles audio processing
- **PCB80C552 Microcontroller** - Controls the complete cellular board
- **27C512 EPROM** – Stores the "Test Harness" program along with the firmware for the phone functions.
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Software Family Integrates Synthesis and Simulation

By Randall W. Rhea
Eagleware

Eagleware has introduced a new matching network synthesis program and has added a new graphical user interface to their products. These improvements go hand-in-hand with the growing sophistication of RF software users. This article presents descriptions of the Eagleware software system and the philosophies of that company concerning the computer as an engineering design tool.

Engineers who are now at the peak of their careers began with slide rules! By the 1970s, scientific calculators and time-share computers had supplanted bamboo. Less than twenty years later, desktop computers provide computing power almost unimaginable.

How fast could we multiply two floating point numbers on a slide rule? About five seconds, which is 0.2 floating point operations per second (FLOPS), with three significant digits of precision. With the calculator we achieved about 2 FLOPS with improved precision and more functions. In 1981, we achieved about 50,000 FLOPS on a 8088 CPU and 8087 coprocessor. Today, desktop personal computers and workstations deliver well over 1,000,000 FLOPS.

Paradise Lost

So how did we get anything done with a slide rule? With them, we had designed telephones, television and radar. Amazing!

Computers crunch numbers; they don't think. In fact, some believe we are relying too heavily on computers and less on thinking.

A respected mentor once told me, "A computer is no substitute for thinking." His ability to reduce a complicated problem to a few simple defining equations was inspiring. He developed innovative products using simple expressions, a calculator, and finally a prototype on the bench.

Paradise Found

When it became available, my mentor quickly embraced time-sharing. It was an important lesson for me — don't advocate only the past or only new technologies. Embrace all available tools and use them wisely.

# Nodes	Reduction	Nodal
4	0.32	1.53
6	0.37	2.07
9	0.45	3.55
12	0.52	6.34
16	0.63	12.8
21	0.76	27.1

Table 1. Branch reduction and nodal execution time (seconds) on a 16 MHz 80386 machine for filters of increasing size (40 frequencies).

What I enjoyed most about the prototype phase was the insight provided by interactivity. More than achieving the desired response, real-time tuning provided insight into circuit behavior. It caused thinking and led to ideas for improvement. When I began writing programs for my own use in the 1970s, time-sharing couldn't support this kind of real-time feedback. That all changed in the early 1980s with the advent of desktop computers.

Synthesis theory finds component values for high-order networks with such numeric efficiency that our desktop computers merely blink. But synthesis is crippled by reality, such as $S_{12}>0$, finite Q, parasitics and discontinuities. Simulation accommodates these difficulties, but because real-time tuning and optimization are required, execution must be fast. When integrated together, synthesis and simulation create a powerful design environment.

Simulation execution speed is crucial for two reasons. Dealing with reality involves optimization with many circuit evaluations. More importantly, viewing the response while tuning encourages thought. Try tuning a complex circuit on the bench with a network analyzer set to 500 ms per sweep, then change it to 5 seconds per sweep. A factor of ten makes a big difference!

Circuit Simulation

STAR (1982) is the genesis of =SuperStar= (1986) and =SuperStar= Professional (1990). Both current versions feature full graphic capability, real-

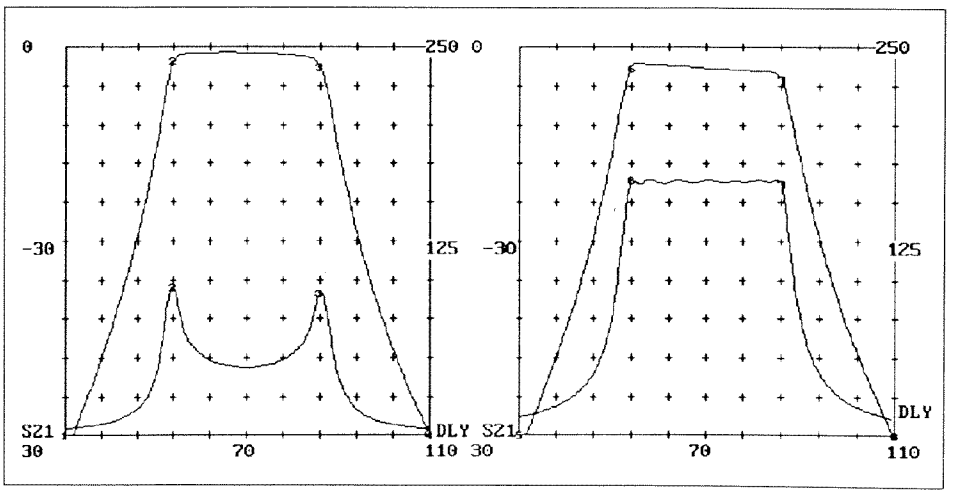

Figure 1. Amplitude and delay response of a symmetrical bandpass before (left) and after (right) group delay equalization.

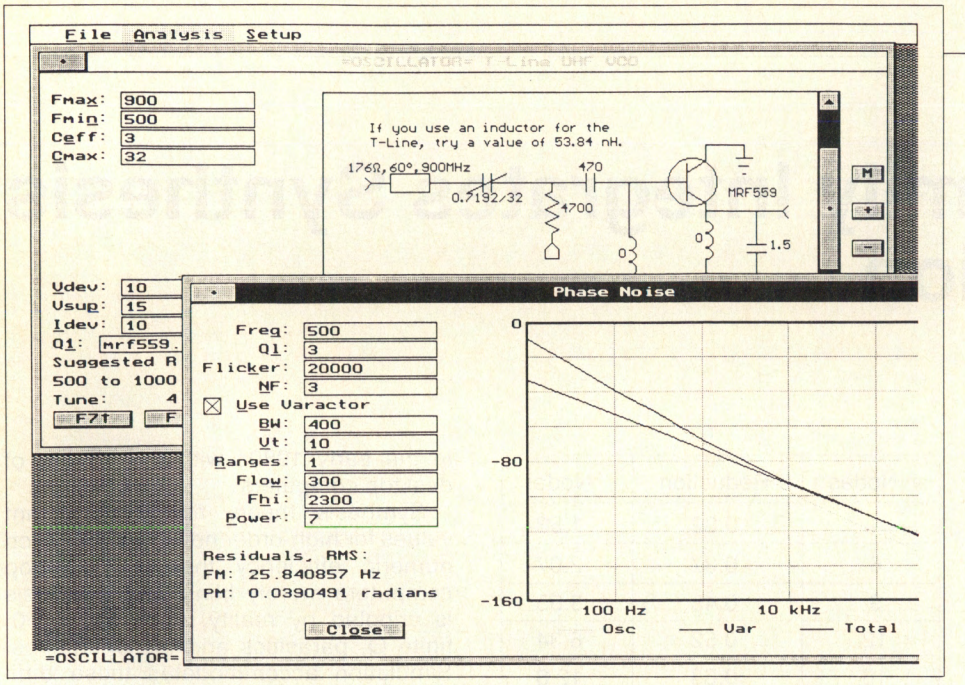

Figure 2. UHF VCO with phase noise displayed in =OSCILLATOR=.

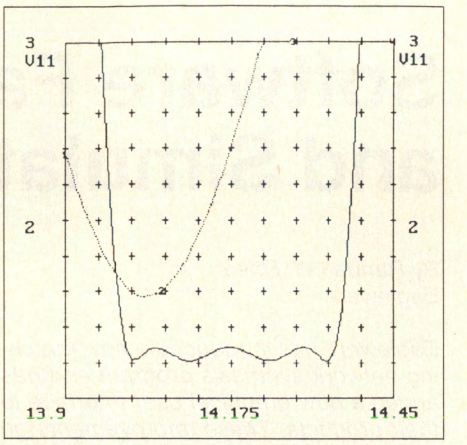

Figure 3. VSWR of an HF antenna before (dotted) and after matching (solid).

time tuning, fast optimization and a complete library of active and passive models. =SuperStar= Professional adds equations for user-defined models, Monte Carlo/yield analysis and microwave discontinuity models.

=SuperStar= provides two network calculation techniques: branch reduction and nodal. Branch reduction involves no arrays larger than 2×2 and is very rapid. Nodal involves arrays with dimensions equal to the number of nodes in a circuit. Nodal deals with general topology, but is slower than branch reduction. Table 1 compares branch reduction and nodal execution times. Notice that nodal analysis time is a strong function of circuit complexity.

Sparse matrix techniques reduce nodal execution time but branch reduction remains significantly faster.

Nodal calculations are provided in =SuperStar= because they are required by certain topologies. However, none of the filters, matching networks, amplifiers, equalizers and oscillators designed by Eagleware programs require nodal description.

Synthesis Family

=FILTER= (1986) synthesizes twenty topologies of all-pole and elliptic lowpass, highpass, bandpass and bandstop lumped element filters, including conventional, narrowband, top-C/top-L/shunt-C coupled, tubular, Blinchikoff, Eagleware symmetric and zig-zag configurations. Transfer approximations include Butterworth, Chebyshev, Cauer-Chebyshev, Bessel, Bessel elliptic, transitional Gaussian, equilinear phase, and table entry.

The =FILTER= package includes =EQUALIZE= (1989) which designs one to ten section group delay equalizers. On the left in Figure 1 is a simulation of a symmetric bandpass filter with finite-Q components. On the right is the response with a five-section group delay equalizer designed with =EQUALIZE=.

=OSCILLATOR= (1988) synthesizes L-C, distributed, SAW and crystal oscillators and estimates phase noise performance. Design is based on two methods: a negative resistance model or an amplifier-resonator cascade. Figure 2 shows a program screen with a UHF VCO phase noise plot.

Announced at the recent RF Expo East, =MATCH= (1991) synthesizes lumped and distributed networks. Since this program deals with single or multistage active or passive networks, it is suitable for a wide range of applications. =MATCH= allows the user to select from several network structures for each stage. Figure 3 is the VSWR of an antenna before and after matching with a broadband Chebyshev algorithm. Figure 4 is the schematic of a MRF901 amplifier designed by =MATCH=. S_{12} was not assumed to be zero, as is often done for synthesis. A worst case return loss of 18.5 dB was achieved from 470-890 MHz without resistive feedback.

Tying it Together

Eagleware synthesis programs automatically write circuit files and invoke =SuperStar= which then quickly displays responses. More than saving a few minutes of circuit entry time, this encourages exploration of alternatives. For example, a conventional, a narrow band and a symmetric bandpass filter can each be synthesized and evaluated in moments. The best candidate is selected, and a design which includes standard value, finite-Q, parasitics and discontinuities is finalized using tuning, optimization and yield analysis in =SuperStar=.

Eagleware synthesis programs use a common interface. This graphical user interface (GUI) conforms to industry standards and is similar to Microsoft Windows, Macintosh OS or X-Windows. The purpose of the GUI is to make the programs easy to use while maintaining their flexibility. The user simply points at what is to be done next and enters data into the input fields.

One feature of the GUI is input parameter tuning by tapping cursor keys. Even the order of a filter may be

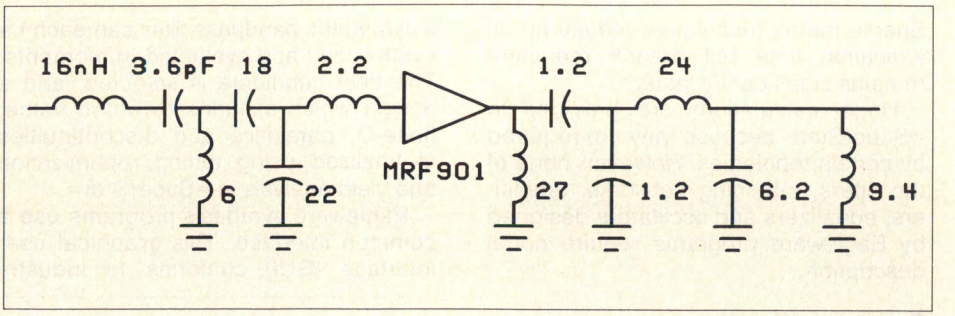

Figure 4. Input and output matching network schematics of a 470 to 890 MHz MRF901 amplifier.

tuned, and the schematic output window automatically scales to hold the schematic with values.

Modular Approach

Synthesis and simulation are distinctly different processes, but when integrated they form a powerful design environment. Synthesis finds complex structures and simulation addresses reality. A modular environment provides for an expanding group of synthesis tools. Eagleware provides free technical assistance to customers wishing to add their own programs to the environment.

Readers desiring more information should circle Info/Card #250. ***RF***

About the Author

Randy Rhea is President of Eagleware (formerly Circuit Busters). He holds BSEE and MSEE degrees, and previously has held engineering design and magament positions at Scientific-Atlanta, Boeing and Goodyear Aerospace. He can be reached at Eagleware, 1750 Mountain Glen, Stone Mountain, GA 30087, or by telephone at (404) 939-0156.

FFT Analyzer Features 90 dB Dynamic Range

The SR760 Fast Fourier Transform (FFT) analyzer offers a full range of features and performance, including 16-bit A/D conversion at a 256 kHz clock rate for 90 dB dynamic range and a fast 100 kHz real time bandwidth. Two 24-bit digital signal processors perform the 512 point FFT. The display has a useful range of 114 dB below full scale. Measurements supported include Total Harmonic Distortion (THD), Power Spectral Density (PSD), third octave, band and sideband analysis. Menu driven measurement and display modes cover a wide range of functions, such as real, imaginary, magnitude or phase display, trace math, up to 50× zoom, dual screen display, limit lines, data tables, harmonic markers, next-peak and delta markers, and 191 mHz to 100 kHz spans. Full scale input as low as −60 dBV makes low level analysis possible without external preamplifiers. Full triggering control, either internal or external, captures transients with both pre-and post-trigger delays. Typical applications include sideband noise analysis, ultrasonic analysis, narrowband spectrum analysis, and high resolution analysis of downconverted signals. The SR760 is priced at $4350.

Stanford Research Systems
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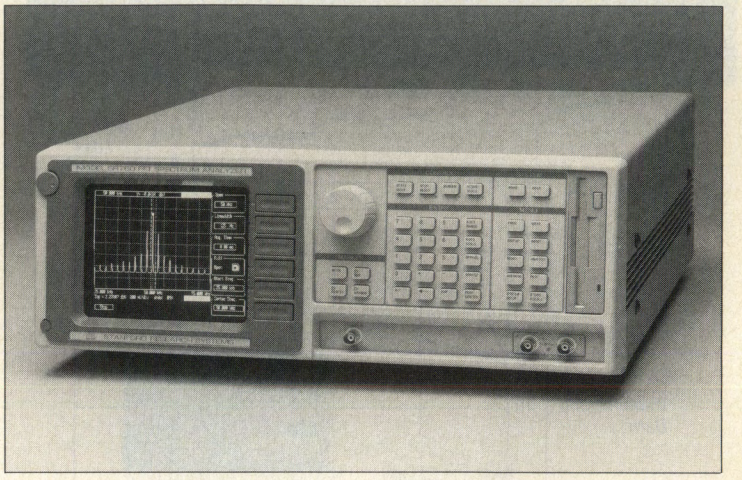

Signal Generation and Modulation NCOs

Two new numerically controlled oscillators (NCOs) have been introduced by Harris Semiconductor. The HSP45106 (16-bit) and HSP45102 (12-bit) are intended for applications requiring accurate control of waveform phase and frequency. The HSP45106 comes in 25.6 and 33 MHz versions, and is capable of FM, FSK, PSK, BPSK, QPSK and 8PSK modulation. The device provides 16-bit sine and cosine outputs with −90 dBc spurious, typical. The HSP45102 is available in 33 and 40 MHz versions, and supports FM and 90 degree phase modulation. A single 12-bit sine wave output is provided, with spurious components of −69 dB. In 1000 quantities, prices start at $34.62 for a 25.6 MHz HSP45106, $44.99 for the 33 MHz version, $15.69 for the 33 MHz HSP45102, and $21.41 for its 40 MHz version.

Harris Semiconductor
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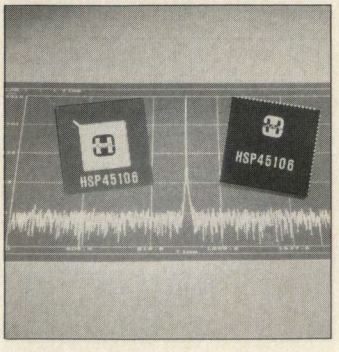


SMT Capacitor Design Kits

American Technical Ceramics announces its two new QUIK DESIGN™ kits, providing a wide range of consecutive values for design and prototyping. Each kit contains 100 of each value in convenient matrix packs, along with a Tuning Stik® for each value. The QK3000 kit is stocked with over 5000 A-case capacitors

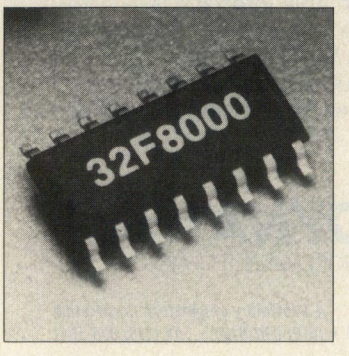
with capacitance values ranging from 0.2 pF to 0.01 uF in tolerance B, C, J, K and M. The QK4000 kit contains over 4000 B-case capacitors in values from 0.3 pF to 0.039 uF in B, C, K and M tolerances. All capacitors are laser marked with value and tolerance. The kits are priced at $499.95 each are available from stock. For production, all values are available in solder plate (nickel barrier) on tape and reel. Solder dipped capacitors are available in matrix packaging or tape and reel on special order.

American Technical Ceramics
INFO/CARD #247

Low Power 27 MHz Filter IC

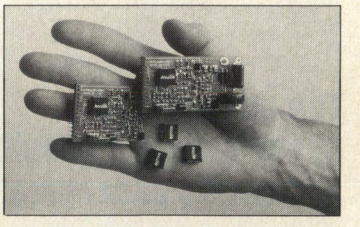
The low power 32F8000 programmable filter IC from Silicon Systems covers the 9 to 27 MHz frequency range, consuming only 5 mW power in the idle mode. The device is a 0.05 degree equiripple-type filter with a signal-to-noise improved by a factor of two over previous offerings. The device can be used in radio applications, as well as in high data rate systems employing constant density recording techniques. A two-pole lowpass and a two-pole highpass feed forward section provide complimentary real axis zeros. A variable attenuator is used to program the zero locations. Both bandwidth and boost can be programmed with external reference currents. Group delay variation is ±2 percent and harmonic distortion is less than 1.5 percent. Samples and a demonstration board are available. In volume, the 32F8000 is priced at less than $5.00

Silicon Systems
INFO/CARD #246



Data Network Components

Intellon Corporation introduces the Spread Spectrum Power Line Modem (SSPM) integrated circuit to implement the proposed EIA CEBus power line physical layer standard. The chip generates and receives all the required spread spectrum signalling information, operating at the CEBus standard



rate ot 10,000 "1" bits per second. The SSPM can also implement Intellon's European Utility Bus (EUBus) version of the CEBus protocol, with a frequency range that can be used with European electrical utilities. Also in development is a chip that works with Echelon Corporation's LONWORKS™ and other devices that implement infrared and RF-based local control networks. The SSPM is priced at $5.00 is 25,000 OEM quantities, plus a $2500 licensing fee. Also announced is a modem board that incorporates the SSPM chip and power line interface and protection circuitry. The board is priced at $105 in quantities of 10. An evaluation system with operating software and three CEBus nodes is available, priced at $3495.

Intellon Corporation
INFO/CARD #245

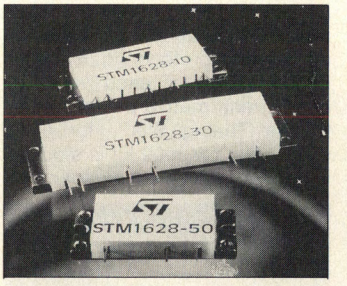
900 MHz SAW Resonators

RF Monolithics, Inc. now offers SAW resonators for frequency control applications in the 902-928 MHz band, for applications under FCC Part 15. Standard resonators are the RP1094 at 915 MHz, the RP1102 at 905.5 MHz and the RP1103 at 924.5 MHz. The devices are built on quartz for stability, and are provided in TO-39 hermetic metal packages. Typical applications include TV transmission, RF ID tags, motion detectors and wireless telemetry systems.

RF Monolithics, Inc.
INFO/CARD #244

L-Band Power Modules

A series of miniature microwave power amplifier modules for use in high power satellite communications equipment has been introduced by SGS-Thomson Microelectronics. Six modules are



available, providing power outputs of 10 W, 30 W, and 50 W. Series STM1628 units operate from 1608-1628 MHz, and Series STM1645 modules cover 1625-1645 MHz. All are designed for 28 V operation. Input and output impedances are 50 ohms.

SGS-Thomson Microelectronics
INFO/CARD #243

Communications Test Upgrades

Four communications test products from Hewlett-Packard have recently been upgraded in features and performance. The new Model 11759B RF channel simulator has frequency coverage and bandwidth increased to cover wider band digital formats, and radio systems using other than the North American dual-mode signal format. The HP 8782B vector signal generator now has calibrated analog in-phase and quadrature (I/Q) modulation inputs for RF carriers from 1 to 250 MHz. This allows engineers to test complex signal formats for radar, EW, cellular and personal communications. Vector modulation analyzer HP 8981B has added magnitude and phase versus time measurements, and has reduced timing skew between channels to improve time comparisons. Finally, the HP 11758U digital radio test system now automatically measures M-curves, revealing quantitatively how well equalizer circuits withstand multipath fading.

Hewlett-Packard Company
INFO/CARD #242

Precision Tuning Elements

Voltronics is now producing a full line of metallic and dielectric tuning elements. These bushings, rotors and dielectric rods may be purchased separately or as assemblies. The tuners allow smooth, precise tuning of DROs, cavities, waveguides filters.

Voltronics Corporation
INFO/CARD #241

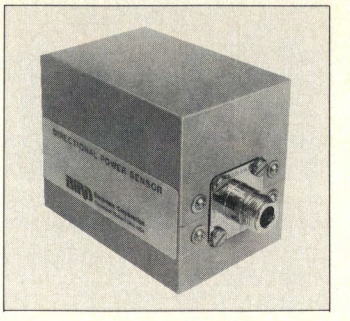
Hybrid Gain Modules

Miniature hybrid gain modules for communications systems are introduced by Microwave Technology. The modules can be cascaded to create amplifiers with various gain and power output combinations. Four units cover 17.7 to 19.7 GHz with 4 to 10 db gain and up to 27.5 dBm output. Three units cover 21.2 to 23.6 GHz with 4 to 10 dB gain and up to 24 dBm output.

Microwave Technology
INFO/CARD #240

Low Frequency 10 kW Power Element

Bird Electronic Corporation has expanded the range of its directional power meters with a 100 kHz to 2.5 MHz, 10 kW sensor with ±3 percent measurement accuracy. THRULINE® Model 4025 is a 50 ohm unit the allows measurement under operating conditions. With other models



already available, the 4420 and 4421 RF Power Meters and 4029 Calibrator now cover 100 kHz to 32 MHz up to 10 kW power, and 1.8 MHz to 1 GHz at 1 kW power levels.
Bird Electronic Corporation
INFO/CARD #239

2.7 GHz Signal Generator

A new synthesized signal generator, Model 3221, has been introduced by Leader Instruments Corp. Signal outputs up to 2.7 GHz can be modulated in 7 modes, or 14 possible combinations of Pulse, Logic, DC-FM, and internal or external AM and FM. Up to 100 front panel setups can be stored in memory. GPIB interface is standard.
Leader Instruments Corporation
INFO/CARD #238

Linear UHF Transistor

Philips Semiconductor's BLV62 linear UHF television transmitting transistor has broad bandwidth (470-860 MHz) and high power (150 W at 1 dB compression). The device has two NPN silicon transistors in a push-pull configuration, providing a power gain of at least 8.5 dB. Typical efficiency is 50 percent with a 28 V supply.
Philips Semiconductors
INFO/CARD #237

Low-Loss Cellular Filters

A series of low-loss filters designed for cellular and other personal communications products is announced by Sawtek Inc. Typical performance characteristics for a 71 MHz center frequency device include 8 dB insertion loss, 360 kHz 3 dB bandwidth, and 250 nsec group delay variation. Center frequencies from 20 to 400 MHz are available with a 1 dB passband of 200 kHz, typical for GSM/PCN. DIP and SMT packages are available.
Sawtek Inc.
INFO/CARD #236

Pulsed Power Capacitors

Mini double-ended (MDE) capacitors from Maxwell Laboratories are intended for pulsed electronic circuits such as lasers, CRT power supplies, and lighting arrestor networks. The line has up to 25 times the capacitance of ceramic capacitors, reducing parts count and number of interconnections.
Maxwell Laboratories, Inc.
INFO/CARD #235

OCXOs to 140 MHz

Oven-controlled oscillator Series CO-724SL2 provides low noise +7 dBm output at any frequency in the 25-140 MHz range. In a 2 × 2 × 1 inch package, the OCXOs offer stability of $\pm 5 \times 10^{-9}$ over 0 to +50C and $\pm 5 \times 10^{-8}$ over −55 to +85C. Phase noise at 100 Hz is −130 dBc/Hz, −157 dBc/Hz at 50 kHz. Power drain is 4 W at turn-on, dropping to 1.8 W stabilized at 25C.
Vectron Laboratories, Inc.
INFO/CARD #234

Low Noise Amplifiers

Two low noise CATV amplifiers from Motorola offer noise figures of 4.5 dB at 450 MHz, 5.0 dB at 550 MHz. The MHW5183 (40-450 MHz) and MHW6183 (40-550 MHz) are designed as input amplifiers in trunk and line extender applications. Typical power gain is 18.5 to 19.5 dB over the frequency range. For 25 or more, the MHW5183 is $35.90 and the MHW6183 is $39.90.
Motorola Inc.
INFO/CARD #233

Tuning Diodes

MSI Series 1S800 hyperabrupt tuning diodes are designed for wide tuning and electronic control applications in surface mount and stripline assemblies. Capacitance change with 2-20 volts bias allow octave tuning. Capacitance of the ten types in the series ranges from 1.8 pF to 45 pF at 4 volts bias. Low inductance and capacitance packaging is suitable for VHF through low microwave applications.
MSI Electronics
INFO/CARD #232

Buffered VCOs

Micronetics' Series VOB-90000 voltage controlled oscillators offer standard output power

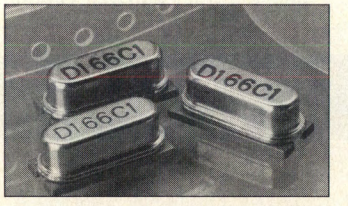
of +20 dBm in 40 percent bands from 100 to 2500 MHz. Harmonics are better than −40 dBc and spurious signals are −60 dBc or greater. Other features are fast settling time and low post tuning drift, with an output buffer to minimize load pulling.
Micronetics
INFO/CARD #231

Low Cost Transistor

The medium power NEC NE46134 is a silicon bipolar transistor for cellular radio, wireless LAN and cordless phone applications. Available for under a dollar in 1000s, this SMT device offers 1/2 watt maximum output (1 dB compression) with a 12.5 V supply, 1.5 dB and 2.0 NF at 500 MHz and 1 GHz, respectively.
California Eastern Laboratories
INFO/CARD #230

Tiny Clock Oscillator

KDS America announces the SO-49, the smallest version of their crystal clock oscillator. The miniature package measures 4.5



× 11.8 mm and is 5.0 mm high. Available frequencies range from 625 kHz to 50 MHz using HCMOS, CMOS or TTL logic. In 1000-piece quantities, the oscillator is priced at $2.20 to 3.00 each.
KDS America
INFO/CARD #229

Broadband Amplifier

Model 310 from Sonoma Instrument is a 10 kHz to 1 GHz amplifier offering typical noise figure of 1.8 dB, 32.5 dB at 100 MHz, and flatness of ±0.5 dB from 25 kHz to 800 MHz. Output power is +11 dBm at 1 dB compression. Time domain performance includes a 350 ps transition time and ±75 ps group delay variation.
Sonoma Instrument
INFO/CARD #228

DPSK Demodulator

Model STEL-2120 is a DPSK demodulator for receivers requiring high performance digital functions. The device includes necessary capabilities to demodulate DBPSK, DQPSK, DMSK, as well as pi/4 DQPSK. Input data rates up to 8 Mbps are handled, and digital AGC and decision directed AFC are additional features. The STEL-2120 accepts 8-bit twos complement I and Q inputs from other digital signal processing system components.
Stanford Telecom
INFO/CARD #227

SMT Inductors

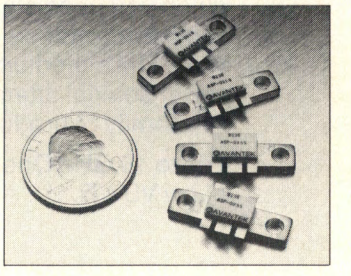
New molded inductors are now available in the standard 1010 EIA size, to meet the needs of higher component density RF products. Phenolic core parts cover the 0.01 to 0.1 uH range, with ferrite core products offered from 0.12 to 27 uH. Terminations are solder plated copper, and the devices are compatible with automatic placement equipment and reflow and wave soldering. Prices average $0.70 in 1000s.
American Precision Industries
INFO/CARD #226

200-300 MHz Amplifier

A 300 watt pulsed power amplifier covering the 200-300 MHz range is introduced by Intech. Maximum pulse width is 25 milliseconds with a switching time of less than 10 microseconds. Microprocessor control of duty cycle and VSWR with graceful degradation of power in the event of transistor failure. CW power rating is 50 watts.
Intech Inc.
INFO/CARD #225

850-960 MHZ Power Transistors

Avantek is introducing a pair of silicon bipolar NPN common-base transistors specifically designed for analog cellular base stations. The ASP-0910 is a 9-

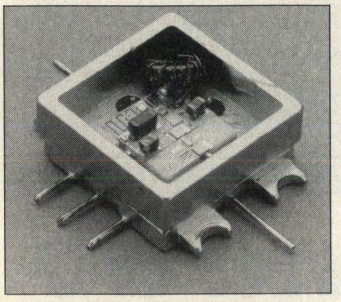


watt device with 9.5 dB minimum gain and operation into a 10:1 VSWR without damage. A 55-watt transistor, the ASP-0955 provides 8.9 dB minimum gain and can safely operate into a load up to 4.3:1 VSWR. The two transis-

tors may be cascaded to provide 55 watts with one watt drive power.
Avantek, Inc.
INFO/CARD #224

High Intercept Amplifier

AML announces a 20-2000 MHZ low noise, surface mount amplifier with a high inter-



cept point of +38 dBm (third order). Gain is 11 dB, noise figure is 4.5 dB, and output power at 1 dB compression is +25 dBm. The units' package is 0.5 inch square.
AML Inc.
INFO/CARD #223

Small Wideband Transformers

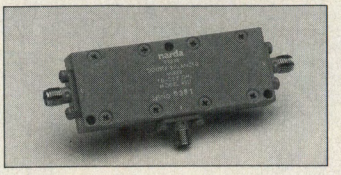
Coilcraft's new surface mount RF transformers feature low insertion loss and high current ratings. Built on a standard 1812 size ferrite body, the top is encapsulated to protect the winding and provide a flat surface for pick and place handling. The units are 1:1 transformers, offered in four models covering 350 kHz through 480 MHz. In 5000-unit production quantities, the price is approximately $1.00.
Coilcraft
INFO/CARD #222

75 MHz Op Amp With AGC

The LT1228 combines a 100 MHz current feedback amplifier with a DC-75 MHz gain-controlled amplifier. The combination provides a wideband amplifier with 60 dB gain control range. The LT1228 has guaranteed ±30 mA output drive, and operates from ±2 to 18 Volt supplies. In video applications, the differential gain and phase while driving 75 ohm cable are 0.04 percent and 0.1 degree. Price is $3.95 in 100s.
Linear Technology Corp.
INFO/CARD #221

Broadband Mixer

Narda introduces the ultra-broadband Model 4817 mixer. RF and LO frequencies o 1 to 26.5 GHz are covered, with an IF



range of DC to 500 MHz. Matched Schottky barrier diodes and planar construction assure symmetry to provide good isolation, low VSWR, and unit-to-unit repeatability.
Loral Microwave-Narda
INFO/CARD #220

Power Hybrids

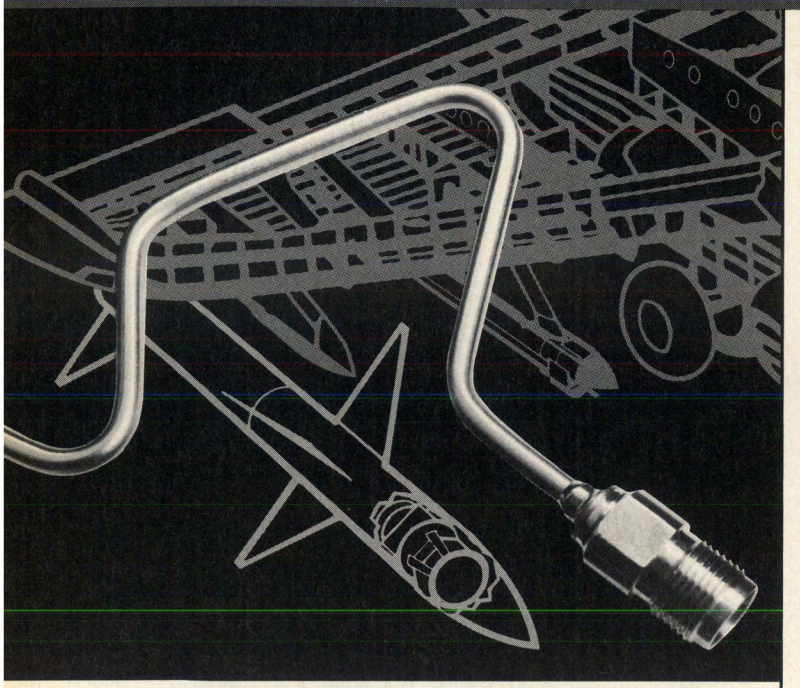
M/A-COM offers three compact, rugged 3 dB quadrature hybrid couplers with 100 watt minimum power handling. These stripline devices have features for high thermal conductivity to allow maximum power rating with SMA connectors. Insertion loss is 0.8 dB maximum. Connector options are SMA or TNC. In 1-4 quantities, the units are $442.30.
M/A-COM Control Components
INFO/CARD #219

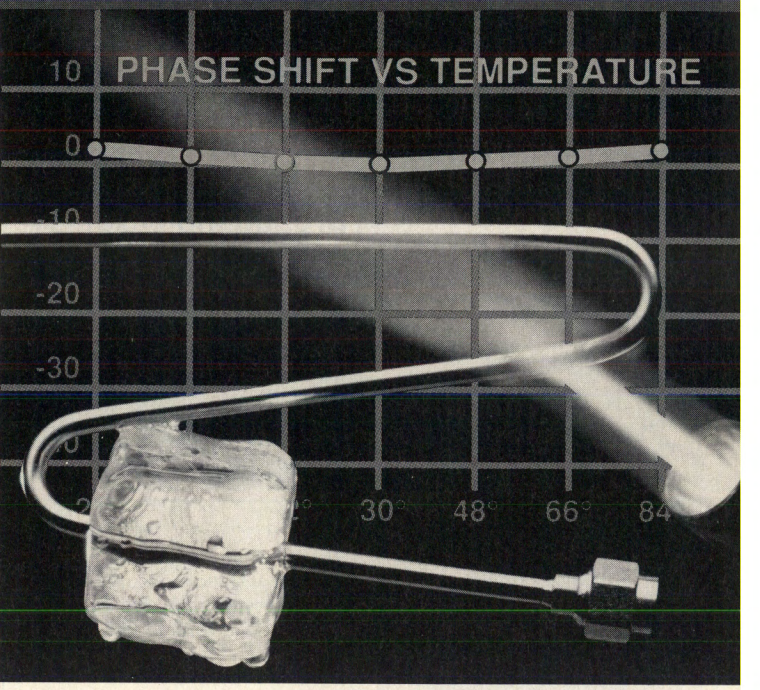
Silver Epoxy Adhesive

Master Bond EP77MHT is a silver filled epoxy resin compound modified for toughness and high thermal shock resistance. Shelf life is 6 months in sealed containers and room temperature. Applications include bonding components to p.c. boards, antenna bonding, RF shielding, and lead attachment.
Master Bond Inc.
INFO/CARD #218

Arc Percussive Welders

Arc percussive butt welding uses an RF arc to create a plasma which conducts the DC welding current with low resistance. This rapid, high intensity process solves many of the problems with the welding of dissimilar metals, including copper to steel, tungsten or aluminum. Short duration minimizes thermal shock in electronic component assembly.
Superior Technologies
INFO/CARD #217





It has to go where?!

...and do what?!

Any microwave integration engineer knows the formidable task of routing coaxial cable through crowded airframes, jammers, missiles, even satellites. Despite the platform, Kaman's semiflexible cable solves these routing obstacles. Although the exterior of Kaman's semiflexible cable looks like PTFE semirigid cable, only SiO_2 dielectric withstands the extreme heat required to fully anneal the stainless steel sheath. The annealing process produces a cable that can be continuously rebent. This, combined with no migration of the center conductor, results in little change in electrical performance, unlike PTFE. SiO_2 cable is also 30% smaller in diameter, 30% lighter per foot, and withstands up to a 60% tighter bending radius than flexible PTFE cable of equal insertion loss per foot. Kaman laser welds hermetically sealed connectors to the cable sheath and produces a hermetic assembly suitable for the most hostile environments. To learn more about Kaman's custom EW interconnects, call for a free Custom RF Cable Assemblies Handbook.

KAMAN SPECIFICATIONS

SiO_2 SEMIFLEXIBLE CABLE

Frequency: Up to 26.5 GHz.

Electrical length change: 7 ppm/°C typical (0.0007%/°C).

Insertion loss change with temperature: 1000 ppm/°C typical (0.1%/°C).

Construction:
Outer sheath: Fully-annealed seamless 304 stainless steel tubing.
Outer conductor: Oxygen-free copper tubing.
Dielectric: SiO_2.
Inner conductor: Oxygen-free copper.

Connectors: Typical MIL-SPEC including SMA and TNC. Also Quick Disconnect, Blind Mate, and other custom designs. Hermetically sealed and laser welded to cable sheath.

Qualifications: MIL-T-81490, MIL-C-39012.

Cable diameters (inches): .090, .125, .141, .200, .270, .295.

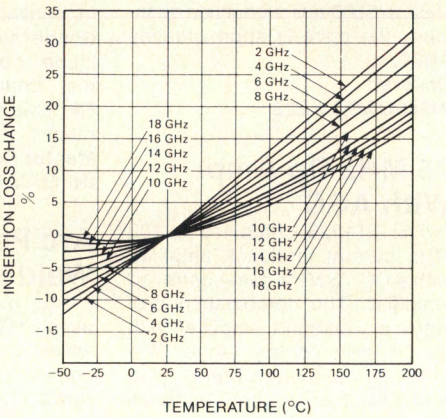
Bend radius: 3x cable diameter. At factory, 1.5x cable diameter.

MTBF: 1,000,000 hours

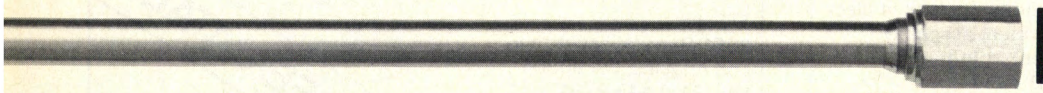
Kaman Instrumentation
1500 Garden of the Gods Rd.
Colorado Springs, CO 80907
719-599-1821 FAX 719-599-1823

800-542-2443

Kaman's cables connect laboratory ideas to platform reality by offering virtually flat phase shift over temperature. This eliminates temperature compensation and frequent phase calibration prohibited by reaction-time budgets. In EW airborne applications, flight-line to 40,000-foot temperature swings would cause phase drift from non-SiO_2 cables. Insertion loss change over temperature is also drastically reduced compared to PTFE cables.



INSERTION LOSS CHANGE VS TEMPERATURE FOR A TYPICAL .141 DIAMETER CABLE



KAMAN

Flexible solutions to rigid problems

INFO/CARD 40

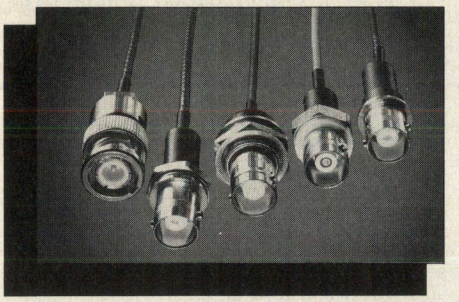
Cables and Connectors — An Industry Barometer

By Liane G. Pomfret
Associate Editor

Universal RF products such as coaxial cable and connectors tend to be excellent indicators of the general health of the market. It comes as no surprise, then, to find that many companies are changing their market focus, changing the way they do business and revamping their product line. There is no consistency in the market either. The variety of answers concerning the RF business' health is as varied as the number of companies asked.

Cable and connector companies who started planning for a recession and a reduction in the military budget a few years ago are coming out on top. They've streamlined their companies and changed their market focus. They've also changed how they do business. Today's companies are far more customer oriented. Total Quality Management (TQM), Statistical Process Control (SPC) and Just In Time (JIT) are all industry buzzwords. Essentially it all boils down to a better product, at a lower cost, and delivered when the customer needs it, not in six weeks. Manufacturers are extremely skittish when it comes to the economy. Virtually no one has predicted that next year will be a boom year. Steve Perry, Sales Manager for Kaman Instrumentation, sums it up, "Although business has been good for Kaman over the last two years, we know we're going into lean years and we've planned for that." Everyone acknowledges that while business has been good until now, it's time to tighten their belts and look to other markets for business.

People agree that the military market is not what it used to be. Many companies realized this several years ago, and began planning for a shift in their market focus. Consequently, they are already moving into more lucrative markets. Brian Holland, Sales Manager for Storm Products notes that, "We've been about 75 percent defense and the rest commercial. However, we've been working at changing that over the last few years. But it doesn't happen overnight." This kind of foresight is what will see cable



and connector companies through the recession and allow them to emerge stronger than when they entered.

This is not to say that the military market is dying. There will always be the need for retrofitting and updating equipment and there will always be new programs that require cables and connectors. However, the military cannot support the number of manufacturers that it once did. Like every other part of the RF industry, cables and connectors are becoming leaner and more competitive. "We seem to be doing very well," comments Belinda Gleghorn, Sales Manager for Micro Coax Components. "MCC has SPC on all semi-rigid cable and this has enabled us to improve process yields, reduce cost and gain a greater market share. We've also expanded our product line with a flexible microwave cable."

There are some interesting new features appearing on the market these days, and they vary from manufacturer to manufacturer. The introduction of surface mount connectors by AEP fulfills what they believe to be a market niche. "There's basically two reasons to want to go to surface mount; one's to save space and the other is to save manufacturing costs. On the commercial side, they'd want to use a lot of them and be able to stick them on with robots but on the military side, which would be a smaller quantity, it would be a packaging/space savings drive," says Jeffrey Buccitti, Sales Manager for AEP.

Smaller sized components are a common request as telecommunications equipment continues to shrink. "They're demanding the smaller size cables and they want smaller interconnects as well," says Gary Passmore, Sales Manager of the Microwave Division at Precision Tube. Hand in hand with smaller size is a trend towards the microwave frequencies. As Scott Spencer, Marketing Manager for M/A-COM Omni Spectra comments, "Our OSX microminiature RF connectors operate up to 6 GHz. They are being used in RF and digital applications for cellular radio, GPS, card transponders, industrial/agricultural motion measuring equipment and wireless LAN's." Michael Nauman, President of Meritec says, "I think the key industry trend is that they are going towards higher speeds.

In some cases, customer support has become as important as the actual product. Ten years ago, companies did not take the interest in customer support that they do now. Today, many customers make technical support a top priority when searching for a cables and connector manufacturer. "Customers are looking for suppliers who can achieve targets in the linkage of quality, cost, and delivery," says Patrick Ladolcetta, Director of Marketing for Amphenol. It has become a far more personal business than it used to be.

No matter what the trends, the key to survival in this market is establishment of a niche for the manufacturer. Naturally, companies will see different trends depending on their customer base. As with the rest of the RF industry, there will be the inevitable downsizings, mergers, and closures, but there will also be companies who survive and continue to prosper. These will be the companies who gave careful thought to their long term goals and instituted a plan to achieve them. ***RF***

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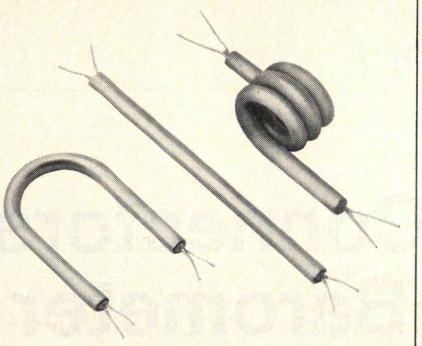

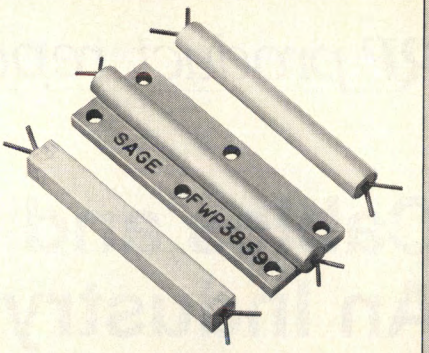

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	A narrow band hybrid	HC1 & JC1 3 dB + .32 − .25 f2/f2 = 1.25 L(inches) = 1850/FMHz	KC1 & JC1 3 dB + .22 − .19 f2/f1 = 1.25 L(inches) = 1970/FMHz
	A directional coupler	A 2″ length is a 10 ± 1 dB coupler from 175 to 229 MHz	A 2″ length is a 10 ± 1 dB coupler from 186 to 244 MHz
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	Low insertion loss	0.3 dB MAX	0.2 dB MAX
	Handles average power	HC 100 Watts / JC 200 Watts	500 Watts
	Handles peak power	2000 Watts	2500 Watts
	Frequency range	100 MHz to 5 GHz	246 MHz to 6.5 GHz
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	High reliability product	Used in communication satellites	Used in high power amplifiers
PLUS THESE ADVANTAGES	It's easy to use	To trim, use a razor blade and thermal strippers	Comes cut to length
	You can bend it	HC min radius of curvature .15″ JC min radius of curvature .30″	Straight lengths only
	You can buy it in bulk	Comes in 5′ lengths	Furnished only to length See below
	You can buy it cut and trimmed	Minimum length .5″	Any length .3″ to 8″
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INFO/CARD 41

An Improved Tau-Dither Technique for Spread Spectrum Code Tracking

By Harry B. Brown, III
Smiths Industries

One of the most exciting trends in modern communications technology is the application of spread spectrum techniques to commercial systems. Despite the well documented advantages of spread spectrum communications (1), commercial use has been slow to develop because of the relative complexity of the equipment. However, as this technology has matured in the military sector, more efficient implementations of the basic signal processing functions have evolved. This paper describes the refinement of one such function.

Spread spectrum communications is characterized by two criteria. First, the transmitted bandwidth must be greater than the information bandwidth. Second, the mechanism which determines the transmitted bandwidth must be independent of the information. This spectrum spreading mechanism is a pseudo-random binary sequence which alters either the phase or frequency of the transmitted carrier. In order for the receiver to recover the information signal which is combined with the pseudo-random (PR) sequence, this process requires that the receiver have knowledge of the sequence, synchronize its local code generator with the transmitted sequence, and maintain synchronization (track the sequence) despite changes in phase or frequency of the transmitted code. In Direct Sequence Spread Spectrum (the carrier is biphase modulated by the PR sequence) precision tracking is not only important for maximum correlation, but crucial for accurate range estimates in navigation systems.

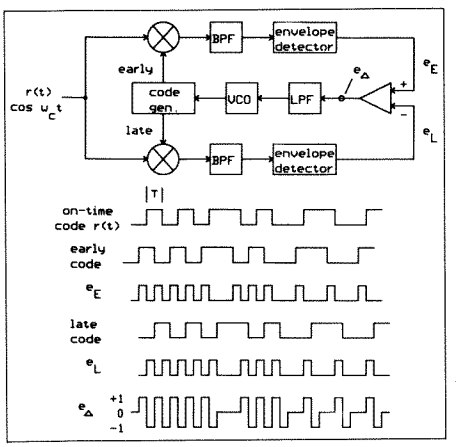


Figure 1. Delay lock loop and timing diagram. When the early and late codes are exactly ±1/2 chip of the on-time code, the VCO error signal (eΔ) averages to zero.

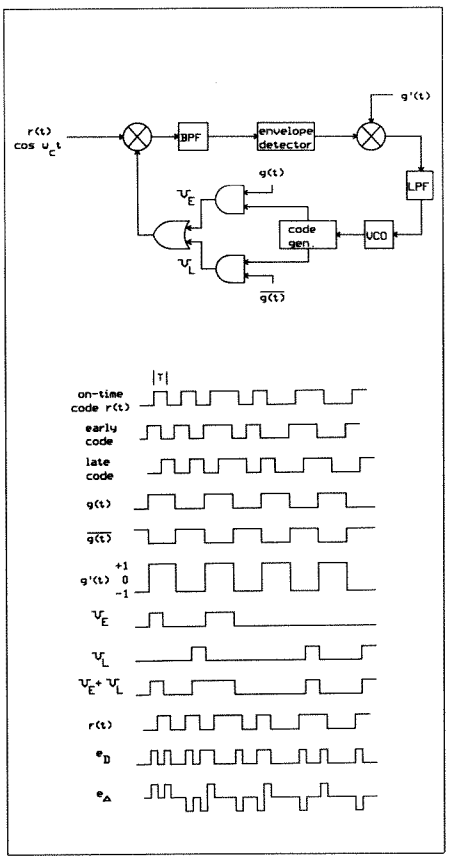


Figure 2. Dithering loop and timing diagram. When the early and late codes are exactly ±1/2 chip of the on-time code, the VCO error signal (eΔ) averages to zero.

There are two basic techniques for tracking the incoming PR code: the delay-lock loop (2) and the dithering loop (3), also called tau-dither. In the delay-lock loop (see Figure 1), the incoming code sequence is correlated in two parallel channels — one with an early version of the locally generated code, and one with a late version of the local code. The difference between the two detected levels is used as an error signal to correct the timing of the local code generator. The error signal is maximized when the early and late code sequences are 1/2 chip (code bit) offset from the on-time sequence (3). The dithering loop (Figure 2) uses only one channel to correlate the incoming code, but applies the early and late versions of the local code alternately (the local code is "dithered" back and forth). The error signal is obtained by alternately inverting the resulting correlated signal (subtracting the late correlation). This error signal then corrects the timing of the local code generator as was done in the delay-lock loop. The disadvantage of the delay-lock loop is that two correlating channels are required (more components than needed for the dithering loop), and furthermore, these two channels must be matched in gain and phase. The dithering loop, on the other hand, incurs a 3 dB worse signal-to-noise ratio be-

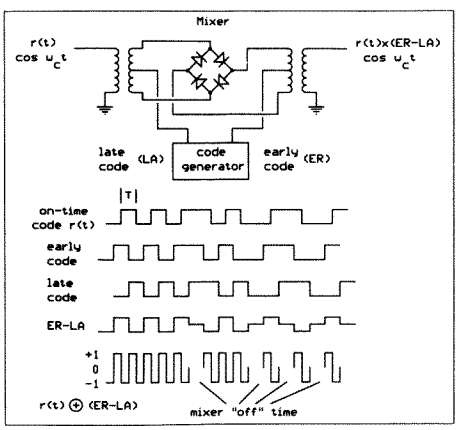


Figure 3. Double-balanced mixer.

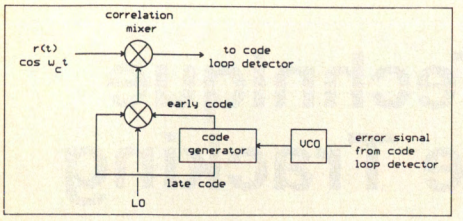


Figure 4. "Off-line" early-minus-late code modulation.

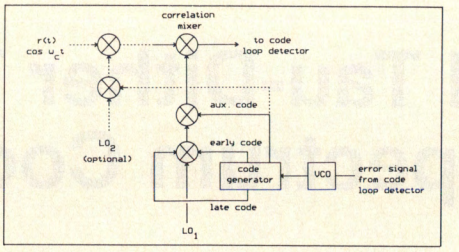


Figure 5. Tandem mixer configuration for improved LO suppression.

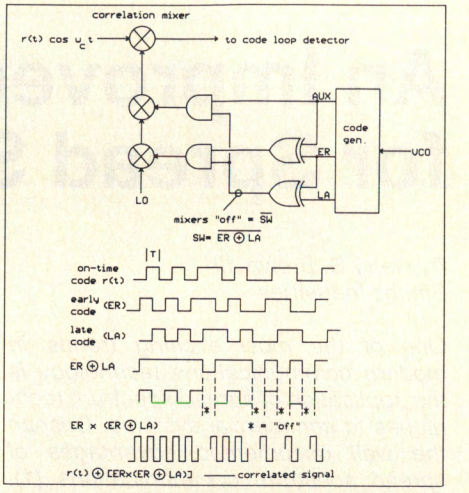


Figure 6. Composite early-minus-late code using a common "mixer off" signal for the tandem mixer.

cause of the time-sharing imposed by the early and late codes. However, the dithering loop approach is the more popular choice of code tracking methods by virtue of its relative simplicity.

Early Minus Late Code Correlation

Improvement on the dithering loop shown in Figure 2 can be obtained by first removing the alternating (inverting) signal which is applied to the detected signal. With very high code rates this inverting signal would also be a very high frequency digital signal. With a high frequency baseband signal, it is necessary to use high frequency, wide bandwidth components which are less available and more expensive than lower frequency components. Thus, inverting the late correlation signal after detection is not desirable. An attractive alternative is to achieve inversion of the late code during the correlation process itself. Because of the inherent symmetry of the double-balanced mixer (Figure 3), this common RF device can be driven directly by the early and late code outputs of the code generator, resulting in a composite of early minus late code states. Unfortunately, this approach also has some performance limitations. The "0" state of the composite early-minus-late states (+1, 0, −1) results in an "off" condition for the mixer diodes. During this "off" period, suppression of the code modulated carrier is limited by the RF to LO isolation of the mixer. Furthermore, during the "on" (+1 or −1) states,

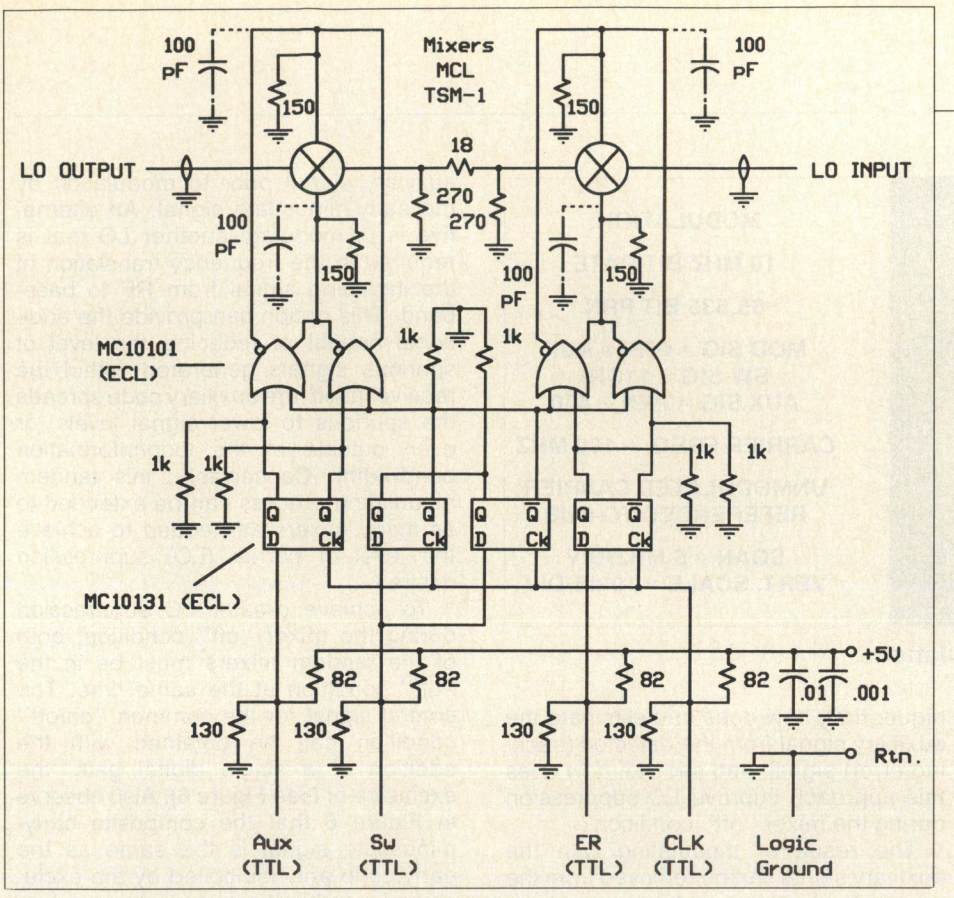
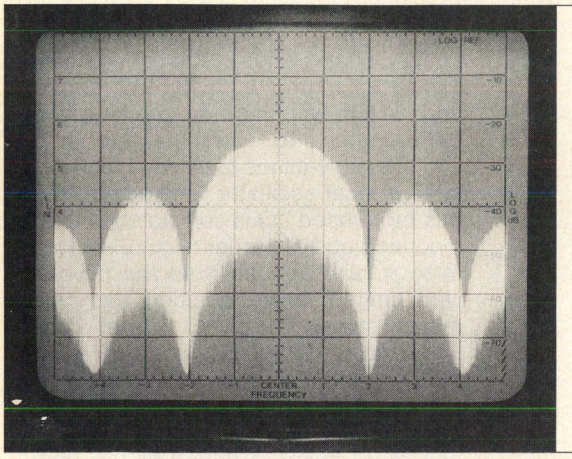


Figure 7. Early-minus-late code modulator.

carrier suppression is also limited (−40 dB typical at VHF/UHF frequencies). Limited suppression of the coded carrier can result in error signal bias or modulation which will degrade tracking loop performance. To overcome this limitation, the early-minus-late code first modulates a local oscillator (LO) signal, then this modulated LO is correlated with the incoming coded carrier (Figure 4). However, it now appears that the problem with limited mixer isolation has been merely moved from the "on-line" correlation mixer to the "off-line" mixer where the early-minus-late code modulates the LO signal (also resulting in tracking loop degradation). To resolve this problem, one more mixer is added to the early-minus-late modulation process.

Auxiliary Modulation

The residual unmodulated carrier appearing at the output of the mixer performing the early-minus-late modulation can be substantially reduced by "remodulating" the signal with an auxiliary signal in a second, or tandem, mixer (Figure 5). This tandem modulation process results in an effective carrier



MODULATION:

10 MHZ BIT RATE

65,535 BIT PRN

MOD SIG = PRN ⊕ AUX
SW SIG = 1 (ON)
AUX SIG = PRN ÷ 400

CARRIER FREQ. = 180 MHZ

UNMODULATED CARRIER REFERENCED TO 0 dB

SCAN = 5 MHZ/DIV
VERT. SCALE = 10 dB/DIV

Figure 8. Tandem biphase code modulation.

(LO) suppression that is twice the suppression of a single mixer. The auxiliary signal sequence must be independent of the early-minus-late code (does not correlate), but can be derived from the code generation process (to test this approach, the "on-time" PR code was divided by 400). Two questions arise about this tandem modulation technique: first, how does one eliminate the auxiliary signal from the detected (tracking error) signal; and second, how does this approach improve LO suppression during the mixer "off" condition?

The result of modulating with the auxiliary signal can be removed from the composite tandem modulation process by modulating the LO signal with the auxiliary signal prior to modulation by the early-minus-late signal. An alternative is to modulate another LO that is required in the frequency translation of the incoming signal from RF to baseband. This option can provide the additional benefit of reducing the level of spurious signals generated within the receiver itself (the auxiliary code spreads the spurious to lower signal levels, or even outside of the loop/information bandwidth). Conceivably, this tandem modulation process can be extended to as many mixers as needed to achieve the level of carrier (LO) suppression desired.

To achieve greater LO suppression during the mixer "off" condition, both of the tandem mixers must be in the "off" condition at the same time. The control signal for the common "on/off" condition can be obtained with the addition of a single digital gate: the exclusive-or (see Figure 6). Also observe in Figure 6 that the composite early-minus-late signal is the same as the early code only multiplied by the exclusive-or combination of early and late codes! Separation of the "on/off" signal

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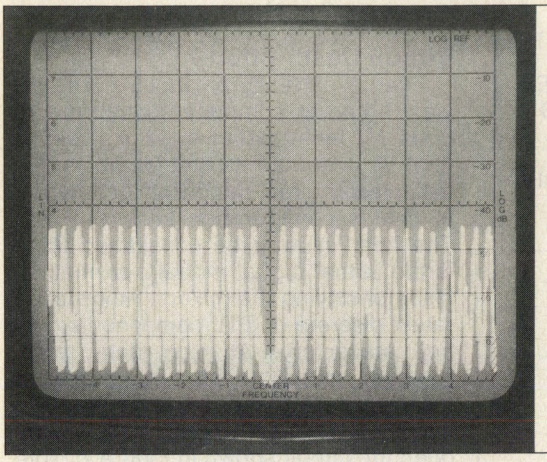


MODULATION:

10 MHZ BIT RATE

16,383 BIT PRN

MOD SIG = PRN ⊕ AUX
SW SIG = 1 (ON)
AUX SIG = PRN ÷ 400

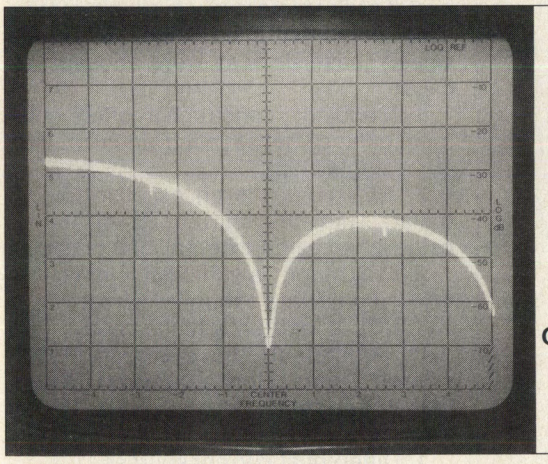
CARRIER FREQ. = 180 MHZ

UNMODULATED CARRIER REFERENCED TO 0 dB

SCAN = 2 KHZ/DIV
VERT. SCALE = 10 dB/DIV

CARRIER SUPPRESSION GREATER THAN 74 dB

Figure 9. Carrier suppression.



MODULATION:

10 MHZ BIT RATE

65,535 BIT PRN

MOD SIG = PRN ⊕ AUX
SW SIG = 1 (ON)
AUX SIG = PRN ÷ 400

CARRIER FREQ. = 180 MHZ

UNMODULATED CARRIER REFERENCED TO 0 dB

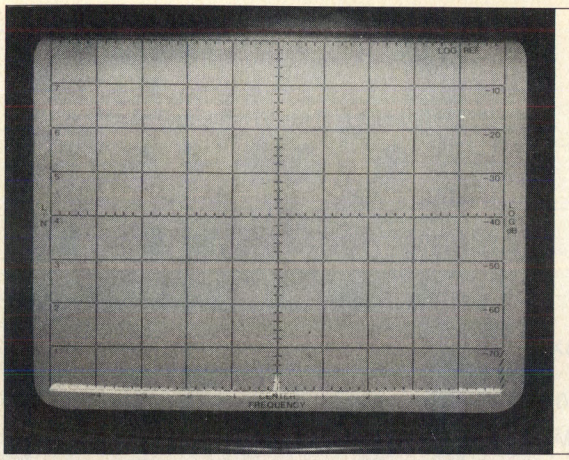
CENTER OF DISPLAY = 190 MHZ (1st SIN X/X NULL)

SCAN = 2 MHZ/DIV
VERT. SCALE = 10 dB/DIV

Figure 10. Code chip balance.

from the code (early) sequence itself then allows the auxiliary code to be combined (via an exclusive-or gate) directly with the early code (or with the on-time code for data recovery), thus eliminating the necessity of injecting the auxiliary code at some other point in the receiver.

With the problem of limited LO suppression overcome, one final source of correlation degradation remains — unbalances due to lack of symmetry in the modulating signal itself. The addition of a simple digital circuit to drive the mixers, and a judicious choice of logic family for the circuit's devices, resolve



MODULATION:

MOD SIG = 1

AUX SIG = 1

SW SIG = 0 (OFF)

CARRIER FREQ. = 180 MHZ

UNMODULATED CARRIER REFERENCED TO 0 dB

SCAN = 2 KHZ/DIV
VERT. SCALE = 10 dB/DIV

Figure 11. Modulator carrier isolation.

all the previously discussed limitations in one small package.

Circuit Description

Even a perfectly balanced mixer will yield a carrier component when modulated by an unbalanced digital signal (that is, unequal rise and fall times due to limited channel bandwidth or inherent to device configuration such as TTL). The final issue to be considered then, is the actual digital modulation mechanism for driving the mixers. At low code rates, discrete or TTL components may be satisfactory. At high data rates, however, adequate bit symmetry (and thus balance) is difficult to achieve. To overcome this limitation, I have developed the circuit shown in Figure 7. Note that the active components used in this circuit are commercially available monolithic emitter-coupled logic (ECL) devices. These devices were chosen because:

1. Monolithic construction offers optimum balance between individual drivers (on a single chip).
2. ECL output is an excellent diode driver, with the current level easily established by an external load resistor.
3. ECL output is sufficient to drive the mixer diodes into saturation directly.
4. ECL is inherently high speed.

In addition to the choice of ECL, several other design features contribute to the performance of this circuit. These are:

1. Differential current sources.
2. "Wire-ORed" driver outputs
3. Reclocking at the code "chipping" rate.
4. TTL compatibility through bias resistors at the input.

The differential drive configuration originating from the Q and $\overline{Q}$ outputs of the flip-flop insures transition symmetry regardless of transition direction. The "wire-ORed" driver outputs share current demand and extend the differential drive mechanism through their own differential outputs. The most significant contribution that the flip-flop makes is that it allows the code to be clocked at the system code bit rate. Since only the clock's leading edge is used by the flip-flop, incoming clock and code waveform distortions are inconsequential. In effect, the modulator circuit can reconstruct the code with more balance and symmetry than that contained in the original signal. Note that only three ECL chips are required to drive the two (tandem) mixers. One bonus of this configuration is that all the drivers for both mixers can be driven to the same

state (via the SW input), thus "turning off" both mixers simultaneously in response to the exclusive-or combination of early and late codes. This feature can be used in other applications as an RF switch or as an AM modulator capable of Mbit/sec rates.

TTL compatibility is highly desirable, and measures were taken to achieve this. Although ECL applications' literature recommends a V_{CC} of 0 V and a V_{EE} of −5 V, a V_{CC} of +5 V and a V_{EE} of 0 V were used. Resistor voltage dividers were used to bias the inputs for TTL transition levels. As a result, the ECL modulator circuit is completely TTL compatible.

Additional resistors load unused ECL outputs in order to provide maximum balance internally to the gates. Capacitors were necessary for RF bypassing of the ECL circuit so that carrier (LO) isolation could be maintained.

Results

The performance of the early-minus-late dithering loop modulator (Figure 7) is shown in Figures 8 through 12. In particular, note the absence of the carrier (LO) component (Figure 9), and the absence of frequency components at the sin x/x nulls (Figure 10) of the modulated signal spectrum. The tau-dither technique and modulator described in this paper were successfully used for the acquisition and tracking of a GPS navigation satellite spread spectrum signal. ***RF***

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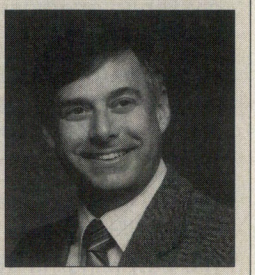
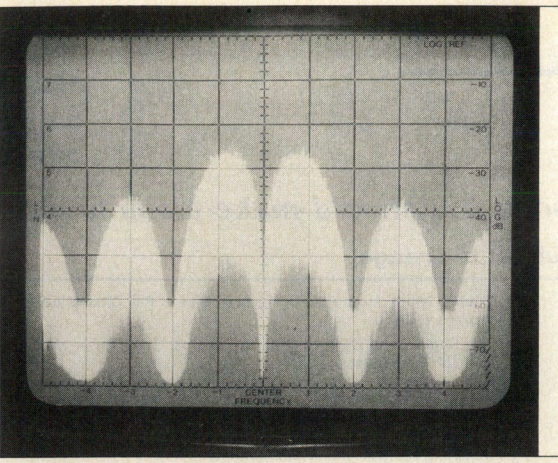
3. H.P. Hartman, "Analysis of a Dithering Loop for PN Tracking," *IEEE Transactions on Aerospace and Electronic Systems*, 1974.

About the Author



Harry Brown is a senior engineer with the Avionic Systems Division of Smiths Industries. He may be reached at 4141 Eastern Avenue, S.E., Grand Rapids, MI 49518-8727. Tel: (616) 241-7757.



MODULATION:

10 MHZ BIT RATE

65,535 BIT PRN

MOD SIG = ER ⊕ AUX
SW SIG = ER ⊕ LA
AUX SIG = ER ÷ 400

CARRIER FREQ. = 180 MHZ

UNMODULATED CARRIER REFERENCED TO 0 dB

SCAN = 5 MHZ/DIV
VERT. SCALE = 10 dB/DIV

Figure 12. Early-minus-late code modulation.

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Learn the fundamentals of oscillator design. Historically, oscillator design has been obscured with pages of equations for particular configurations. In this course, basic concepts are applied to design various oscillators using a unified approach. Attendees learn how to evaluate oscillator designs accurately. L-C distributed element, SAW and crystal oscillators are studied. Also considered are output level, starting time, harmonic levels and phase noise performance. Instructor: Randy Rhea, Eagleware/Circuit Busters.

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Analysis Program for Coaxial Cable

By Eric L. Stasik
Consultant

This entry in the 1991 RF Design Awards Software Contest analyzes coaxial cable electrical parameters using physical data. In addition, the program synthesizes physical dimensions from the user's input, with tables showing various parameters across a range of frequencies or physical dimensions. The program should prove invaluable for designers of coaxial couplers, power dividers and combiners, filters, cavities, and transformer sections.

Although the analysis and synthesis functions for round coaxial cable transmission lines is almost trivial, the program presented here offers a practical, accurate, and convenient method for these calculations. Called COAX, the program calculates nearly every possible parameter. Electrical properties use the dimensions and dielectric properties, with loss calculations that include surface roughness, dielectric loss and conductivity considerations.

Calculations Performed

The COAX program will compute the following parameters from the user's data:

- Characteristic impedance
- Capacitance per inch
- Inductance per inch
- Free space wavelength
- Wavelength in the coax
- Conductor, dielectric and total losses per foot
- TE_{11} mode cutoff
- Peak power handling

A sample printout of the program, using the option of analysis versus frequency is shown in Figure 1. The wavelength and loss calculations may be computed a specified intervals over the desired frequency range. The data

```
        RF/Microwave Computer-Aided Engineering Software.

            Program = COAX (v. 1.3)      DATE = 25 OCT 1991
                                         TIME =  9:41:21

      This program performs IMPEDANCE ANALYSIS and DIMENSIONAL
      SYNTHESIS for COAXIAL transmission lines.

Please Select Program FUNCTION:
    *1 : ANALYSIS  of Impedances from known Dimensions.
     2 : SYNTHESIS of Dimensions from known Impedances.
FUNCTION selected = 1

Please enter the following DIMENSIONAL DATA:
     -Outer Conductor Diameter(B), Inches = .24
     -Inner Conductor Diameter(D), Inches = .0625
     -Relative Dielectric Constants:
              Teflon = 2.022
          Fluoroly  H = 2.430
      Noryl EN265  PPO = 2.690
      Boron Nitride  M = 3.700
      Boron Nitride  A = 4.080
      Boron Nitride HP = 4.110
     Enter Dielectric Constant (Er)  = 2.022
     -Dielectric Loss Tangents:
              Teflon = .0002
          Fluoroly  H = .0003
      Noryl EN265  PPO = .0007
      Boron Nitride  M = .0075
      Boron Nitride  A = .0017
      Boron Nitride HP = .0056
     Enter Loss Tangent (DLTAN)      = .0002
     -Dielectric Breakdown Voltages (Volts/Mil):
              Teflon = 1500
          Fluoroly  H =  500
      Noryl EN265  PPO =  500
      Boron Nitride  M =  986
      Boron Nitride  A =  950
      Boron Nitride HP =  790
     Enter Dielectric Constant (Er)  = 1500
     -Conductor Resistivities, Ohm-cmx10E-6:
        -Outer Conductor       (RESB)      = 1.694
        -Inner Conductor       (RESD)      = 1.694
     -RMS Surface Roughness,    Inchesx10E-6:
        -Outer Conductor       (SRB)       = 1
        -Inner Conductor       (SRD)       = 1

Select one of the following ANALYSIS OPTIONS:
   *OPTION 1: Frequency Analysis of Coax with Loss.
    OPTION 2: Sensitivity Analysis of Zo vs. Dimensions.
OPTION selected = 1

Please enter Frequency Range for Frequency ANALYSIS:
     -Start Frequency, GHz = .2
     -Stop  Frequency, GHz = 2
     -Step  Frequency, GHz = .2

Is disk data STORAGE desired? (1=YES) =
```

```
-----------------------------------------------------------------------
COAX (v.1.3)                                      DATE = 25 OCT 1991
                                                  TIME =  9:41:21
      RF/Microwave Computer-Aided Engineering Design Data
                 For Coaxial Transmission Lines:

B   = .240000"          Frequency Analysis        SRB =   1.000u"
D   = .062500"         ====================       SRD =   1.000u"
Er  =  2.022                (OPTION 1)          DLTAN =  .00020
Zo  = 56.733 Ohms                                 Vbr =1500.00 V/mil
CAP =   2.12 pF/Inch                             RESB =   1.694
IND =   6.84 nH/Inch                             RESD =   1.694

                                   Transmission Losses  (dB/Foot)
          Wavelength (Inches)  ------------------------------------
  Freq.   Free-                Conductor Losses    Dielec.    Total
  (GHz)   Space     "Guide"     Inner     Outer      Loss      Loss
*********************************************************************
    .200    59.014    41.502     .0171     .0045      .0016     .0231
    .400    29.507    20.751     .0242     .0063      .0032     .0337
    .600    19.671    13.834     .0296     .0077      .0047     .0421
    .800    14.754    10.375     .0342     .0089      .0063     .0494
   1.000    11.803     8.300     .0383     .0100      .0079     .0561
   1.200     9.836     6.917     .0419     .0109      .0095     .0623
   1.400     8.431     5.929     .0453     .0118      .0110     .0681
   1.600     7.377     5.188     .0484     .0126      .0126     .0736
   1.800     6.557     4.611     .0513     .0134      .0142     .0789
   2.000     5.901     4.150     .0541     .0141      .0158     .0840

  TE11 Mode Cutoff =   17.468 GHz      Peak Power =   883.45 kW
-----------------------------------------------------------------------

Coaxial Transmission Line calculations completed.
Select next OPERATION:
        1. Select new OPTION.
        2. RECYCLE and CONTINUE.
       *3. EXIT to operating system.
OPERATION selected = 3
```

Figure 1. Example printout of the COAX program, analyzing performance of a coaxial transmission line over a range of 0.2 to 2.0 GHz.

is presented in a table, as shown in the figure.

In the analysis mode, the user may opt for a sensitivity analysis of coax dimensions versus characteristic impedance. For this, the program requires that a dimension interval and range be specified. The results are presented in a table similar to the analysis versus frequency.

With the synthesis option, the program determines the diameter of either the inner or outer conductor, while holding the other constant. The output can be chosen as either a dimensional sensitivity analysis, or as the wavelength and loss data shown before in the analysis mode.

Users should remember that the dimensions are inner diameter for the outer conductor, and outer diameter for the inner conductor.

Program Operation

In general, operation is guided by the program. The user should have the required information on dielectric constant and loss tangent for the desired dielectric material. Information for some common types are given in the program. Conductor conductivity and surface roughness information is needed as well. It may be accept able to use ideal data (very low roughness and perfect conductivity) for early iterations and low frequency applications.

Printed results can be obtained by pressing CTRL-P before running the program. This sets the printer to follow what is displayed on the screen, including all program prompts and user entries, as well as the results. After using the program, the same command turns off the printer-follow mode.

COAX is written in Microsoft FORTRAN, version 5.0. The program source code is heavily annotated, including both the author's comments and references for the various equations used in the computations.

This program is available from the RF Design Software Service. See page 65 for ordering information. The program disk contains source code and a directly executable compiled version.

Acknowledgements

The author would like to acknowledge the contributions of Mr. Robert M. Garvey and Mr. Mark E. Coles for their constructive and beneficial comments during the development of this program. ***RF***

About the Author

Eric L. Stasik holds a BSEE from the Georgia Institute of Technology. He has extensive experience in the design of passive microwave devices in all types of transmission media. He has worked for RCA Missiles and Radar, Electromagnetic Sciences, and was a founder and officer of Microwave Resources, Inc. He is currently working as a consultant while completing coursework toward a MSEE at Georgia Tech. He can be reached at 3148 Rehoboth Dr., Decatur, GA 30033.

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RF software

Schematic Interface

RFD Schematic Interface provides multidirectional communication between the analysis/optimization/synthesis programs RFDesigner and RFSynthesist from ingSOFT and DesignWorks schematic capture application from Capilano Computing Systems. The interface allows the user to enter analysis/optimization circuit data, edit them and tune the circuit through the schematic environment. Schematic component parameters can be updated with the data modified or optimized in RFDesigner. The interface sells for $250 or $1000 including DesignWorks.
ingSOFT Limited
INFO/CARD #215

Filter Design

FilterMaster creates designs for lowpass, highpass, bandpass and bandstop LC passive filter circuits. A special "smart" optimization feature speeds development by suggesting different filter specifications based on user-entered values. The program requires an IBM PC or compatible, 640K RAM, hard disk, mouse and DOS 3.0 or greater.
Intusoft
INFO/CARD #214

Noise and S-Parameter Library

A noise and S-parameter library for Philips Semiconductors' complete range of RF wideband transistors is available on two 3.5 inch floppy disks. The disks can be used with industry standard software such as Touchstone, Microwave Development System and Supercompact. Additional files give a complete overview of Philips' wideband transistor range, with gain and noise data on most types.
Philips Semiconductors
INFO/CARD #213

DSP Development Tools

Analog Devices recently issued a line card detailing their set of DSP Development Tools including hardware. The development software includes an assembler, linker and simulators. A DSP/C Compiler and Runtime Library are also available.
Analog Devices
INFO/CARD #212

FET-Model System

A new feature is available with the HP 85150B Microwave Design System high frequency design software. The HP Root Model produces processed, measured data, which can be used directly in MDS rather than coefficients or parameters. It provides large signal, nonlinear simulations that are closer to the actual performance of a transistor than existing physical and empirical models. Price of the NP 85150B is $38,000 including the Root Model.
Hewlett-Packard
INFO/CARD #211

RF literature

RF & Cellular Components

The new Anzac RF & Cellular Component Catalog includes product listings, data sheets and applications information on a new series of low cost components. Included are mixer, modulator and passive products for commercial markets.
M/A-Com, Inc., Anzac Operation
INFO/CARD #210

Coaxial Products Catalog

Pasternack Enterprises' catalog number 1991C includes a wide range of connectors, adaptors, coaxial and twinaxial cable, cable assemblies, plus connector and cable tools. Transmission components such as attenuators, switches, amplifiers, terminations, and power dividers are also included.
Pasternack Enterprises
INFO/CARD #209

Noise Products

A new catalog from Micronetics offers a complete line of amplified and unamplified noise sources, noise diodes and drop-in noise hybrids, plus specialized MMICs are presented. Noise nomographs and application notes are also included.
Micronetics
INFO/CARD #208

Capabilities Brochure

Teklogix has issued a new brochure that summarizes the company's systems, products and services. It explains how RF/DC technology can improve the accuracy, efficiency and productivity of inventory control and distribution management operations.
Teklogix, Inc.
INFO/CARD #207

Di-Cap Capacitors

A new brochure describes Dielectric Laboratories line of parallel plate microwave ceramic capacitors for applications up to 12 GHz. The brochure describes capacitors for high Q and broadband applications, and includes ordering information with available options.
Dielectric Laboratories, Inc.
INFO/CARD #206

Manufacturing Technology Video

Microwave and RF Component and Subsystem Manufacturing Technology is a new video course available from Artech House. The course covers basic materials, machining, finishing processes, fabrication methods, waveguide components and subsystems, planar circuit technology, and system and subsystem packaging.
Artech House
INFO/CARD #205

RF Coaxial Connectors

A 12 page catalog details the K Connector from ITT Cannon/Sealectro. The catalog also includes details on mechanical design, applications and compatibility with SMA type connectors. The catalog contains the full product line including plugs, jacks, launchers, feedthrus, attenuators, adaptors, fixtures and tools.
ITT Cannon/Sealectro
INFO/CARD #204

Products Services Brochure

A brochure describing a new product sourcing tool on microform called the Taiwan Industrial Products Services (TIPS) is now available. The brochure describes the service

in detail, demonstrating its ease of use and comprehensive coverage of Taiwanese manufacturers' catalog information.
Information Handling Services
INFO/CARD #203

Filter Catalog

TTE's new 100 page catalog offers a broad line of active and passive filters. Included are Bessel, Butterworth, Chebyshev, Elliptical Function including anti-aliasing and custom designs. Information includes general specifications, attenuation curves, response comparisons, case drawings and mounting dimensions.
TTE, Inc.
INFO/CARD #202

MMIC Data Sheets

Data sheets covering a series of GaAs MMIC s for use in Ku-Band direct broadcast satellite down convertors for TV home receivers are available without charge from Anadigics. The data sheets cover price, performance and delivery considerations.
Anadigics, Inc.
INFO/CARD #201

Hermetic Packages Brochure

A multi-page brochure that identifies and describes the complete line of metal packages that are designed and manufactured by Hermetic Devices. Also described is HDI's in-house capabilities such as serialization and hermetic sealing with emphasis on the company's Quality Control, Quality Assurance, and Acceptance Testing programs.
Hermetic Devices, Inc.
INFO/CARD #200

Connectors Catalog

A new 226 page catalog from Solitron contains a full range of microwave connectors such as SMA, SSMA, HF SSMA, SMB, SMC, TNC, HF TNC and TY-N.
Solitron/Microwave
INFO/CARD #199

GaAs MMIC Selection Guide

A new GaAs MMIC Products Selection Guide provides specifications for M/A-COM's currently available products as well as those under development. Products include switches, analog attenuators, digital attenuators, amplifiers and mixers. Information on available foundry services is also included.
M/A-COM Semiconductor Division
INFO/CARD #198

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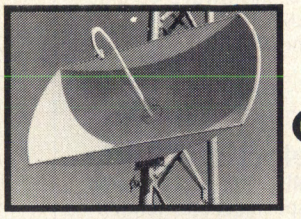

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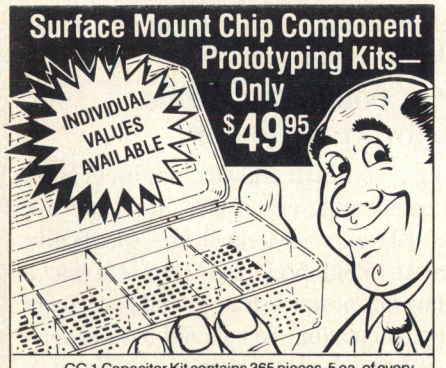

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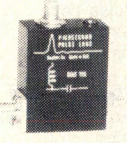

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5520A	20 ps	DC	0.4 dB	15 V	30 mA
5530A	28 ps	25 kHz	0.2 dB	200 V	10 mA
5531	28 ps	750 kHz	0.2 dB	1500 V	20 mA
5532A	28 ps	150 kHz	0.2 dB	1000 V	20 mA
5535	32 ps	10 kHz	0.2 dB	50 V	10 mA
5540	8 ps	160 kHz	0.6 dB	50 V	100 mA
5550B	20 ps	100 kHz (<50 mA)	0.9 dB	50 V	500 mA
5555	20 ps	100 kHz	0.9 dB	50 V	500 mA
5575A	32 ps	10 kHz (<20 mA)	0.6 dB	50 V	500 mA
5580	32 ps	10 kHz	1.0 dB	50 V	1 Amp
5590	150 ps	10 kHz	0.1 dB	50 V	500 mA

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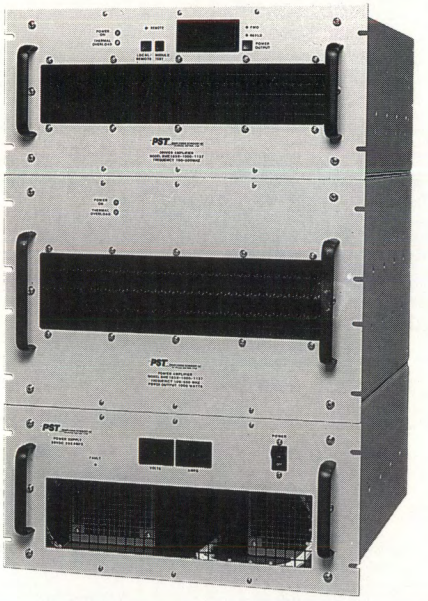

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INFO/CARD 68

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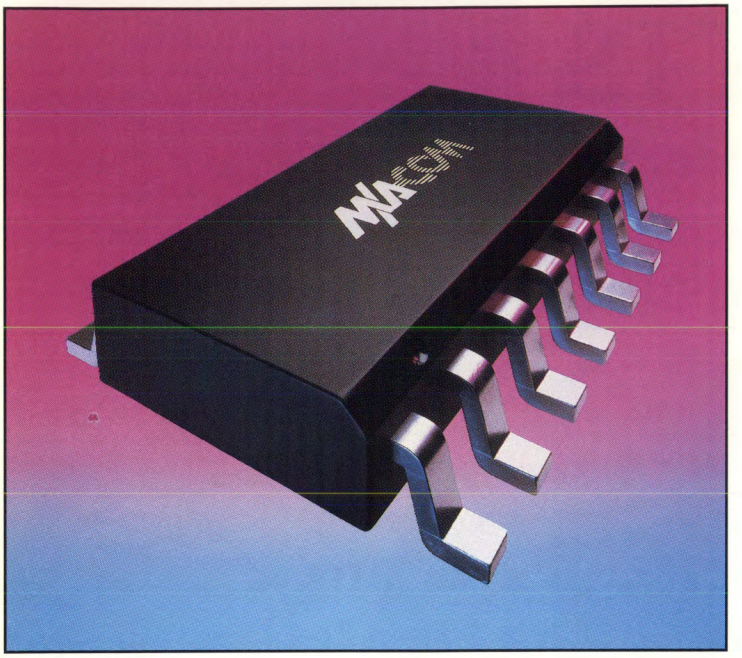

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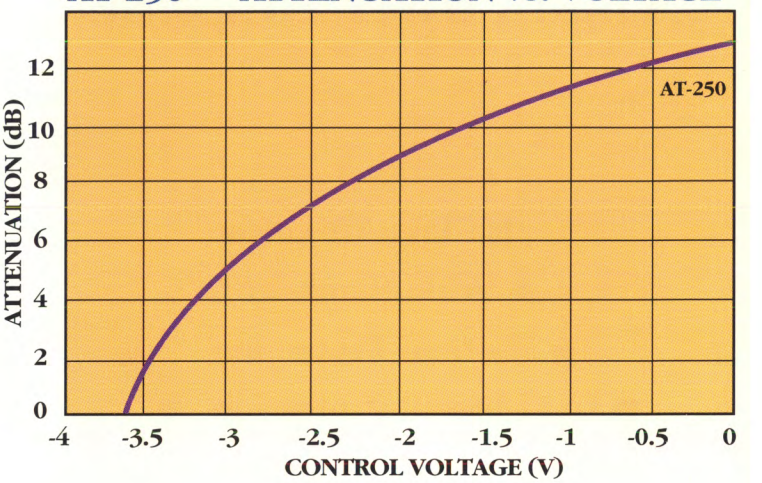
AT-250 — ATTENUATION vs. VOLTAGE



DIGITAL ATTENUATORS

MODEL	DESCRIPTION	INSERTION LOSS (dB)	VSWR	Ip3 dBm	PACKAGE
AT-210	4bit, 1dB step to 15 dB	1.8	1.5:1	45	SOIC, 16 lead
AT-220	4bit, 2 dB step to 30 dB	1.8	1.5:1	45	SOIC, 16 lead
AT-230	3bit, 4 dB step to 28 dB	1.8	1.5:1	45	SOIC, 14 lead

DIGITAL /ANALOG ATTENUATORS

MODEL	DESCRIPTION	INSERTION LOSS (dB)	VSWR	Ip3 dBm	ANALOG ATT. LINEARITY ATT/CONTROL V.	PACKAGE
AT-240	3bit, 4 dB step to 28 dB + 12 dB V VA	4.5	1.8:1	35	±10%	SOIC, 20 lead

VOLTAGE VARIABLE ATTENUATORS

MODEL	DESCRIPTION	INSERTION LOSS (dB)	ATTENUATION RANGE (dB)	VSWR	LINEARITY ATT/CONTROL V.	Ip3 dBm	PACKAGE
AT-250	Single Control Linear	2.8	13	1.5:1	±10%	35	SOIC, 8 lead
AT-309	Dual Control	1.1	20	1.5:1	N/A	15	SOIC, 8 lead
AT-339	Dual Control	1.1	40	1.5:1	N/A	15	SOIC, 8 lead
AT-635	Single Control Linear	6.0	30	2.0:1	±10%	33	SOIC, 20 lead

* - All parameters are typical specs @ 1.0 GHz.
** - All V VAs are non-reflective.

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