rf design

ideas for engineers

October 1985

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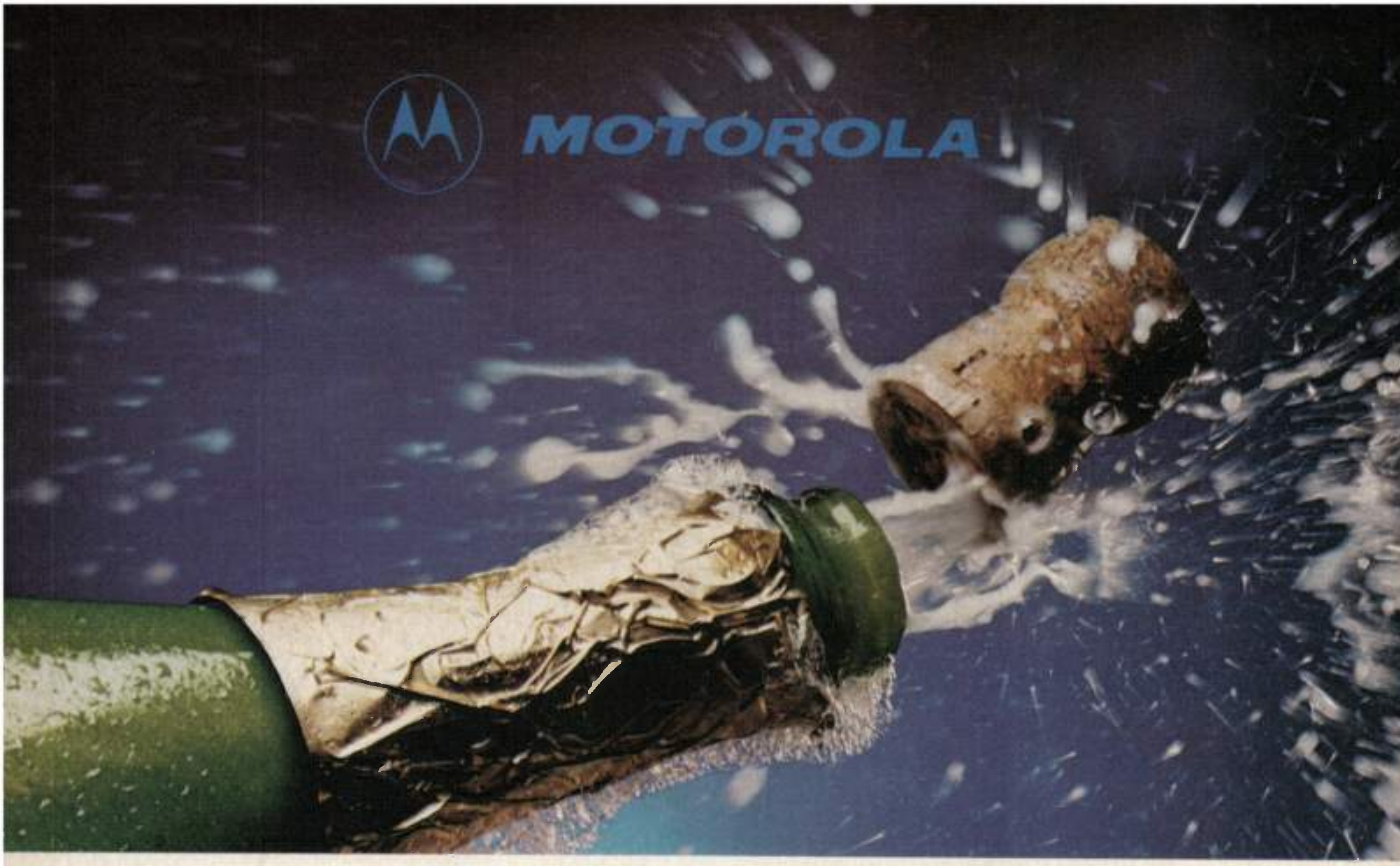
Special Report: Noise Generating/Medical Uses



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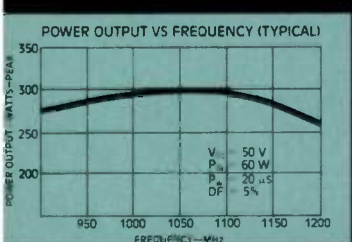

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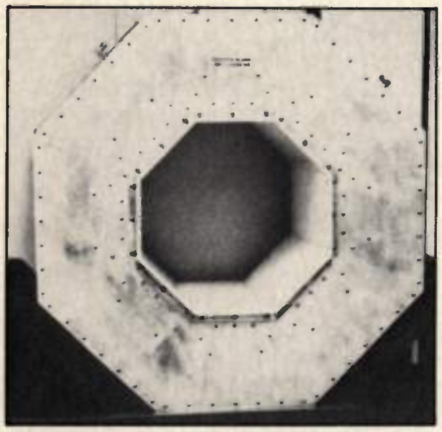
rf design

October 1985

Cover

Our cover features the Noise Com NC7000 noise generating instrument appearing on the market this month. The instrument combines programmable controls with white Gaussian noise generators in one unit. Standard models cover the 10 Hz to 2 GHz frequency range and feature seven switchable discrete filters. The instrument can be connected to IEEE-488, RS-232, RS-422 or RS-423 interfaces for automatic testing and other external control.



Features

29 **Special Report: The New Uses of RF.**
Part I — Noise Generating Instruments
Part II — Medical Uses of RF Energy
Part I of this two-part Special Report covers the relatively new field of noise generation. The reasons for noise generation and the basics of noise are explained, along with a description of two noise generating instruments. Part II is a report on the use of RF radiation for internal imaging of the human body and for cancer treatment. — Gary A. Breed and James N. MacDonald

41 **Re-Normalizing the Scattering Parameters**
Network S-parameters are not independent of source and load impedances. Measurements using standard network analysis equipment may not accurately reflect device characteristics if the source and load impedances of the equipment do not match those of the system being designed. The author shows how to mathematically correct data to reflect the actual circuit configuration of a two-port network. — Daniel N. Meeks

45 **Elliptic Filter Wins A Comparison Test**
In a comparison of Butterworth, Chebychev and elliptic low-pass filter implementations, the author finds the elliptic filter to be the best choice for most applications in terms of insertion loss and component value sensitivity. COMPACT is used for the analysis. — Peter Vizmuller.

59 **ESD Sensitivity of a Diode Mixer**
This article describes a test procedure used to measure the ESD sensitivity of mixers using the double-balanced diode-ring configuration. The mixers were tested relative to the Category B classification of MIL-STD-883 Method 3015. — David Geiser.

Departments

53 **Designer's Notebook — Another One-Transistor FM Transmitter**
This article describes a variant of a similar design published in the February 1985 issue. — S. Kan

57 **RFI/EMI Corner — Medical RF Applications Require Special Shielding**
This article examines the special problems of shielding RF apparatus in hospitals, especially the kind of equipment mentioned in the Special Report, and describes the Lindgren modular enclosure. — Gary A. Breed

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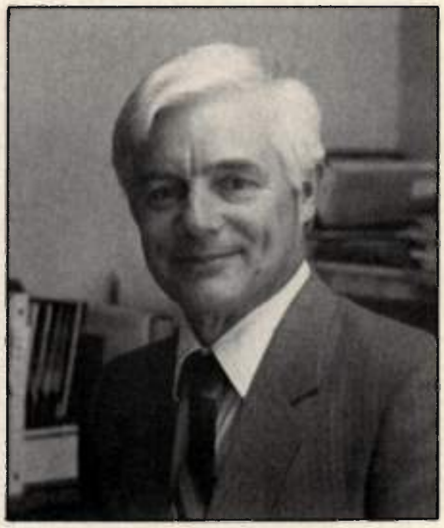
rf editorial



James N. MacDonald
Editor

This month we begin our second three-part series of Special Reports, this series featuring the new uses of RF. Writing these reports is a learning experience for us because we are investigating areas few people know much about.

The first subject is medical uses of RF. As with the other subjects, we knew there were some interesting uses of RF in medicine, but we did not know how dramatic the uses were and what potential they have for saving lives. Included with the Special Report is an image of the inside of a rat's head made using RF radiation, showing far more detail than an X-ray. We could not include color images made by the same process that are so realistic they look like photographs made during an autopsy. Such images are made with no discomfort and no health risk for the patient because they are made with low frequency radiation. The technique described in this Special Report has been used less than five years.

Another use of RF has a longer history, but the technology has been made to work successfully only in the last few years. This is hyperthermia. Researchers, who do not like to make predictions, speak cautiously about the potential of RF induced hyperthermia to cure cancer, but investigational use on hopeless patients has demonstrated that properly directed RF radiation can kill large, inoperable tumors. Once again, the safety of RF is a significant factor, especially compared to the severe effects of massive chemotherapy, X-ray or surgery.

This month's Special Report is in two parts because we recently became aware of a relatively new use of RF that is becoming increasingly important. Most of us think of noise as something to keep as low as possible, swamping it with a high S/N ratio. In a world of increasing RF sources, however, it becomes necessary to factor noise into the calibration of receivers and other equipment. Two companies manufacture general purpose noise generating test instruments and many others manufacture diodes to be built into transmitters and test equipment for easy calibration. To cover this new use of RF in a timely manner we have devoted part of the Special Report to the subject of noise and featured the newest noise generator on the cover.

Another relatively new use of RF is in testing susceptibility of electronic equipment to radio frequency interference. This RFI susceptibility becomes more important almost daily as RF signal transmitting devices become more portable and more numerous. In November we will report on RFI testing and provide an update on the status of US and foreign regulations. We'll try to clear up some of the confusion caused by recent regulatory changes and the different requirements of US and foreign agencies.

Susceptibility testing is becoming more important because RF devices are proliferating rapidly. Two-way alarm systems for home or business or construction sites, shoplifting detectors, remote meter reading and personnel locating systems are a few of the unusual industrial uses of RF that will be covered in the December Special report. We are literally surrounded by RF.

Attendees at the RF Technology Expo 86, next January, will be surrounded by RF in a different way. The exhibit space, doubled from last year, will be filled by 89 companies showing their latest RF products. A two-and-a-half day program has been assembled with 75 papers to be presented, in addition to the Fundamentals of RF Design course. It will be the most comprehensive forum of RF design knowledge ever offered. Papers will be presented in five simultaneous sessions, and Proceedings will be available at the conference, so attendees will be able to read the papers they could not hear and perhaps consult with the authors.

We're looking forward to it.

James N MacDonald

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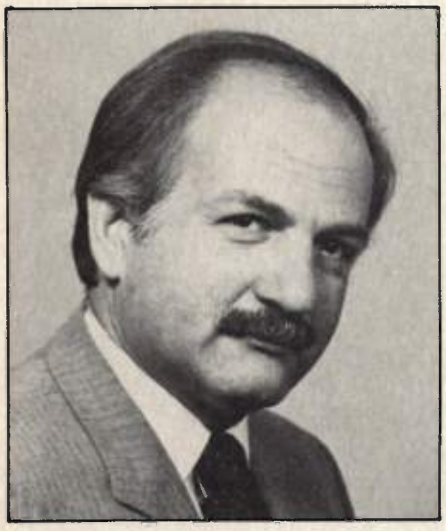
INFO/CARD 5

rf viewpoint

Where Is the RF Marketplace Heading?



By J.R. Harris
President
Acrian, Inc.

In our travels we often meet executives and managers with valuable insights into the business side of RF electronics. We have wished that we could provide a forum for some of the observations these people have passed on to us. We know that even our most design oriented readers care about the manufacturing and marketing of their products.

Publisher Keith Aldrich has decided to make this space available for such commentary. The Publisher's Notes column will be discontinued, and we invite all readers to consider this column as a place to share their ideas. Material may be submitted to the editor.

Our first guest column is from Jack Harris, president of Acrian, Inc., who describes the benefits of vertical integration in manufacturing. — Editor

The technology advances required to develop state-of-the-art components in the RF market are becoming more costly. Within a limited volume market that is price sensitive, a solution is needed so that additional revenues are generated to finance necessary research and development. Vertical integration into modules, or higher-order assemblies, seems to be an answer to the problem, while also lowering overall costs.

There are two primary reasons why a customer is willing to consider acquiring modules from suppliers: lower costs and the customer's lack of available engineering talent. Vertical integration at almost any level gives the customer more for the dollar while transferring some of the engineering burden to the supplier.

It is essential for manufacturers to provide a customer with a true and flexible resource — to manufacture from specifications, to work cooperatively with customer design engineers, and to design an appropriate unit. Knowing the transistor and circuit technology, as well as the system's applications, is critical in the design and manufacturing of quality modules, and the ability to deliver products on time is as important as design capabilities.

In the late 1960s, digital IC systems houses realized the critical nature of their components to their system design. They therefore moved to build alliances or acquire the basic technology. As a result, very few independent semiconductor manufacturers are left in the RF marketplace. Now, RF customers are beginning to recognize that products which are costly to develop can be acquired even within an inelastic, low volume market, from suppliers who have made such alliances and taken a vertical integration posture.

This flexibility gives a company a distinct edge over competitors that are not fully integrated, because the competition will be forced to design-in standard parts purchased at retail costs. A number of new applications areas require RF modules, such as medical instruments, laser drives, space defense initiatives, military systems and broadcast systems. These areas, unlike traditional RF applications, will grow fastest and accept vertical integration in the short term.

Traditional engineering investments associated with good designs and attention to quality and production issues must be redoubled if vertically-integrated products are to reach the market and be a successful solution. Companies cannot let traditional boundaries or system architectures prevent the use of latest technologies. The coming years will continue to challenge suppliers to bring the highest performance products to the market within a shorter design cycle without compromising quality and economic benefits.

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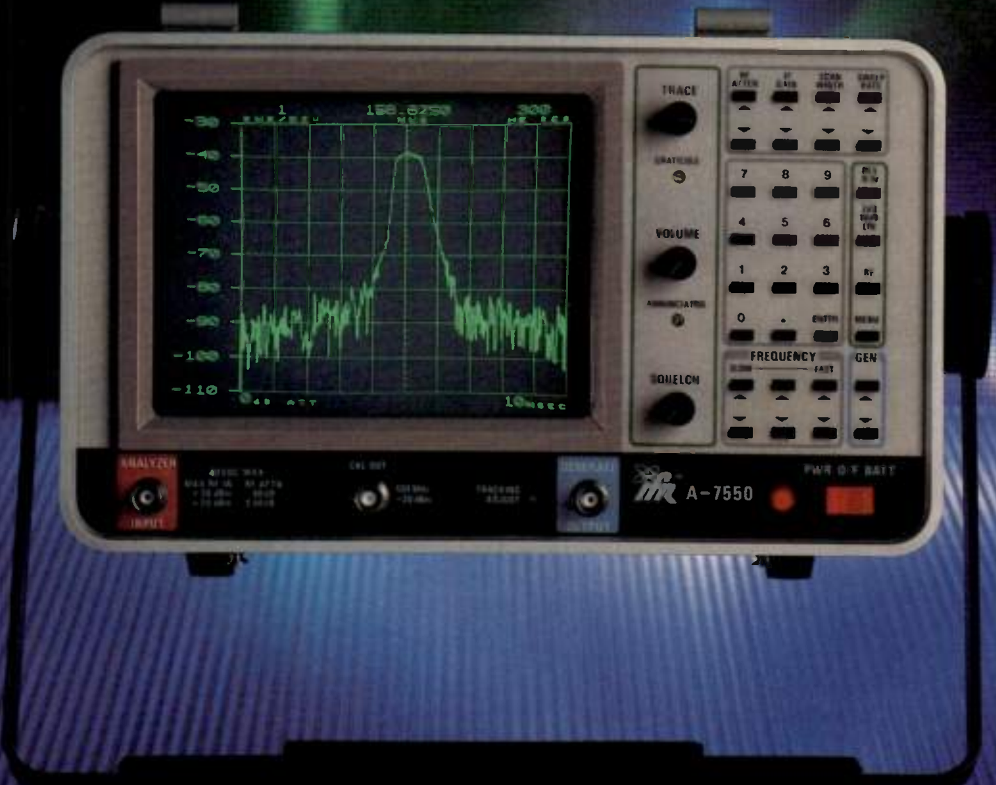

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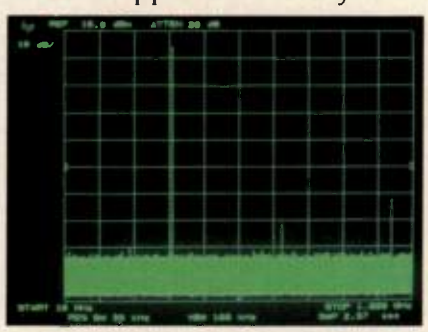

Frequency spectrum of Andersen Model SO-314-600-V Oscillator over 0 to 1 GHz range. Fundamental frequency is 314 MHz. Second harmonic is −65dBc, third harmonic is −55dBc. Spurious responses are essentially nonexistent.

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INFO/CARD 9

rf letters

Editor:

I read with great interest the article in the July 1985 issue of *RF Design;* "Helical-Resonator Filter Design — A Basic Program" by Vincent Heesen. I would like to offer the following comments:

1) The calculations, as stated by Mr. Heesen, are for cylindrical resonators. These are not as practical to build as resonators with square shields. It would be more useful to use a square shield design.

2) The coupling between the resonators is most often capacitance, not inductive as he states but either or both may be used.

3) It is true that the coupling shield height is determined empirically, but data exists that allows for accurate calculation.

4) Line 940 prints out the tap position. It appears that the publisher cut off the last line of the outputted data.

5) No mention is made as to how to determine the resonator-to-resonator coupling, without which the resonator information is useless and the filter cannot be designed. The only place the filter bandwidth is used is in the calculation of the insertion loss.

6) Insertion loss calculations are limited only to Butterworth filters (order 2-7).

7) Having been involved in filter designs for over 19 years this is the first time I have seen suggested the use of a trimmer capacitor at the resonator ends. It may work but most likely will not provide the necessary resolution required for proper tuning. As for providing support to the resonators it is useless.

In general I find this type of article worse than useless, in that it not only provides incomplete information on design, but wastes the reader'a time in trying to understand what's going on. I would suggest that anyone interested in Helical Filter Design review the following article.

"Need a Helical Filter? These Design Aids Will Make it Easy," by Lee R. Watkins, *RF Design* May/June 1981.

One correction to the above article should be made. On page 46:

eq. $\Theta = \text{ARCSIN} \dfrac{R_b R_{tap}}{2Z_o^2}$

Should be:

$$\Theta = \text{ARCSIN} \sqrt{\frac{R_b R_{tap}}{2Z_o^2}}$$

Lee R. Watkins P.E.

Mr. Heesen's response:

Re: Item #1

Stated in the text (an alternate approach is to reduce the square shield width by 20 percent of the computed diameter of the cylindrical shield).

Re: Item #2

See text: "Coupling into or out of the resonator may be accomplished by probes, etc.," Probes, by definition, include passive capacitive networks.

Re: Item #3

Accurate calculation of the coupling window between resonators requires knowledge of the precise location of the open-ended end of the helix — a task beyond the scope of this program.

Re: Item #4

Reader Watkins is correct. Then too, the program lines 650 and 660 are also missing.

Re: Item #5

The intent of this article is to provide accurate dimensional information to facilitate fabrication and/or feasibility of design. Neither this nor reader Watkins' article are "stand-alone" design presentations. Readers are encouraged, indeed expected, to consult the references cited.

(continued on next page)

rf calendar

October 15-17, 1985
Automated Design and Engineering for Electronics East
Bayside Exposition Center, Boston, Massachusetts
Information: Show manager, ADEE East, 1350 East Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017-5060; Tel: (312) 299-9311.

October 21-23, 1985
Fifth International Electronics Packaging Conference
Marriott Hotel, Orlando, Florida
Information: Evelyn Ashman, International Electronics Packaging Society, P.O. Box 333, Glen Ellyn, IL 60137; Tel: (312) 260-1044.

October 22-24, 1985
Northcon/85 High Technology Electronics Exhibition and Convention
Portland Memorial Coliseum, Portland, Oregon
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

November 19-22, 1985
Wescon/85 High Technology Electronics Exhibition and Convention
Moscone Center, Brooks Hall/Civic Auditorium
San Francisco, California
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

January 28-30, 1986
Systems Design and Integration Conference
Brooks Hall, San Francisco, California
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

January 30-February 1, 1986
RF Technology Expo 86
Anaheim Hilton and Towers, Anaheim, California
Information: Kathy Kriner, Cardiff Publishing Co., 6530 S. Yosemite St., Englewood, CO 80111; Tel: (303) 694-1522.

March 11-13, 1986
Automated Design for Engineering for Electronics West
Moscone Convention Center, San Francisco, California
Information: Show Manager, ADEE WEST, Cahners Exposition Group, 1350 East Touhy Ave., P.O. Box 5060, Des Plaines, Illinois 60017-5060; Tel: (312) 299-9311.

March 11-13, 1986
Southcon/86 High Technology Electronics Exhibition and Convention
Orange County Convention Center, Orlando, Florida
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

April 8-10, 1986
Test and Measurement World Expo
San Jose Convention Center, San Jose, California
Information: Meg Bowen, Conference Director, Test and Measurement World Expo, 199 Wells Avenue, Newton, MA 02159.

Re: Item #6

As stated in the text, Helical Resonators are employed where small, selective, low loss filters are required. Obviously, other filter designs, e.g., Chebyshev, could be used; but since the Butterworth exhibits the lowest loss it is the logical choice for this device.

Re: Item #7

Mechanical instability is one of the major draw-backs of the Helical Resonator. All core materials lower the resonator's Q and should be avoided, where possible. The use of heavy gauge wire self-supported at the grounded end and terminated in an air-variable "trimmer" capacitor at the open-circuited end is "common practice." The text refers to this practice as a practiced procedure, not as a requirement.

Frankly, I'm surprised that reader Watkins has never in all his 19 years experience seen the "trimmer" employed as a tuning and mechanical support element. Perhaps during the next 19 years, as he catches up to some of us, he will have an opportunity to peruse through a copy of the Radio Amateur's Handbook, which has illustrated this technique for years.

I have received far too many accolades from reputable RF circuit designers for this article to take this reader's views seriously.

With the addition of the missing program lines 650 and 660, this article remains, as intended, a very useful tool for the design and fabrication of Helical Resonators.

Where else can one find a "free" computer program which will yield: coil length, coil diameter, wire diameter (min. and max.), number of turns, wire spacing, shield diameter or square shield width, shield length, unloaded Q, tap location, plus insertion loss for up to seven poles — all within twenty seconds?? All this on a "Home Computer!!!" Where else, indeed, but the July 1985 issue of *RF Design* magazine.

Vincent G. Heesen P.E.

Editor:

I have found some additional difficulties with Alan J. LaPenn's article "Basic Program Computes Values for 14 Matching Networks," April 1985. Included are my formulas and changes for your consideration. The errors appear to have originated with Alex J. Burwasser's article "TI-59 Program Computes Values for 14 Matching Networks," Nov./Dec. 1983. They were also repeated in an "RF Letter" from Keats A. Pullen, Jr., June 1985.

Article: "Basic Program Computes Values for 14 Matching Networks," *RF Design*, pgs. 44-46, April 1985, Alan J. LaPenn.

Network #9, p. 45:

$$X1 = \sqrt{R_S R_L - R_S^2 - QR_S}$$

$$X_2 = QR_S$$

$$X_3 = \frac{-R_S R_L}{X1 + X2}$$

Should be:

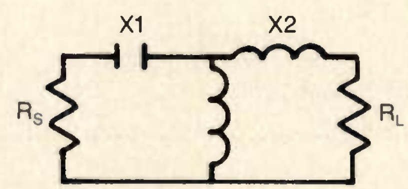
$$X1 = (Q \times R_S)\ X - 1$$

$$X3 = \left(R_L \sqrt{R_S/(R_L - R_S)}\right)\ X - 1$$

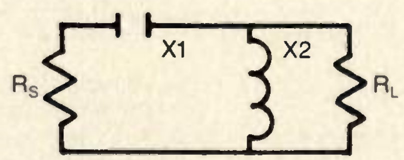
$$X2 = \left(X1 + \frac{R_S x R_L)}{X3}\right)\ X - 1$$

```
810 X1=Q*RS*-1
820 X3=RL*SQR((RS/(RL-RS)))*-1
830 X2=(X1+RS*RL/X3)*-1
```

Diagram on page 46 for Network #14.



Should be:



The corrected program seems to verify tabulations in the Motorola RF Data Manual and the ARRL Electronics Data Book as well as verifying the results on the "Smith Chart Program" (Lynn A. Gerig, June 85).

Thank you for providing us with a top grade magazine for the RF field.

S. Ticknor, President
Wide Band Engineering Co., Inc.

Mr. Burwasser's response:

Mr. Ticknor is quite correct in his finding that there are errors in the equations for network #9 ("TI-59 Program Computes Values for 14 Matching Networks," Nov./Dec. 83), and is to be commended on his constructive "detective" work.

The most major of these errors is a typographical one in the equation for X1, where the radical sign incorrectly extends over the quantity "$-Q \cdot R_S$." In the original manuscript, the equation reads as follows:

$$X1 = \sqrt{R_S \cdot R_L - R_S^2} - Q \cdot R_S$$

Even with this typographical correction, however, the reactance values for X1, X2 and X3 are somewhat at variance with those values obtained using Mr. Ticknor's equations. Yet, networks synthesized using either set of equations are legitimate series enhanced -Q L reactance matching networks for the source and load resistances specified. A further investigation by this author of the original TI-59 article manuscript found corrections to the equations that, regrettably, were never mailed in to *RF Design*. The corrected equations for network #9 should have been as follows:

$$X1 = -Q \cdot R_S$$

$$X2 = \sqrt{R_S \cdot R_L - R_S^2} - X1$$

$$X3 = \frac{-R_S \cdot R_L}{X1 + X2}$$

In the above equations, the network Q is defined in terms of X1 (rather than X2 as was done in the original equations). Thus, networks synthesized using the original equations will have Qs slightly different than the specified value (for moderate and high Q values, this difference is small). The corrected equations above yield the specified Q value. Although these equations appear different than Mr. Ticknor's, the same values for X1, X2 and X3 are obtained using either set,

A similar correction is also required for the equations of the shunt enhanced — Q L reactance matching network. The corrected equations for network #11 are as follows:

$$X1 = R_S \cdot \sqrt{\frac{R_L}{R_S} - 1}$$

$$X3 = \frac{R_L}{Q}$$

$$X2 = \frac{-X3}{\frac{X1}{Q \cdot R_S} + 1}$$

Alex J. Burwasser
RF Products

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Ohio State University Tests Color Slow-Scan Video

The feasibility of delivering color slow-scan video via FM subcarrier was demonstrated by radio station WOSU of Ohio State University at Columbus, Ohio. Using a Colorado Video Model 250C transmitter and a Harris 92 kHz subcarrier generator, video images were delivered to the Ohio State University regional campus in Newark, Ohio, 60 miles distant. The slow-scan video pictures were single field NTSC color, with an eight second transmission time. Picture quality was considered excellent and there was no degradation in either the main channel signal (classical music) or the 67 kHz subcarrier channel (a reading for the blind service).

The intended application of this test is to provide on-site continuing engineering education to industry located near Newark. This test is part of a program exploring the delivery of telecommunication based continuing education by the School of Engineering, under the leadership of Dean Donald Glower. Slow-scan video is viewed as an enhancement to existing technology, i.e. radio and the telephone. The FM radio subcarrier will economically deliver instruction to distant locations while conventional phone circuits will be used for audio interactivity.

The test was coordinated by Eric Seabrook, Teleconferencing Services Coordinator at Ohio State. The project is targeted for implementation in the spring of 1986.

Unitrode Acquires GE's Signal Diode Operation

Unitrode Corporation has announced the acquisition of General Electric's signal diode operation. The acquired product families include stabistors, as well as low leakage general purpose and high voltage diodes. The scope of the agreement encompasses all product design, manufacturing technology and equipment, test and burn-in equipment and product inventories.

Scientists Compare Clocks With Unprecedented Accuracy

The Commerce Department's National Bureau of Standards (NBS), in cooperation with their colleagues at the Radio Research Laboratory in Tokyo, have performed the most accurate clock rate comparison ever achieved across the Pacific, checking the U.S. primary time standard at NBS in Boulder, Colo., against the Japanese primary standard. The U.S. Defense Department's Global Positioning System of navigation satellites, which contain on-board atomic clocks, was the intermediary in this comparison, which was performed to an accuracy of one second in a million years.

"This experiment confirms that atomic clocks anywhere in the world may now be compared with unprecedented accuracy," said David W. Allan, a physicist in NBS' Time and Frequency Division who is in charge of the clock comparison project. It means that Japan has now joined the United States, Canada, and West Germany as full contributors for the determination of the international atomic second, making International Atomic Time more accurate. It also means that the National Aeronautics and Space Administration (NASA) and the scientific community will be able to obtain a better time reference for such things as deep space probes and pulsars.

Most major industrial nations use laboratory clocks based on the vibration of the cesium atom as their national standards of time. Making comparisons between any two of these extremely accurate primary standards used to be limited by the method of comparison; for example, a less accurate portable atomic clock carried between the national laboratories. Now this comparison can be done quickly — and is not limited by the method — by receiving a radio signal from a Global Positioning System satellite when it is in common view by both time laboratories.

Also at NBS

NBS has developed a new technique for calibrating the linearity of 1.25 MHz attenuators and voltage of power detectors which achieve a resolution and stability of better than 0.00001 dB. Total schematic error in measuring a 6 dB change is estimated to be less than 0.00005 dB, which is considerably better than any other attenuation standard at this frequency known to NBS. The technique uses a five-port device with three power detectors. The system determines a very accurate 2:1 voltage ratio at one detector in terms of the readings of the other two. The linearity of the two detectors is unimportant because they remain at an essentially fixed power level. While NBS is currently offering a special test measurement service for voltage doublers at 1.25 MHz, the new technique should find broad application at any frequency.

Surface-Mount Device Directory Now on VideoLog

A directory of 12,000 active semiconductor devices and sources available in surface mount packaging is now online through VideoLog, an interactive technical information service for engineers. The directory is supplied to VideoLog by AWI of Sunnyvale, Calif.

VideoLog provides current data on more than 500,000 semiconductors, as a directory of 14,000 suppliers. The database includes product and industry news, semiconductor pricing, selection guides and short form catalogs.

AWI's Phil Marcoux stated that "there is little doubt surface mounting will become increasingly competitive with through-hole technology in all segments of the electronics industry. In consumer, commercial, industrial and military applications, savings are moving on a steadily upward curve. Having this directory online is a significant benefit for engineers."

According to VideoLog president Alan Brigish, "SMT is having a tremendous impact on the size, shape and price of today's electronics products." Continued Brigish, "Advances in automated SMT capitalize on the proven dependability of miniaturized components to produce assemblies that are smaller, faster and less costly than traditional printed circuit boards. Size savings can be up to 70 percent and cost savings as high as 50 percent." VideoLog is headquartered in Norwalk, Conn.

Motorola Discontinues TTL-ALS Logic Line

Motorola Semiconductor Products Sector announces its termination of the Advanced Low Power Schottky (54ALS/74ALS/) TTL family. Current open orders will be honored and shipped as customers have requested. Motorola believes there is not a widespread, long-term market need for TTL-ALS, and that the vast majority of those applications can be

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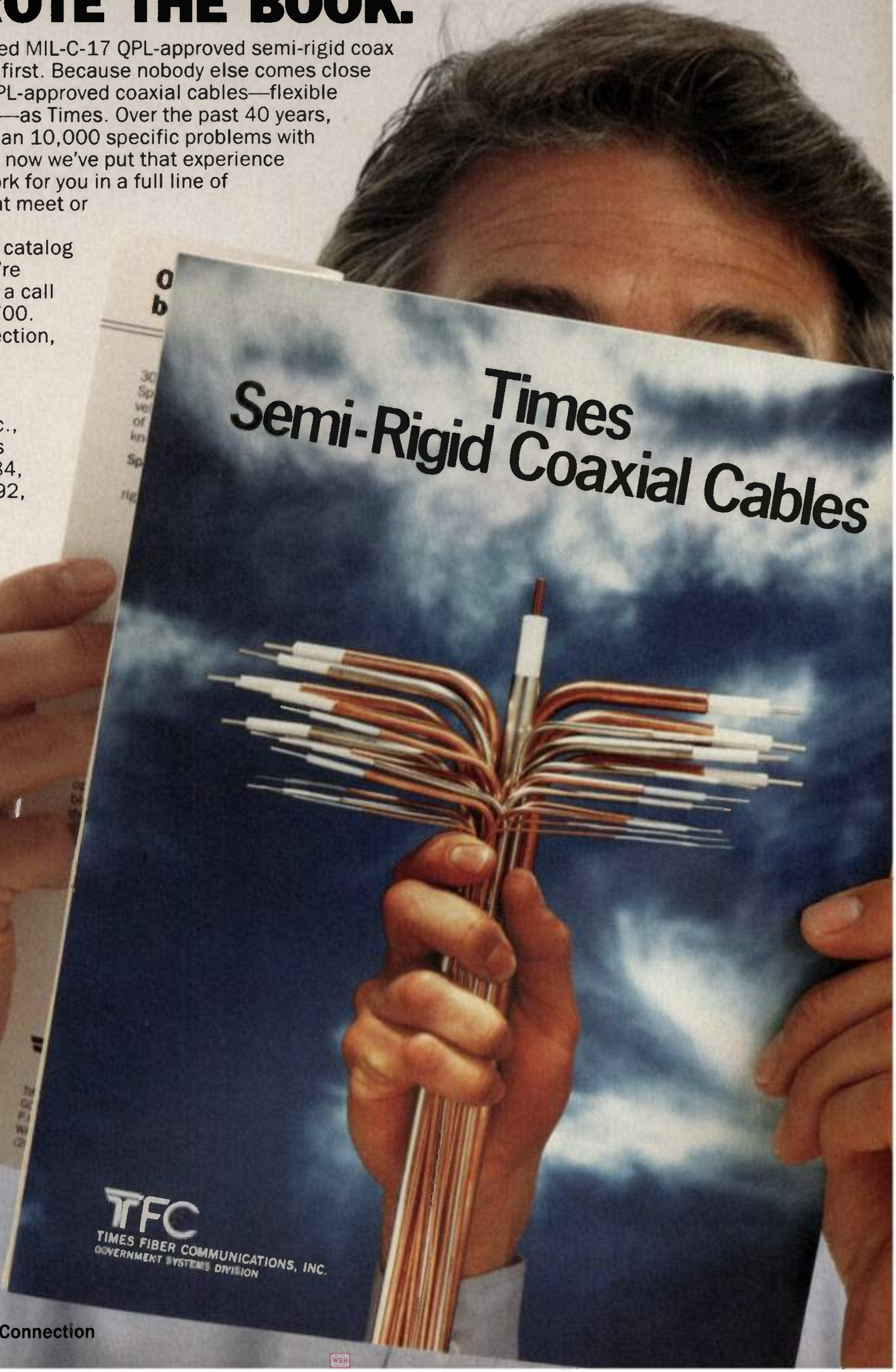

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satisfied by their current digital logic product portfolio of metal-gate CMOS, high-speed CMOS, low-power (LS) Schottky TTL, TTL-FAST, ECL10K and ECL10KH.

Car Telephone Users Are Safer

Drivers with car telephones spend twice as much time on the road, yet have half as many accidents as people without such phones, according to a study released by the American Automobile Association (AAA), AT&T and Bell Atlantic Mobile Systems. Cellular phone owners also are twice as likely to be good samaritans, reporting road hazards, accidents or other serious incidents, according to the report, based on the six-month experience of more than 750 drivers in the Washington/Baltimore area. Cellular customers of both Bell Atlantic Mobile Systems and Cellular One — participating service companies in the survey — were selected at random; non-car phone drivers, which formed the "control group," were members of the Potomac division of the AAA, which helped conduct the AT&T-sponsored study.

Highlights of the 62-page study include:

The car phone customers were involved in one traffic accident for every 317,000 miles driven; the control group's ratio was one in every 115,000 miles. (The national average, according to the study, is one accident per 89,000 miles.)

Car phone owners said they averaged fewer accidents *after* cellular installations.

About 35 percent of the cellular drivers said they called authorities to report collisions, erratic driving and so forth — compared to 13 percent in the non-phone control group.

In addition, four out of five car phone owners said the cellular units made either no difference or *improved* their driving behavior.

The study pointed out that the participating car phone owners average about 24,000 miles a year behind the wheel, compared to 11,800 for AAA members.

Cellular customers use their car phones about five times during a typical workday, which finds them on the road for three hours, according to the survey. The average cellular customer is less talkative while in the car than at home; the usual cellular conversation lasts about three minutes, the typical residential call runs five minutes. Copies of the study are available through AAA, AT&T, CTIA, Cellular One or Bell Atlantic Mobile Systems.

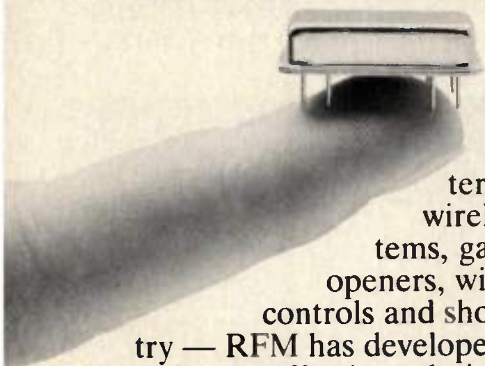
New Book From IEEE

The publication of *Television Technology Today* has been announced by the IEEE PRESS. A volume in the IEEE PRESS Selected Reprint Series, *Television Technology Today,* was prepared under the sponsorship of the IEEE Consumer Electronics Society. This book presents the most recent technological advances that are changing the face of the television industry.

Containing 50 of the best original papers and articles assembled from worldwide sources, the volume is divided into eight parts, as follows: CATV and broadband communications, direct broadcast television from satellites; advanced

The solution to FCC Part 15 is right at your fingertips.

Introducing the easiest solution to FCC Part 15 UHF transmitter requirements.



For the many applications that use low-power UHF transmitters under Part 15 — wireless security systems, garage door openers, wireless remote controls and short-range telemetry — RFM has developed an easy, rugged, cost-effective solution to transmitter design.

With our SAW resonator stabilized hybrid transmitters, you just add a simple antenna, 9V battery and digital input. Our hybrids do the rest. No need for a protracted rf design effort on your part.

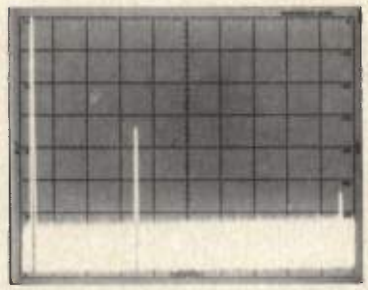
Hybrid oscillators are designed for wireless security products and other remote control devices.

Full operating range.

RFM's hybrid transmitters can be easily adjusted to achieve full legal radiated power (operating range) with a variety of wound-coil or printed-loop antennas.

Excellent stability and signal purity.

Quartz SAW resonator frequency control assures that our transmitters won't drift out of your receiver's bandpass — or into a military "forbidden band" — despite temperature or battery voltage changes, component aging or body capacitance effects.



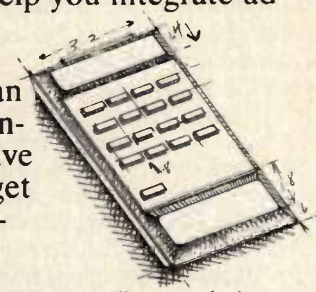
Typical harmonic spectrum of hybrid transmitter.

Also, our transmitters feature low harmonic output and tight modulation bandwidth control. Harmonic radiation above 1000 MHz is well under 125 uV/m @ 3 meters when used with recommended antennas.

The right options. The right support.

Both pulse and FSK modulation options are available to match either super-regenerative AM or superheterodyne FM receivers. Matching hybrids are also available for receiver local oscillators (10.7 MHz i-f). Plus, we offer two transmitter output power ranges — for FCC Part 15 Subpart D or Subpart E. All RFM transmitters are fully compatible with CMOS encoder chip drive levels.

At RFM we have a staff of expert rf engineers ready to help you integrate advanced SAW technology into your product. And you can always count on an innovative, cost-effective solution. We didn't get to be the world's volume leader in UHF SAW resonators and hybrids by following the competition.



Hybrid oscillators make low-cost AM/FM UHF-based remote control systems possible.

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television systems; digital television; teletext; multichannel television sound; projection television, videotape.

Each part is introduced by one of eight experts in the industry who gives an overview of the particular subject: Harold J. Benzuly, Matsushita Industrial Company; Barry G. Haskell, AT&T Bell Laboratories; Ronald L. Hess, General Electric — Video Products Division; Akinao Horiuchi, Sony Corporation — Advanced Engineering Division; Joseph L. Lo Cicero, Illinois Institute of Technology; Dimitrios P. Prezas, AT&T Bell Laboratories; Anthony Troiano, RCA David Sarnoff Research Center.

The editor, Theodore S. Rzeszewski, a member of AT&T Bell Laboratories Technical Staff, is also Associate Professor at the Midwest College of Engineering. His past credits include Project Engineer on the first microcomputer controlled frequency synthesizer for television.

Television Technology Today (PC01818) is available from the IEEE Service Center, 445 Hoes Lane, Piscataway, NY 08845-4150, U.S.A. For information, please circle INFO/CARD #100.

Radar System Remotely Monitors Atmospheric Conditions

An electromagnetic radar device for remotely monitoring the structure and dynamics of the atmosphere has been announced by Radian Corporation. Called CAPSONDE,® the new system provides continuous, real-time measurement of such meteorological conditions as wind speed, wind direction and turbulence. Typical application areas include weather prediction, aerospace research, environmental studies, and defense. A prototype of the system has already been used to determine optimal conditions for launching and landing the space shuttle Challenger. According to Radian Vice President F. Scott LaGrone, CAPSONDE is the first comprehensive system capable of remotely monitoring conditions in all levels of the atmosphere simultaneously and in real-time.

"CAPSONDE reveals a complete cross-section of current atmospheric phenomena, from 500 meters to 50 miles up," said LaGrone. "The system is a breakthrough for applications in which critical decisions depend on access to accurate, up-to-the-minute information — for example, determining flight trajectories for space vehicle launchings."

Based on technology developed at the Max Planck Institute for Aeronomy in West Germany, CAPSONDE employs a radar technique to detect atmospheric fluctuations caused by temperature, humidity, and electron density variations. Large-scale background conditions in the atmosphere can be assessed by continuously monitoring these fluctuations. The heart of the system is an array of 196 four-element Yagi antennas controlled by a Hewlett Packard 1000 minicomputer. Each antenna sends out electromagnetic waves of about 50 MHz or 400 MHz. The waves are radiated in pulses straight up and at various angles to obtain vertical and horizontal measurements and this produces a three-dimensional profile of atmospheric phenomena. The pulsed waves scatter when they encounter turbulence, and reflect a fraction of their energy back to earth where it is detected by the Yagi antennas. Precise information about atmospheric conditions is obtained by measuring the intensity of the radar echoes and the shift in their frequency, according to the principle of the Doppler effect.

Other available methods for monitoring atmospheric conditions involve a mixture of techniques employing sounding rockets, aircraft, weather balloons, and conventional radar to collect data from different parts of the atmosphere at different times.

"CAPSONDE fills in the gaps left by other methods by providing simultaneous measurements of conditions in all levels of the atmosphere," said LaGrone. "The system's continuous, remote scanning eases the logistical problems associated with 'in situ' measurement techniques and offers a real-time assessment of atmospheric phenomena." CAPSONDE's applications span several areas including meteorology, defense, and environmental studies.

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New Instrument Specialties strips shield RFI/EMI; control noise, dust, moisture and chemical contaminants!

These new Sticky Fingers® electronic gaskets combine beryllium copper finger strips with a neoprene rubber seal. Providing shielding characteristics comparable to other Instrument Specialties shielding strips, they also serve as an environmental seal. Thus, they are especially suited to applications where protection against noise, dust, moisture, and chemical contaminants is required as well as electronic interference protection.

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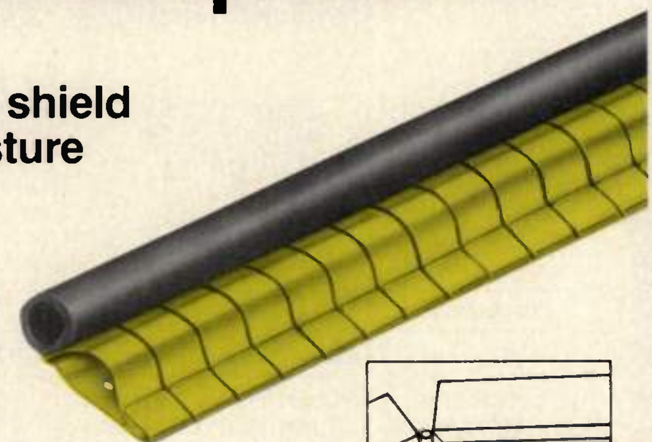
Catalog E³-58 provides complete information, including exact specifications, dimensional drawings, etc., on these and other Instrument Specialties shielding strips. Use this publication's Reader Service Card, or write to us directly at Dept. RFD-23.



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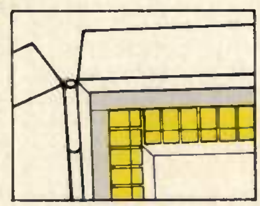

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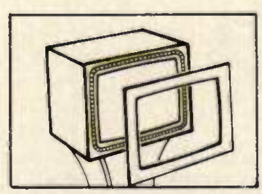
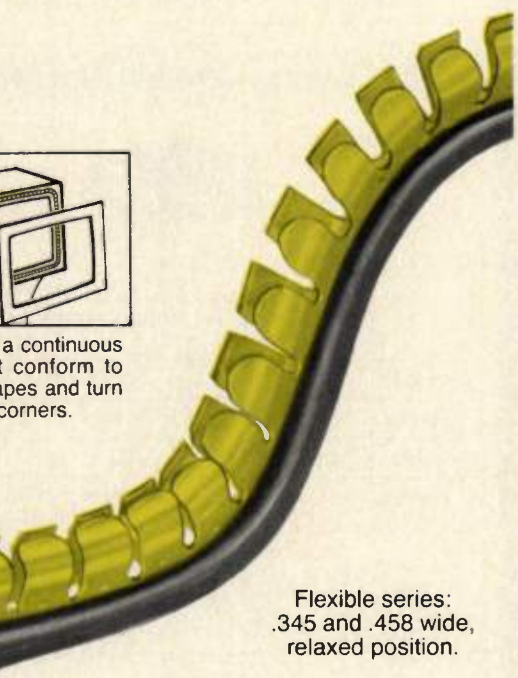


Ideal where a continuous shield must conform to irregular shapes and turn tight-radius corners.



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Temp. Stability Options:	±25 ppm over 0/+70°C ± 3 ppm over 0/+50°C ±50 ppm over −55/+85°C	$\pm 2\text{x}10^{-7}$ over 0/+50°C $\pm 5\text{x}10^{-7}$ over −20/+70°C $\pm 1\text{x}10^{-6}$ over −55/+85°C	$\pm 1\text{x}10^{-8}$ over 0/+50°C $\pm 3\text{x}10^{-8}$ over −20/+70°C $\pm 5\text{x}10^{-8}$ over −55/+75°C
Aging:	5 ppm/year (2 ppm/year optional)	1 - $2\text{x}10^{-6}$/year (depending upon frequency)	$1\text{x}10^{-8}$/day (as low as $1\text{x}10^{-10}$/day available)
Phase Noise (@ 50 MHz)	1 KHz / 50 KHz	1 KHz / 50 KHz	1 KHz / 50 KHz
Standard:	−125dBc/Hz / −150dBc/Hz	−130dBc/Hz / −145dBc/Hz	−140dBc/Hz / −150dBc/Hz
L2 Option:	−140dBc/Hz / −160dBc/Hz	— / —	−150dBc/Hz / −160dBc/Hz

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Linearity:	±10% to ±20%	±1% to ±5%	±1% to ±10%
Stability: (0-50°C)	±.001%	*±.001% to ±.01%	±.3% to ±1%
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ECL	5 MHz-500 MHz	5 MHz-200 MHz	5 MHz-150 MHz
Accuracy (at 25°C):	±10 ppm, ±15 ppm, ±25 ppm or ±50 ppm (most models also available settable to ±1 ppm via either internal or external variable capacitor).		
Stability:	Standard: ±25 ppm over 0°C to +70°C Option 2: ±50 ppm over −55°C to +125°C Option 5: ± 5 ppm over 0°C to +50°C		

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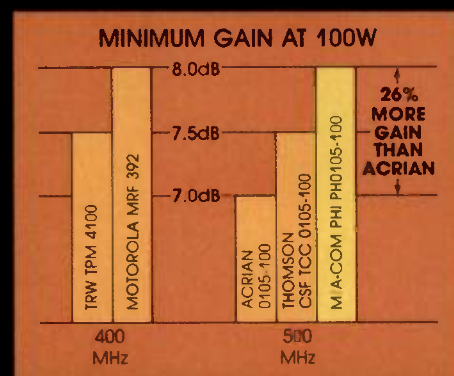
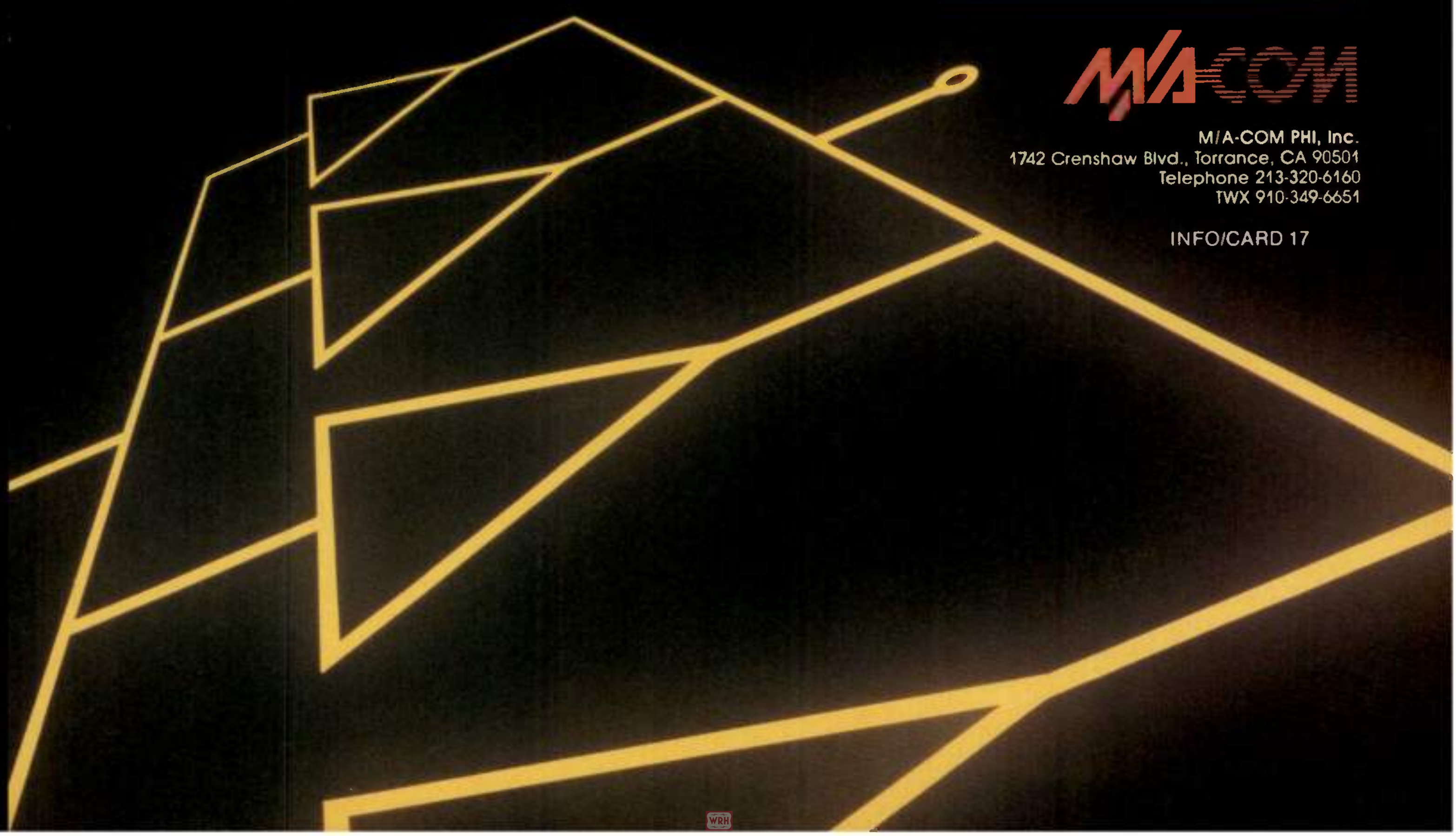
The PH0105-100 is the first in a series of exciting new products being offered in the VHF/UHF band at power levels from 3W to 125W, fully characterized, competitively priced, and in high volume production. Call us. We'd like to drop in.





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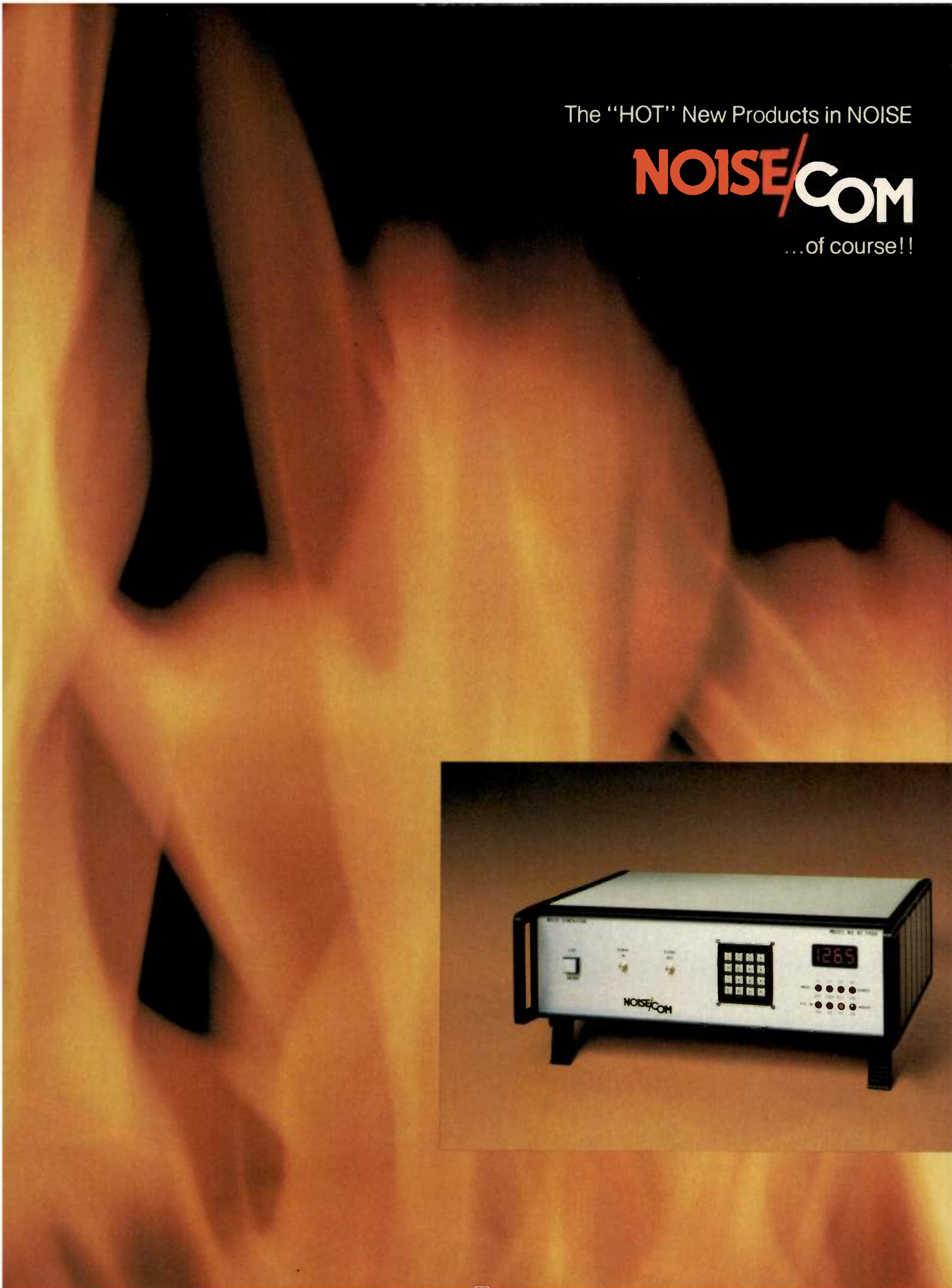
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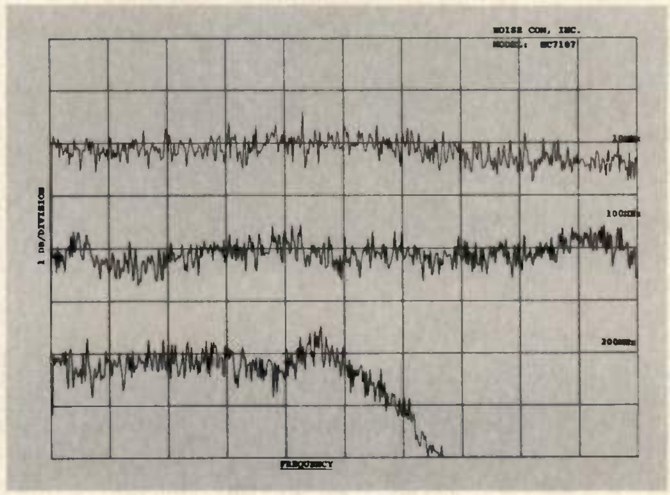

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NC 7100 Series/ + 10 dBm Output

MODEL	FREQUENCY RANGE	OUTPUT DBM/BAND	OUTPUT FLATNESS	OUTPUT DBM/ Hz	OUTPUT uv/ $\sqrt{Hz}$	VSWR MAX
NC7101	10Hz-20KHz	+13	±.75DB	−30	7071	2.0
NC7102	10Hz-100KHz	+13	±.75DB	−37	3162	2.0
NC7103	10Hz-500KHz	+13	±.75DB	−44	1414	2.0
NC7104	10Hz-1MHz	+13	±.75DB	−47	1000	2.0
NC7105	10Hz-10MHz	+13	±.75DB	−57	316	2.0
NC7106	100Hz-25MHz	+13	±.75DB	−61	200	2.0
NC7107	100Hz-100MHz	+13	±.75DB	−67	100	2.0
NC7108	100Hz-500MHz	+10	±1.5DB	−77	31.6	2.0
NC7109	100Hz-1000MHz	+10	±2.0DB	−80	22.4	2.0
NC7110	100Hz-1500MHz	+10	± 2.5DB	−81.8	18.3	2.0
NC7111	1GH-2GHz	+10	± 2.5DB	−80	22.4	2.0

NC 8200 Series/ + 30 dBM (1 Watt) Output

MODEL	FREQUENCY RANGE	FLATNESS	RF OUTPUT
NC8203	500Hz-500KHz	± 2 DB	− 27DBM/Hz
NC8204	500Hz-1MHz	± 2 DB	− 30DBM/Hz
NC8205	500Hz-10MHz	± 2 DB	− 40DBM/Hz
NC8206	2KHz-25MHz	± 2 DB	− 44DBM/Hz
NC8207	250KHz-100MHz	± 2 DB	− 50DBM/Hz

OPTIONAL: Remotely switching to filters to select seven different sub-bands. Combine output with selected input signals.

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INFO/CARD 19

This month's Special Report covers two subjects. Part I describes noise and noise generating instruments and the uses of noise. We introduce the Noise Com NC7000, the latest noise generating instrument. Part II begins our series on the new uses of RF energy with a look at some surprising medical applications.

Part I — Noise Generating Instruments: New Capabilities, New Applications

By Gary A. Breed

Noise is all around us, at every wavelength we can observe. From the subaudible rumblings of the earth's seismic activity to gamma rays bombarding us from distant parts of the universe, noise constantly frustrates engineers and scientists by limiting their capabilities of observation and measurement. But noise itself can be valuable, giving us insight into the nature of its source and the medium through which it has been propagated. The useful aspect of noise as a measurement tool is examined in the first part of this Special Report.

The presence of noise is impossible to avoid, since all matter above the temperature of absolute zero emits noise. Electronic circuits are limited in performance by the noise generated within their own components, as well as by the external noise that permeates the environment through which their electrical and electromagnetic signals travel. To help the engineer deal with these problems, noise generating instruments are available to provide accurate, controllable sources of noise for test and measurement of their circuits. These instruments range from a diode fabricated to enhance its noise generating characteristics to units such as the one featured on this issue's cover, which amplify and control the noise output of the basic diode, offering programmable control over the amplitude and bandwidth of the output noise signal.

Noise diodes represent the simplest class of noise generating devices. They can be manufactured with repeatable, predictable noise output characteristics and have supplanted the older gas discharge tubes as standard reference devices. Noise diodes are easy to use, inexpensive, and provide excess noise ratios (ENR) of 15 to 40 dB (see Noise Basics). They can be incorporated as components in equipment, used as calibration standards, or used as low-power test signal sources. Useful noise output to 200 GHz can be obtained with current technology, and enhancements are continually under development.

A variation on the basic diode is the amplified noise source module. With output levels in the +10 dBm range and the use of filtering to shape the output spectrum, these modules provide additional design flexibility over diodes alone. As modules, they are easily incorporated into the design of equipment or systems, as well as being used as test signal sources.

The most recent development is the introduction of noise generating instruments designed solely as sources of test signals. The Noise Com NC7000 (on the cover), and the Micronetics MX5000 represent the current state of noise generator development. These instruments make available high noise power (+30 dBm), control over all important functions, and programmability, placing the greatest range of noise test functions at the engineer's disposal.

Applications of Noise

The use of noise as a tool for research or in practical applications is as varied as the spectrum of noise itself. At audio frequencies, researchers use noise for psychological testing, as a reference standard for audiometry testing, and as simulation of existing sources of noise in the world around us. Practical uses at audio frequencies include acoustic analysis of structures from auditoriums to submarines, amplifier testing, and masking of low-level background noise in offices, motels, and other semi-public places where quiet cannot be achieved. Many of us recall trips to the dentist where headphones with a mix of music and noise were used to reduce our sensitivity to the pain associated with such visits, by overloading our brains with excess auditory information. Now we have tapes with synthesized ocean roar (noise to help us relax), music synthesizers which start with noise and filter the desired frequencies from that random foundation, and record producers who add noise to rock music to make it sound louder without increasing the actual dB level! All this, and we haven't gotten past 20 kHz.

At radio frequencies, the applications are no less diverse. We are familiar with the measurement of noise figure, amplifier gain, and broadband measurements replacing sine wave or swept-frequency signals with noise, but the list of applications doesn't stop there. The advent of high power noise generating instruments has enhanced the traditional applications and created entirely new uses of noise as a design tool.

With the help of several manufacturers of noise generating devices and equipment, a list of applications especially suited to the use of higher power (+30 dBm range) noise signals has been attempted. Some of the possible uses are:

Expanded dynamic range testing of amplifiers, mixers, and receiving systems.

S/N testing of telecommunications and digital data communications circuits.

Interference susceptibility testing for man-made and natural interference sources.

Testing susceptibility to jamming signals.

Reflection coefficient testing of antenna systems and related equipment.

Providing secure communications by masking the desired intelligible information with noise.

Simulation of existing noise or interference conditions.

Replacement of swept-signal testing, to avoid frequency-dependent response errors (i.e., testing with AGC, AFC, or phase lock functions enabled).

Jamming of clandestine "bugs."

A/D and D/A conversion system testing.

Large dynamic range calibration of spectrum analyzers and other measuring equipment.

This list is by no means definitive, and the potential for more applications is unlimited, especially as the instruments

Noise Basics

Noise is a unique commodity. By definition, it has random behavior at any given instant, but over time is has very well defined characteristics. It is the perfect statistical model, and as such it offers the engineer a valuable tool for analysis. The random amplitude fluctuations of noise tend to occur around a specific mean, analogous to the DC value of a rectified AC signal. Since noise is a fluctuating signal, the AC characterizations of RMS and peak amplitude values can be applied to noise as well. Since the amplitude of noise is statistically random, it follows a Gaussian distribution (the familiar "bell" curve), which lends itself to established statistical analysis methods. Practical avalanche diode noise sources exhibit amplitude characteristics which approximate very closely the Gaussian distribution of an ideal random noise source.

The frequency-domain characteristics of noise are of equal importance to amplitude but are more dependent on the nature of the noise source. No currently known noise source can generate noise with random distribution at all frequencies, but devices have been developed with the frequency characteristics needed for the most valuable applications. The measure of energy versus frequency is spectral power density, expressed in watts/MHz or other convenient units. The spectral content of a particular noise test signal is determined by the diode noise source and the bandpass filtering used to shape the frequency response of the signal.

The ability to characterize noise in terms of basic measurement units allows accurate calibration of noise sources, which has led to standardized parameters for the use of noise in various test functions. This capacity for accurate measurement of noise characteristics is the key to its usefulness.

Definitions

Noise Power — Defined in terms of the temperature of a resistor in degrees Kelvin: $P = kTB$

where P = power (watts)
k = Boltzman's constant
T = temperature (°K)
B = bandwidth (Hz)

Noise Temperature — Equivalent temperature of a resistor of the same value as the terminating resistance, which generates the same level of noise as the noise source.

Excess Noise Ratio (ENR) — A standard measure of performance, ENR expresses noise power as the noise which is in excess of a resistor at room temperature (290°K):

$$\text{ENR (dB)} = 10 \log \left(\frac{T}{290} - 1 \right)$$

where T = noise temperature (°K)

Spectral Power Density — The measurement of power per unit bandwidth. For example, in a 50 ohm system, 290°K noise temperature equals –174 dBm/Hz.

Peak Factor — The ratio of peak to RMS noise power of a particular noise source. Determines the equivalent duty cycle of the noise signal.

White Noise — Noise having equal power per unit bandwidth, over a specified frequency range.

Pink Noise — Noise having equal power per octave bandwidth, over a specified frequency range.

Gaussian Noise — Noise having an amplitude distribution according to the Gaussian Probability Density function.

Thanks to Dan Shea and Dr. Lon Edwards of Microwave Diode Corporation, Philip Basse of Micronetics, and Gary Simonyan and Kurt Stern of Noise Com for providing information and assistance in preparing this review of noise basics.

available to the engineer become even more powerful and flexible. Programmable instruments will increase the use of automated testing with noise signals. Higher power levels will make broadband measurements practical under difficult conditions of high interference or background noise levels.

As the available radio spectrum is used to support more and more users, the demand for rigorous testing of RF circuits and equipment will increase dramatically. It should be noted that many of the applications listed above have direct application to problems of a crowded spectrum. Interference susceptibility filter measurement, dynamic range tests, and amplifier spectral purity measurements will be needed more than ever. The engineers developing tomorrow's RF equipment need to have the best tools available, in order to meet the challenges a heavily populated radio spectrum will demand. Test procedures using noise generating instruments will play a major role in the continuing development of better RF products.

The Noise Com NC7000 Programmable Noise Generating Instruments

In the field of test and measurement, where the demand for automated test systems continues to grow, the Noise Com Inc. NC7000 series of instruments combines programmable controls with white Gaussian noise generators in one unit. The instruments can be interfaced to IEEE-488 (GPIB), RS-232, RS-422, or RS-423 for external control.

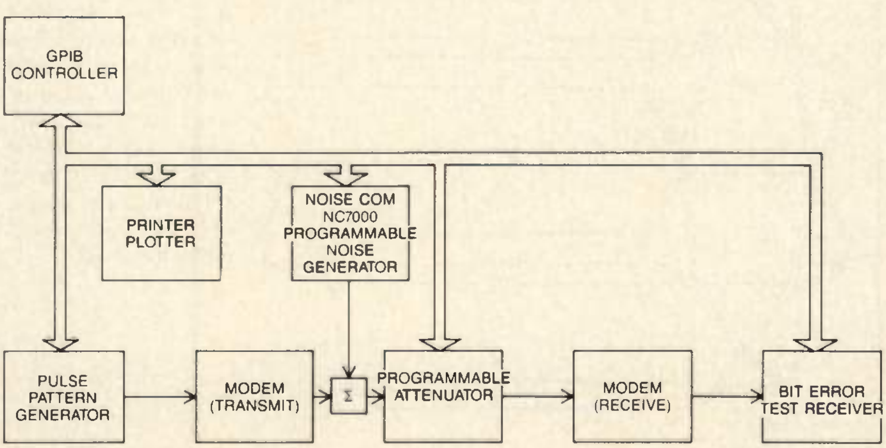
Standard models cover the 10 Hz to 2 GHz frequency range with 0-127 dB attenuation in 1 dB steps. Options include 0.1 dB attenuation increments, selection of up to seven discrete filters, and frequency coverage up to 20 GHz (depending on the availability of programmable attenuators). The instruments contain non-volatile memory of preprogrammed parameters, including attenuation level and incremental step size, signal bandwidth, GPIB listener address, standby function status, serial baud rate, and user-programmed control sequences.

Gary Simonyan of Noise Com has suggested an excellent application of a programmable noise generator, in the testing of digital RF modems, as used in Local Area Networks (LANs). The modems transmit directly into coaxial cable, to which receivers are also directly connected. The connection of multiple devices and the cascading of amplifiers increases the noise level of the system, degrading the carrier-to-noise ratio (CNR).

Since the bit error rate is directly related to the CNR, the modem's bit error rate must be tested as a function of CNR to verify design performance, or to periodically check production units. Also, since the bit error rate is not only a function of CNR, but also a function of absolute signal level, a family of curves must be generated to accurately represent the performance of the device under test. Even with high data rates, if the bit error rate is low a relatively long time is required to record one error. If the modem under test has a large dynamic range, the family of curves is large, and automated testing is easily justified.

The test setup in the block diagram below has independently variable signal and noise levels, allowing automatic control of both absolute signal level and the ratio of carrier to noise. This application can be adapted to a large number of analog and digital systems, and is just one of many possible uses of a programmable noise generating instrument.

Automatic test application suggested by Noise Com Inc.



The following companies also manufacture noise generating devices. For information please circle the appropriate INFO/CARD numbers.

Micronetics Inc. . . . . INFO/CARD #114

Microwave Diode Corporation . . . . INFO/CARD #113

Microwave Semiconductor Corp. . . . . INFO/CARD #112

Hewlett-Packard Co. . . . . INFO/CARD #111

Marconi Instruments . . . . INFO/CARD #110

Eaton Corp., Electronic Instruments Div. . . . . INFO/CARD #109

Frequency Sources — Semiconductor Div. . . . . INFO/CARD #108

Comstron Corporation . . . . INFO/CARD #107

Part II — Medical Uses Of RF Energy

By James N. MacDonald

Our second series for 1985 covers new uses of RF energy not widely known among RF engineers. To begin the series we look at two medical uses of radiated RF that show great promise in diagnosing and treating cancer and other major diseases. RF technology is able to accomplish things that other techniques and treatments cannot, with far less risk, and researchers are excited about the potential for the investigational devices mentioned in this report.

Attempts to use radio frequency to treat disease began soon after RF technology was developed. Unfortunately, many early devices were useless gadgets assembled by quacks or charlatans who took advantage of the mystery surrounding radio and electricity. This made legitimate scientists reluctant to investigate the therapeutic possibilities of RF.

The earliest successful medical use of RF was radiothermy, heating the body with radio waves. Heating body tissues as therapy is an ancient treatment, going back to the first hot baths. Radiothermy was a logical heating method to try as a substitute for hot water and steam, but little was known about the best frequencies and power to use.

Around the middle of the 19th century, physicians observed that cancer sometimes regressed for no apparent reason after a patient suffered from a high fever caused by some other disease. They did not know whether the spontaneous regression resulted from the high body temperature or the stimulation of the immune system, but some physicians induced fever-causing disease as a treatment for cancer.

Investigations early in this century showed that cancer cells were killed more readily than normal cells by high temperature, and scientists determined that a temperature above 41°C (106°F) was necessary for a significant destruction of cancer cells. (The normal body temperature is 37°C and a fever seldom exceeds 40°C.) During the 1930s, RF-induced hyperthermia at temperatures above 41°C was combined with X-ray as a treatment for some cancer cases.

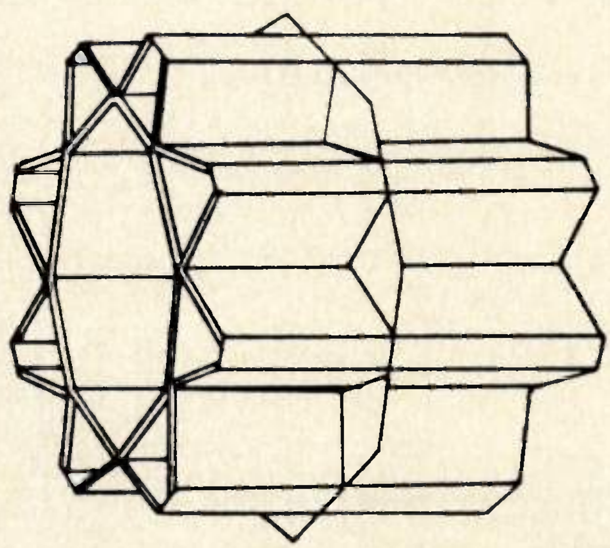
There were many difficulties with this technique. Among the worst was that perspiration, being more conductive than flesh, would overheat, causing burns in the armpits. The technique fell into disfavor with the development of chemotherapy. Interest in thermal treatment of cancer has rekindled recently, partly because of the possibility of destroying internal cancers formerly considered untreatable. Hyperthermia is combined with radiation and other traditional therapies to attack the disease on several fronts.

The leading manufacturer of RF hyperthermia equipment is BSD Medical Corp., Salt Lake City, Utah. BSD was the first company to produce and receive FDA approval for a complete hyperthermia system. It is designed to produce temperatures between 41°C and 45°C in malignant tissue by heating the tumor itself. Developed in 1978, the system was described in a paper written by BSD staff engineers J. Gordon Short and Paul F. Turner and published in the Proceedings of the IEEE (Vol. 68, No. 1, Jan. 1980).

Techniques available can provide either whole body hyperthermia or heating of specific regions. Whole body heating is appropriate when the cancer is widespread or large and internal. The problem is that the body temperature cannot be raised very high without the risk of damage to sensitive normal organs. The accepted limitation is 41.8°C. Treatment at this temperature requires sessions as long as six hours at weekly intervals, which can be physically and psychologically stressful.

Tissue can be heated capacitively or inductively at frequencies between 1 and 100 MHz or by radiation at higher frequencies. Each method has disadvantages. It is difficult to treat deep tumors with radiated RF because of attenuation in the intervening tissue. With capacitive surface heating heavy fat layers will heat faster than other tissue and can be damaged.

Theoretically, selective heating of internal organs can be achieved by electromagnetic coupling of RF radiation from different directions. This could provide energy for heating at a specific location in the body without overheating intervening tissue. At BSD Turner has developed a synchronous phased array which



Internal construction of the Annular Phased Array. The APA is designed with two annular rings of eight radiating apertures each. These apertures are tapered parallel plate horns loaded with high dielectric fluid.

radiates energy from as many as 16 points to arrive in phase and with identical polarity at the target location. The Annular Phased Array (APA) is designed to focus heating power directly into the deepest regions of the thorax, pelvis and abdomen.

Described by Turner in the IEEE Transactions on Biomedical Engineering (Vol. BME-31, No. 1, Jan. 1984)), the APA is composed of 16 radiating apertures in an octagonal structure. The patient lies in the center of the structure with a distilled water-filled bolus between him or her and the apertures. The bolus improves energy coupling, reduces stray fields and cools the patient.

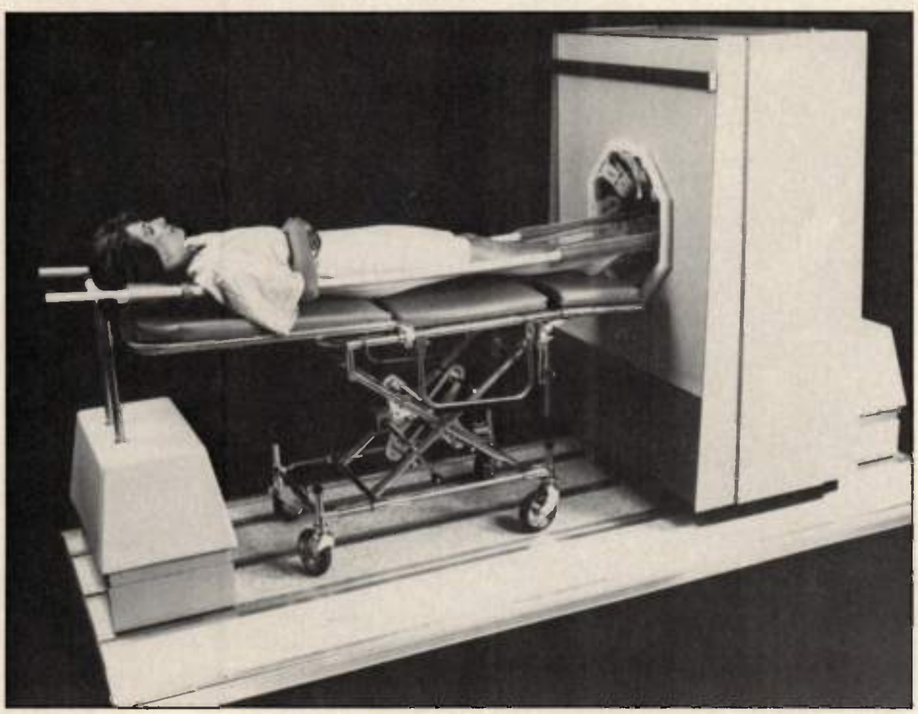
The APA operates between 50 and 110 MHz, and the frequency can be set to alter the focal size. Power comes from the 2 kW amplifier through a 4:1 power splitter. The splitter output goes through four coaxial cables that provide equal path delay to the apertures. Each output is again split to feed the 16 apertures. Heating patterns can be modified by changing the relative phase and amplitude of the splitter outputs or by changing the frequency to move phase nulls.

Turner said in investigational use on approximately 300 patients the APA has caused regression of many tumors. It has been approved by the FDA as an investigational device for use by approved institutions doing cancer research. It can be used only on patients whose disease has progressed beyond help from other forms of treatment. More general use may be coming soon, however. The APA recently was given pre-market approval in Japan.

The problem with directing RF energy within the body is that the human body is not homogeneous. Achieving the proper focusing is possible in a cylinder filled with a homogeneous material, but is far more difficult with an irregularly shaped torso composed of tissue, bone and fat. Furthermore, while the physician is trying to heat a specific area within the body, the body is reacting by trying to disperse the heat and maintain a normal temperature. The designer of such an apparatus must deal with Maxwell's equations and principles of thermodynamics at the same time.

The process is further complicated by the inability to measure temperature accurately within the body. Thermometer probes can be placed in natural orifices, surgically implanted or put into catheters inserted by hypodermic needle, but this provides only a limited number of temperature measurements from which to control the treatment.

To improve clinical focusing, miniature dipole antennas can be surgically implanted in the tumor to radiate during treatment setup, optimizing APA phase and amplitude by reciprocity. Non-clinical research is being done in this area.



Typical clinical view of the APA in patient installation procedure.

Hyperthermia is a challenging use of RF energy with a high potential for service to humanity.

Another promising use of RF in medicine is Magnetic Resonance (MR), which includes Magnetic Resonance Imaging (MRI), and Magnetic Resonance Spectroscopy (MRS). MR is sometimes referred to as Nuclear Magnetic Resonance, which actually is the principle involved, but many avoid this term because of the general public apprehension about the word "nuclear." Used by chemists for almost 40 years to study molecular structures, MRI only recently was brought into the medical field.

MR works by sensing the RF energy radiated by the nuclei of atoms as they relax after being propelled to higher energy states by magnetic fields. The leading company in this field is the GE Medical Systems Business Group, headquartered in Milwaukee, Wis. Herb Taus, general manager of the group's NMR Instruments Division, Fremont, Calif., explained the principle upon which their work is based.

Atomic nuclei with an odd number of protons or neutrons have magnetic moments produced by their normal spin. When subjected to a strong magnetic field these nuclei tend to align the axis of their spin to that field. They cannot align precisely, however, and they precess around an axis parallel to that field, tracing an invisible cone as a top does when its spin starts to slow and gravity begins to pull it down. If a person is placed within a strong cylindrical magnet, appropriate nuclei in the body precess around the longitudinal axis of the magnet at precise, known frequencies determined by the magnetic field strength. Within the 2 Telsa superconducting magnet used in research at the NMR Instruments Division, Taus told us, hydrogen nuclei (protons) precess at 85 MHz. Within the 4.7 Tesla magnet they precess at 200 MHz. (One Tesla $=10^4$ Gauss). The precession frequency of a nucleus is known as its Larmor frequency.

If an RF field at the Larmor frequency of the hydrogen nucleus (a proton) is introduced into the magnetic field with the RF magnetic component at 90° to the magnetic field, the hydrogen protons in body tissues will re-orient themselves to the RF field. When the RF energy is turned off they will return over a period of time to their previous orientation, re-radiating the resonant energy that impelled them into the new plane of rotation.

Antennas pick up the energy radiated by the protons returning to their previous states of rotation and the decay rate of that return. Hydrogen protons in different body tissue relax at different rates, varying from a few hundred milliseconds to about two seconds, providing a signature that identifies the tissue. This information is analyzed through Fast Fourier Transform by a computer which produces a frequency vs. amplitude graph. Large amplitude peaks from fat and water show up on the graph at frequencies determined by the chemical composition of the tissue. These chemical shift frequencies, or MRS, allow researchers to identify the composition of minute areas of the body.

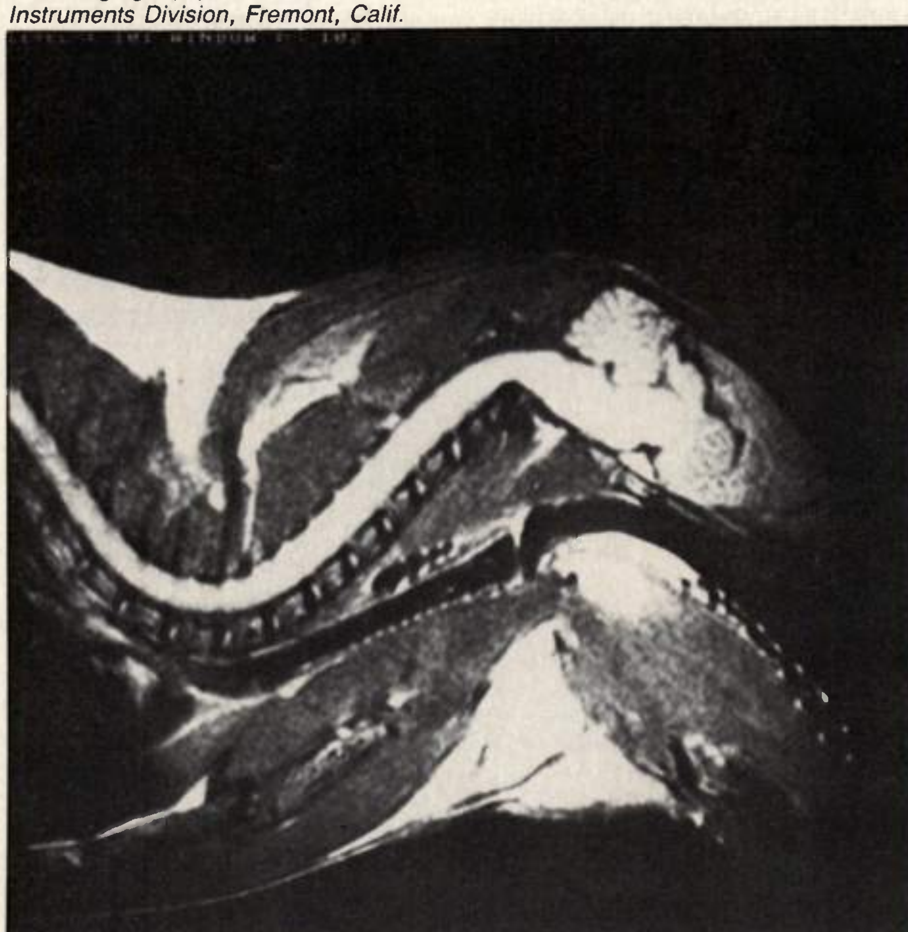
GE researchers derive spatial information for imaging by introducing a pulsed DC linear field into the magnetic and RF fields, a technique developed about 10 years ago at the State University of New York at Stony Brook. Decreasing in strength with distance, this field creates a gradient within the image area, giving every point within the space a specific frequency, as the nuclei react to the magnetic field intensity at that point. This 3-dimensional information, digitally processed into colors or shades of gray, provides the TV or film image. The gradations in color and the image detail possible with this technique provide an astonishing picture of the inside of the body. It is like slicing the body in two in any direction to look inside.

Although MRI provides high resolution, Taus said it is not necessarily superior to X-ray in all respects. He said a trained radiologist can spot most abnormalities in an X-ray without the fine detail. Unlike X-rays, however, MRI can magnify images and can show soft tissue. In fact, MRI does not show bone. It shows cartilage, marrow, soft tissue, veins and arteries, but not bones or teeth. Extending MRI systems to include MRS will provide specific site tissue identification.

A significant advantage of MRI over X-ray for tissue examination is that MRI can show a slice of tissue as thin as 1 mm in any plane. GE researchers expect to achieve voxel (volume element) sizes at least as small as .030 mm eventually. This would allow tumor detection at a very early stage and would let physicians observe the effects of treatment within days, instead of weeks. The aim of MRI, with MRS, is non-surgical microscopy and tissue identification, which will be useful in determining heart damage and other tissue abnormalities, as well as cancer.

Like RF hyperthermia, MRI with MRS is approved only for investigational use in the United States. MRI by itself is approved for clinical use. Although it is highly effective and is being used on humans, there are several improvements to be made before MRI with MRS can be marketed for general hospital use. Taus said there is a great need for RF engineers in this research.

MRI imaging equipment used for small animal investigation at General Electric NMR Instruments Division, Fremont, Calif.



Side view of a rat's head (facing right) magnified 3x with MRI. Voxel size is less than 0.08mm. Image made by GE NMR Instruments Div. in collaboration with J. Gore and M. Brown, Yale University, Dept. of Radiology.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Re-Normalizing the Scattering Parameters

By Daniel N. Meeks
Q-bit Corporation

Many component and subsystem users rely on normalized scattering parameter data (S-parameters) to determine compatibility of the component or subsystem in an overall system configuration. Fortunately, the S-parameters are easy to measure using standard network analysis equipment. In some cases, the S-parameters may even be supplied by the manufacturer of a component. However, the S-parameters of a network are not independent of the source and load impedances. In the strictest sense, the actual S-parameter data is meaningless unless the source and load impedances of the measurement system are known. It therefore follows that if the unit is to be designed into a system that provides input and output impedances other than those specified with the S-parameter data, the test data will not accurately reflect the device characteristics. Two alternatives present themselves in this situation: Test data may be obtained from a network analyzer with the desired source and load impedances, or the data on hand may be mathematically corrected to reflect the actual circuit configuration.

The first alternative has obvious practical limitations, especially for component users who may not actually have access to the required test equipment and fixtures. To utilize the second alternative, the following discussion presents a mathematical solution of the normalized scattering parameters of a two-port network operating into source and load impedances different from those used to measure the original S-parameters.

A two port terminated by Z_0 at both ports (Fig. 1) may be described by the associated normalized scattering matrix:

$$[S] = \begin{bmatrix} S11 & S12 \\ S21 & S22 \end{bmatrix}$$

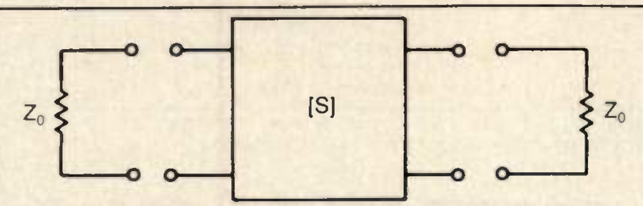

Figure 1. A two-port terminated in real impedances (Z_0).

This is the conventional model, and [S] may be easily determined using standard test methods and equipment, or [S] may be supplied by the manufacturer of the component or subsystem. Thus, it is assumed that [S] is known for the given two-port.

Using transmission line voltage-current relationships and the definition of the scattering parameters, the normalized scattering matrix [S'] of a two-port is given by:

$$[S'] = [R_e\, Z_{On}^{1/2}]\,[S_I]\,[R_e\, Z_{On}^{-1/2}] \tag{1}$$

$$\text{where, } [R_e\, Z_{On}^{1/2}] = \begin{bmatrix} \sqrt{R_e Z_{01}} & 0 \\ 0 & \sqrt{R_e\, Z_{02}} \end{bmatrix} \tag{2a}$$

$$[R_e\, Z_{On}^{-1/2}] = \begin{bmatrix} \dfrac{1}{\sqrt{R_e\, Z_{01}}} & 0 \\ 0 & \dfrac{1}{\sqrt{R_e\, Z_{02}}} \end{bmatrix} \tag{2b}$$

Z_{01} and Z_{02} are the complex source and load impedances the two-port is operating into (Fig. 2).

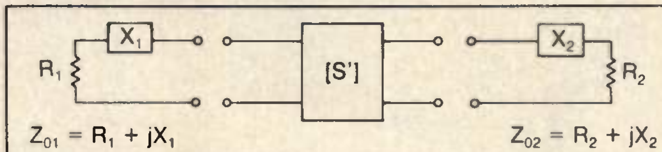

Figure 2. A two-port operating into complex source and load impedances.

$[S_I]$ is the current scattering matrix and is given by:

$$[S_I] = ([Z] + [Z_{On}])^{-1}\,([Z] - [Z_{On}^*]) \tag{3}$$

where [Z] represents the impedance matrix of the two-port.

(1) and (2a, 2b) give [S] to [z] transformations. Using these transformations and noting that $[Z] = Z_o\,[z]$ gives:

$$[Z] = \frac{Z_0}{D}\begin{bmatrix} (1 + S_{11})(1 - S_{22}) + S_{12}\,S_{21} & 2\,S_{12} \\ 2\,S_{21} & (1 - S_{11})(1 + S_{22}) + S_{12}\,S_{21} \end{bmatrix} \tag{4}$$

where $D = (1 - S_{11})(1 - S_{22}) - S_{12} S_{21}$, and Z_0 is the characteristic impedance of the system used to measure [S].

Using equation 3 and noting that:

$$Z_{On} = \begin{bmatrix} Z_{01} & 0 \\ 0 & Z_{02} \end{bmatrix}$$

and,

$$Z_{On}^* = \begin{bmatrix} Z_{01}^* & 0 \\ 0 & Z_{02}^* \end{bmatrix}$$

gives:

$$[S_i] = \begin{bmatrix} Z_{11} + Z_{01} & Z_{12} \\ Z_{21} & Z_{22} + Z_{02} \end{bmatrix}^{-1} \begin{bmatrix} Z_{11} - Z_{01}^* & Z_{12} \\ Z_{21} & Z_{22} - Z_{02}^* \end{bmatrix}$$

Solving the inverse matrix and multiplying through gives:

$$[S_i] = \frac{1}{D'} \begin{bmatrix} (Z_{22}+Z_{02})(Z_{11}-Z_{01}^*) - Z_{12}Z_{21} & Z_{12}(Z_{02}+Z_{02}^*) \\ Z_{21}(Z_{01}+Z_{01}^*) & (Z_{11}+Z_{01})(Z_{22}-Z_{02}^*) - Z_{12}Z_{21} \end{bmatrix} \quad (5)$$

where $D' = (Z_{11} + Z_{01})(Z_{22} + Z_{02}) - Z_{12}Z_{21}$

Using (1) and combining (2a), (2b) and (5) gives:

$$[S'] = \frac{1}{D'} \begin{bmatrix} (Z_{22}+Z_{02})(Z_{11}-Z_{01}^*) - Z_{12}Z_{21} & 2Z_{12}\sqrt{(R_eZ_{01})(R_eZ_{02})} \\ 2Z_{21}\sqrt{(R_eZ_{01})(R_eZ_{02})} & (Z_{11}+Z_{01})(Z_{22}-Z_{02}^*) - Z_{12}Z_{21} \end{bmatrix} \quad (6)$$

where D' is a given, as in (5) above.

Therefore, the scattering parameters for the two-port, augmented by the complex source and load impedances of Z_{01} and Z_{02}, are given as [S'] by (6). The impedance parameters [Z] in (6) are found using the scattering parameters [S] of the original two-port configuration shown in Figure 1 and 4.

References:

1. R. Carson, "High-Frequency Amplifiers," John Wiley & Sons, N.Y., 1982, pp. 188-201.
2. Hewlett Packard Application Note 95-1, "S-Parameter Techniques for Faster, More Accurate Network Design."

About the Author

Daniel Meeks is an RF Design Engineer with Q-bit Corporation, 311 Pacific Avenue, Palm Bay, FL 32905-2699. He received his B.S.E.E.T. degree from Capitol Institute of Technology, and has worked on large automated RF test systems, as well as his current work in RF and microwave circuit design.

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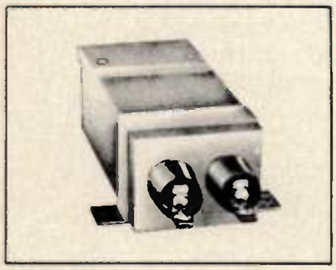

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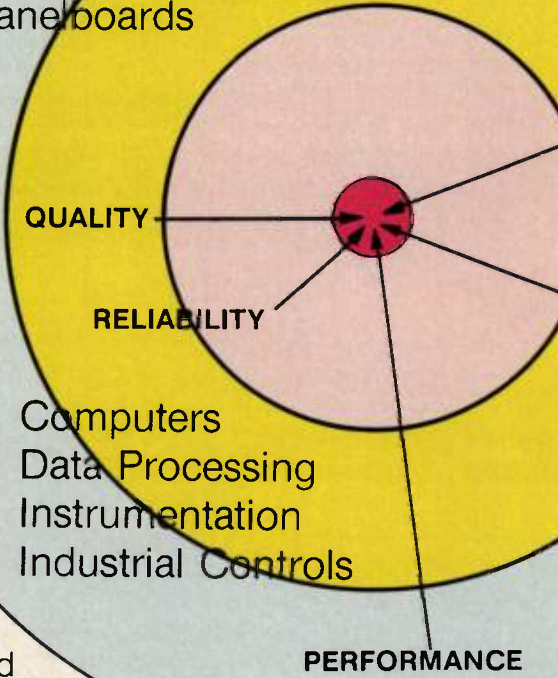

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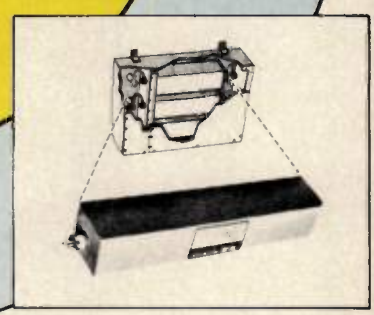

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INFO/CARD 23

Elliptic Filter Wins A Comparison Test

By Peter Vizmuller
Motorola Canada

Modern computer-aided circuit analysis and optimization programs can provide important insights into circuit operation and shorten design time. In this article, COMPACT® was used to analyze and optimize the performance of Butterworth, Chebychev and Elliptic low-pass filters for comparison purposes. Of the different low-pass filter implementations, the elliptic filter turns out to be the best choice in terms of insertion loss and component value sensitivity, for most applications.

Filter design with ideal, lossless components is quite straightforward, with component values tabulated in many sources (1). The filter designer only needs to perform frequency and impedance scaling for his selected filter shape and decide how to realize the required components using discrete components, sections of transmission line or coupled resonators. Unfortunately, in the real world, lossless components do not yet exist and we have to design with inductors and transmission lines that are lossy and capacitors that are self-resonant.

Most reference books on filter design treat the problem of lossy components in a rather artificial manner, by assuming that capacitors and inductors contribute to the losses equally. (1, 2) By assuming equal losses, a technique called predistortion is used to modify component values so that the basic filter shape is preserved. Predistortion thus maintains the desired shape (Butterworth, Chebyshev, etc.) but at the expense of increased insertion loss and degraded return loss.

For many filter designs predistortion is quite unacceptable as a realization procedure since capacitors have much lower losses (higher Qs) than inductors and, therefore, must be made lossy by placing resistors in parallel to satisfy the requirement for equal component losses. If one of the objectives of a filter is to minimize insertion loss, as it is for a majority of filters, increasing component losses ar-

Table 1. Sample of COMPACT® analysis for ideal Chebyshev filter:
Sensitivity Analysis With 7 Variables:
Initial Circuit Analysis

Polar S-Parameters in 50.0 ohm System

Freq.	S11 (Magn<Angl)		S21 (Magn<Angl)		S12 (Magn<Angl)		S22 (Magn<Angl)		S21 dB
20.00	0.15<	−152	0.99<	−62.3	0.989<	−62.3	0.15<	−152	−0.10
40.00	0.04<	144	1.00<	−126.3	0.999<	−126.3	0.04<	144	−0.01
60.00	0.15<	−105	0.99<	164.5	0.989<	164.5	0.15<	−105	−0.10
80.00	0.03<	−4	1.00<	85.9	1.000<	85.9	0.03<	−4	−0.00
100.00	0.15<	67	0.99<	−22.6	0.989<	−22.6	0.15<	67	−0.10
102.00	0.31<	51	0.95<	−39.2	0.951<	−39.2	0.31<	51	−0.43
104.00	0.48<	33	0.87<	−56.9	0.875<	−56.9	0.48<	33	−1.16
106.00	0.65<	15	0.76<	−74.5	0.761<	−74.5	0.65<	15	−2.37
108.00	0.78<	−1	0.63<	−90.7	0.631<	−90.7	0.78<	−1	−4.00
110.00	0.86<	−15	0.51<	−104.6	0.508<	−104.6	0.86<	−15	−5.89
250.00	1.00<	−139	0.00<	131.3	−72.9 dB	131.3	1.00<	−139	−72.90
260.00	1.00<	−141	0.00<	129.5	−75.5 dB	129.5	1.00<	−141	−75.49

Sensitivity Analysis With Following Variables and Gradients

VARIABLES		GRADIENTS	
(1):	37.600	(1):	−.43170E−01
(2):	113.20	(2):	.24999E−01
(3):	66.700	(3):	.55469
(4):	125.20	(4):	.78824
(5):	66.700	(5):	.55570
(6):	113.20	(6):	.24603E−01
(7):	37.600	(7):	−.43950E−01

ERR. F. = 0.057

tificially to preserve some elegant mathematical theory is simply not justified. In practical filter design, the number of lossy components should be minimized, even though having the minimum number of inductors does not always guarantee lowest insertion loss, as shown below.

In some cases, choosing a particular filter realization for minimum insertion loss can be quite easy. For example, a given elliptical filter can be realized using two inductors and five capacitors or by its dual, which uses two capacitors and five inductors (Fig. 1).

The filter using five inductors should be expected to have a higher insertion loss than the filter using only two inductors. In other cases, it is not really obvious which realization is preferable. Let us look at some representative filter designs using lossless capacitors and lossy inductors and investigate, by means of a numerical comparison, the effect of inductor losses on filter performance to see if the component values can be changed to partially compensate for inductor losses, minimizing the insertion loss.

The Basis For Comparison

The comparison was carried out by following these four steps:

1. Butterworth, Chebyshev and Elliptic low-pass filters were designed with approximately the same 3 dB bandwidth of 100 MHz and approximately the same attenuation at some out-of-band frequency, i.e. around 70 dB at 255 MHz.
2. Performance of each circuit was analyzed with infinite inductor Q and with an inductor Q of 80.
3. With inductor Q = 80, circuits were optimized using COMPACT, with the same optimization function for each circuit:
   a) insertion loss < 0.3 dB, 20 to 100 MHz
   b) insertion loss > 70 dB at 255 MHz
4. Component value sensitivities were evaluated in the optimized design.

It is perhaps surprising to some readers how small are the differences among the different realizations, which in every case differ from each other by less than 0.5 dB in the passband. On the other hand, filters of fairly low order were chosen for illustration. With higher order filters, the differences would be greater. In some applications even the small differences would be significant; for example, in miniature transmitter filters where a fraction of a dB might mean several additional watts of power that the filter would have to dissipate.

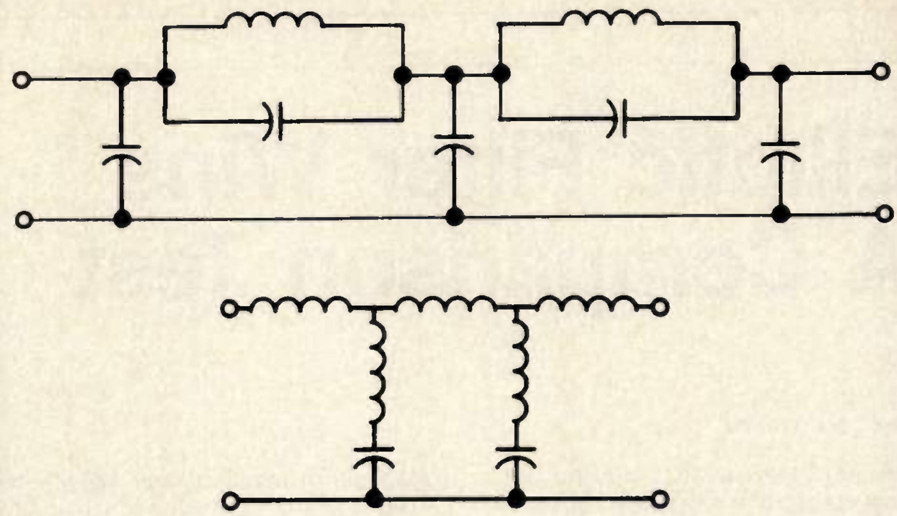


Figure 1. An elliptic low-pass and its dual, both realizing the same low-pass function

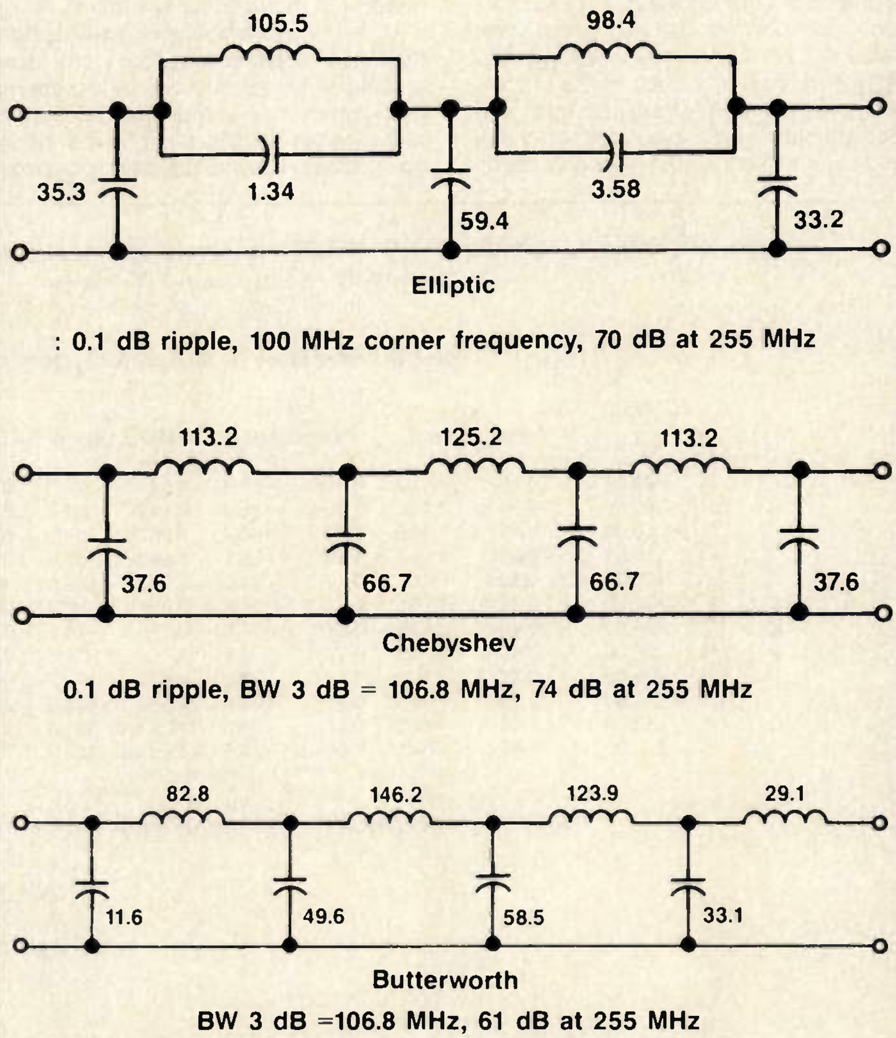


Figure 2. Theoretical designs (inductor Q = infinite): (Capacitors in pF, inductors in nH, 50 ohms in/out)

Table 2. Sample computation of insertion and return loss

Insertion loss = S21 (dB)
Return loss = 20 log (S11)

Stage	Component
0	50 ohms source resistance
1	37.6 pF, parallel C
2	113.2 nH, series L, 100,000 Q of series L
3	66.7 pF, parallel C
4	125.2 nH, series L, 100,000 Q of series L
5	66.7 pF, parallel C
6	113.2 nH series L, 100,000 Q of series L
7	37.6 pF, parallel C
8	50 ohms load resistance

Freq (MHz)	Ins Loss (dB)	Ret Loss (dB)
5	.011	25.639
10	.041	20.183
15	.075	17.626
20	.097	16.546
25	.096	16.604
30	.071	17.862
35	.035	20.876
40	6E-03	28.15
45	1E-03	34.247
50	.025	22.34
55	.065	18.256
60	.096	16.588
65	.095	16.647
70	.058	18.786
75	.012	25.621
80	4E-03	30.165
85	.054	19.045
90	.1	16.406
95	.038	20.57
100	.096	16.603
101	.224	12.989
102	.433	10.233
103	.741	8.045
104	1.165	6.286
105	1.71	4.876
106	2.373	3.758
107	3.142	2.883
108	3.998	2.207
109	4.919	1.689
110	5.886	1.295
250	72.899	0
255	74.211	0
260	75.492	0

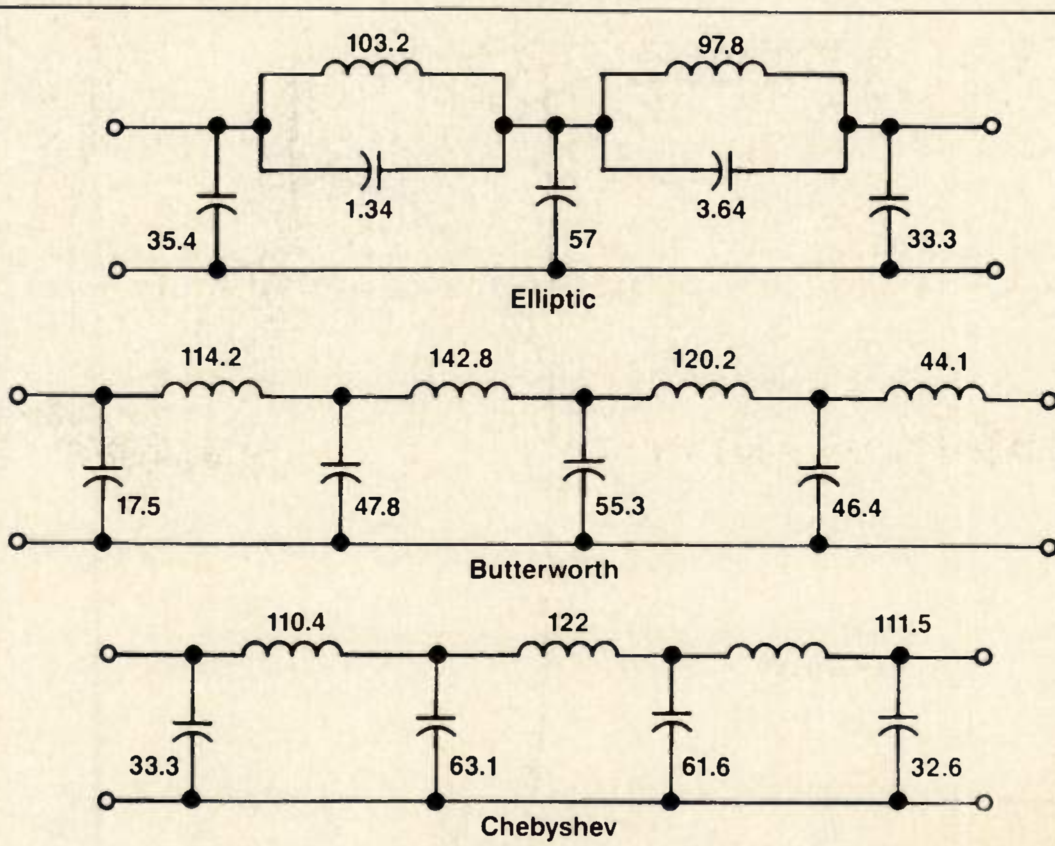


Figure 3. Schematics of the three optimized filters (Capacitors in pF, inductors in nH, 50 ohms in/out)

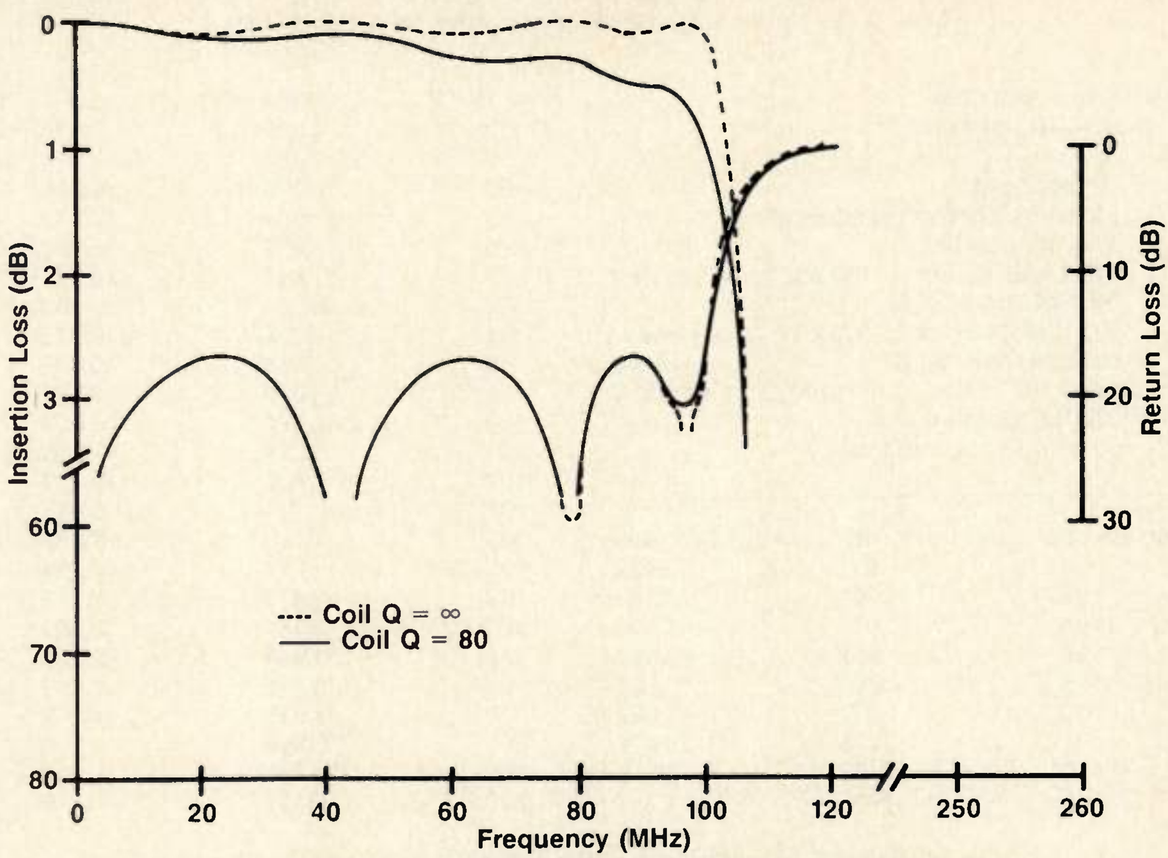
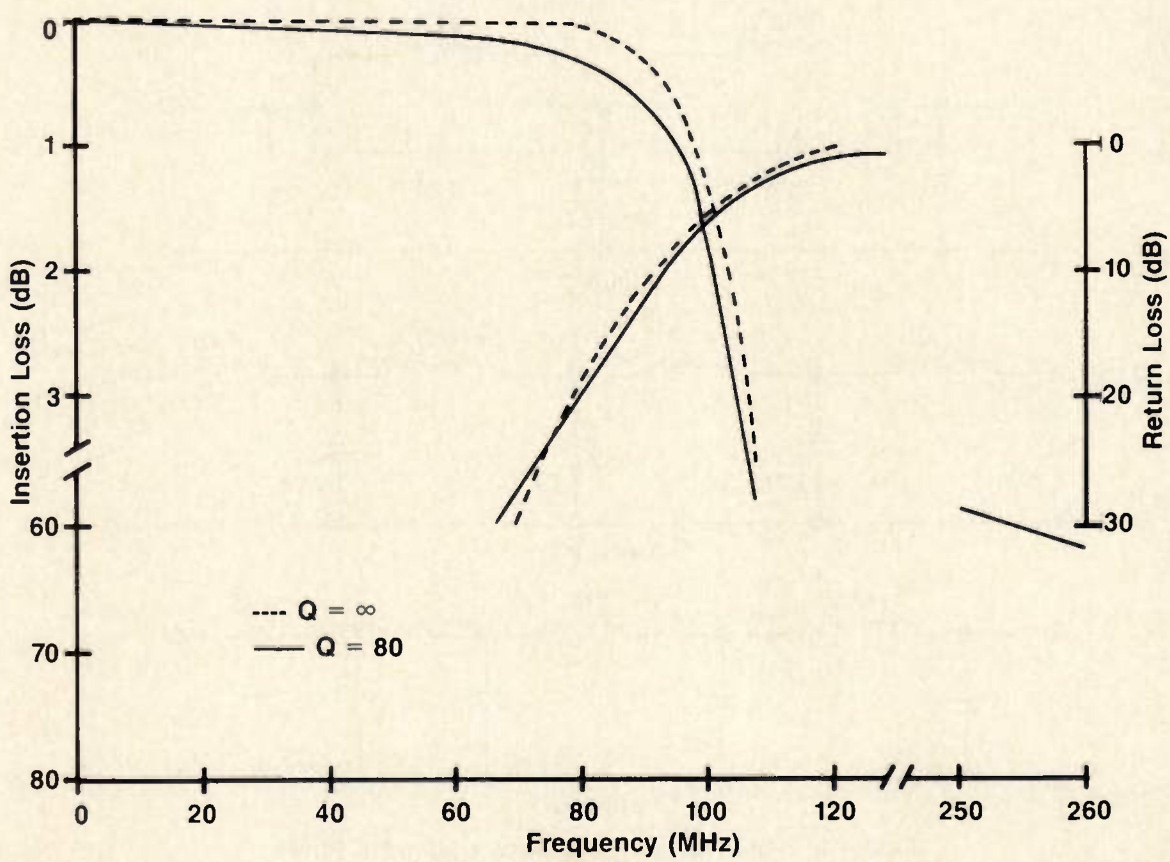
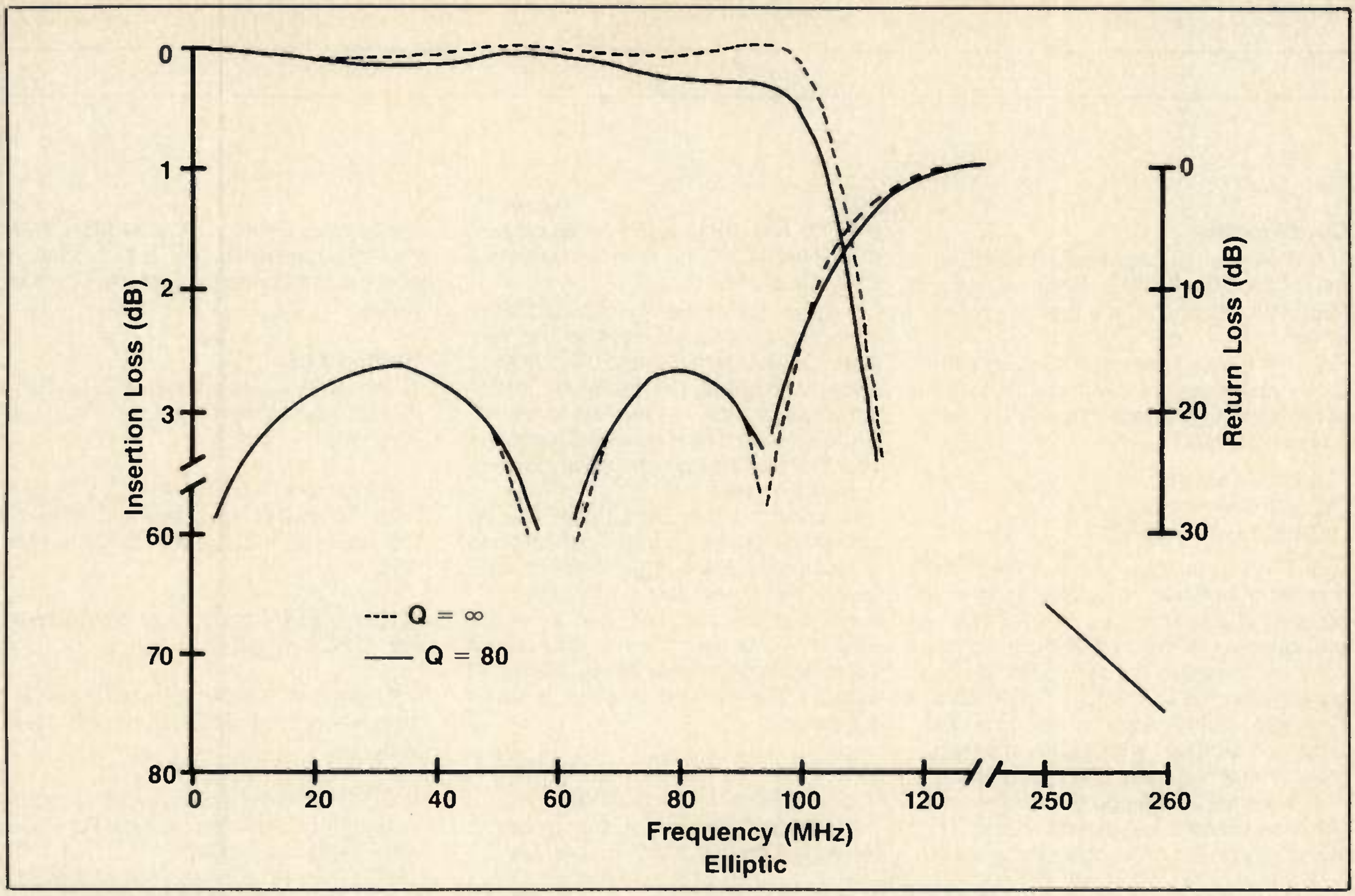


Figure 4. Comparison of filters realized using lossless and lossy inductors (Q = 80)

Chebyshev



Butterworth



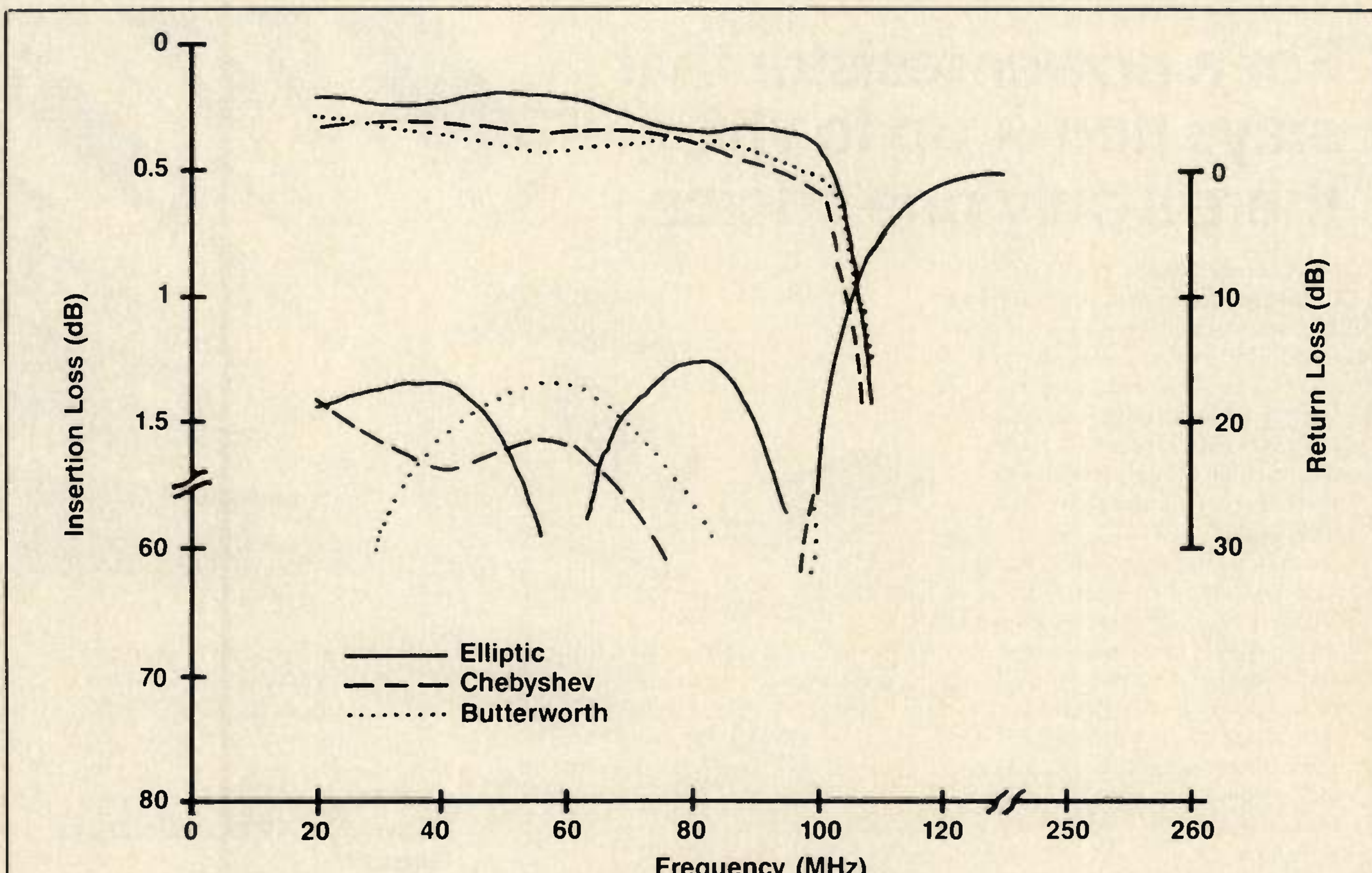


Figure 5. Performance of filters realized with lossy inductors (optimized by COMPACT)

Conclusions

1. For finite Q components (inductors) the Elliptic filter has the lowest insertion loss in the passband, whether optimized or not.

2. The Elliptic filter has the lowest sensitivity to component tolerances. Average sensitivities of the optimized filters per component are:

0.133 Elliptic
0.202 Chebyshev
0.268 Butterworth

3. The Elliptic filter required the least amount of optimization, Butterworth the most. In other words, the amount of improvement obtained by trying to change component values to compensate for inductor losses was minimal for the Elliptic filter. The Chebyshev filter lost its ripple after optimization, with some improvement in insertion loss and return loss.

4. Near the band-edge, the Chebyshev filter has the greatest insertion loss; so, in this case a filter with three lossy components has worse insertion loss in part of its passband than than one with four lossy components!

5. If the optimization function is changed slightly to minimize insertion loss from 60 to 100 MHz rather than 20 to 100 MHz (while at 255 MHz, the loss is still 70 dB), the Elliptical filter still has the lowest insertion loss, but now it is the Chebyshev filter that has the least sensitivity to component tolerances.

In summary, the Elliptic filter can be designed as if it were ideal (with lossless components) with a high degree of confidence that once it is built with lossy components it will perform close to its optimum. A low sensitivity to component value variation counts as an additional bonus, if the filter is to be used as a true low-pass.

About the Author

Peter Vizmuller is a staff engineer at Motorola Canada; 3125 Steeles Ave E., North York, Ontario, Canada M2H 2H6. Readers may contact him for information about a circuit analysis program he has written.

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2. Humphreys, S.D., The Analysis, Design and Synthesis of Electrical Filters. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1970.

3. Motorola RF Data Manual, Second edition 1980, p.17-160.

4. Close, C.M., The Analysis of Linear Circuits, Harcourt, Brace & World, Inc., New York, 1966.

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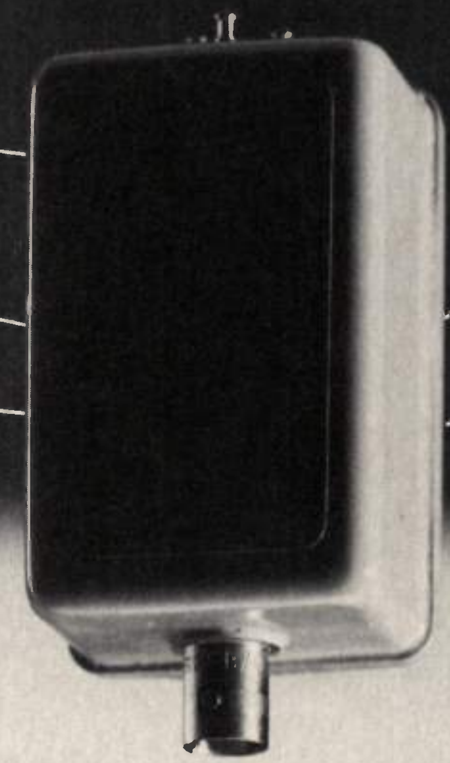

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Another One-Transistor FM Transmitter

By S. Kan
Institut d'Electronique Fondamentale
Universite Paris

A variant of the one transistor FM transmitter published in the February issue of RF design (1) is as shown in Figure 1. It has been used to transmit an audio signal over a frequency modulated carrier at 106 MHz. Very good quality sound reproduction can be assured using an ordinary commercial portable FM radio receiver at a distance up to 50 meters.

The Clapp-Gouriet type oscillator (2, 3) using a junction FET (BF 256 L/B) was designed to operate at a gate-source voltage of about −1.5 V, thus biasing the two varicaps (BB 105 A) without extra components. Inductance L, a spiral antenna, was also printed on the same copper-clad PC board. Its value can be calculated fairly accurately by Dill's formula (4). Audio signal is fed via a potentiometer R_p in series with R_1 to modulate the RF carrier. The chosen transistor has a drain-source current of about 1 mA at the operating gate-source voltage. In spite of this low biasing voltage, the Q of the varicap is well over 200 measured with the HP 4191 A RF impedance analyzer.

(1) RF Design, "A one transistor FM transmitter," William Rynone, February 1985, p. 64.
(2) PIRE, "An inductance capacitance oscillator of unusual frequency stability," J.K. Clapp, Vol. 36, 1948, pp. 356-358.
(3) Wireless Eng., "High stability oscillator," G.G. Gouriet, Vol. 27, 1950, pp. 105-112.
(4) Electronic Design, "Designing inductors for thin-film applications," H.G. Dill, February 17, 1964, pp. 52-59.

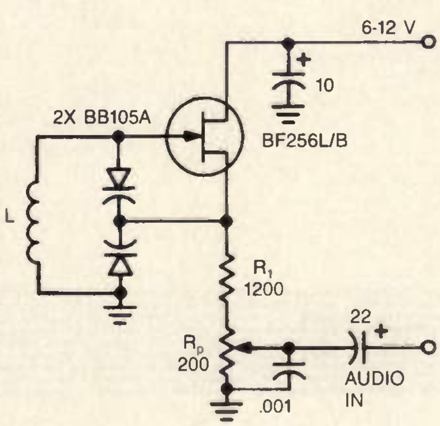

Figure 1. Schematic of the one-transistor FM transmitter with capacitance in µF and resistance in ohms.

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Chuck Abronson, president. Was founder of Amplica, a manufacturer of microwave components and subsystems.

Dr. Bill Childs, executive vice president: manager of advanced development. Fifteen years of microwave hardware design, and development of CAE and CAD software tools used throughout the industry—including the first commercial MIC layout program.

Dr. Chuck Holmes, vice president and chief scientist: advanced development of linear simulators; liaison with outside experts in mathematical modeling of microwave elements. Was principal architect of Super Compact™; assistant dean of electrical engineering, Auburn University.

Dr. Dave Morton, senior scientist: development of linear engineering. While at Tektronix, he authored the time domain module used by Compact,™ and managed support of all microwave CAE activities.

Steve Hamilton, vice president of engineering and operations: directs EEsof's application engineering and support, documentation and continuing product development. At Hughes and Microwave Products, was responsible for management, design and development of microwave components and systems for programs like the Phoenix, AMRAAM, and Patriot.

Yo Chien Yuan, senior scientist: advanced development of nonlinear engineering products. Developed a proprietary version of SPICE used within Hewlett-Packard.

Larry Lerner, senior scientist: development of interactive test equipment support. Over 5 years experience in test instrument programming and device characterization.

Paul Adams, manager of systems programming: advanced software applications and porting of EEsof software to other workstations. Experience in advanced systems programming and integration at Calma and CGIS.

Max Medley (not pictured, based on east coast), senior scientist: responsible for development of EEsof's synthesis products. Was author of Compact's synthesis module; author of Microwave Circuit Design Using Programmable Calculators.

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INFO/CARD 28

Some Questions You Should Ask Your EMI/RFI Test Equipment Supplier

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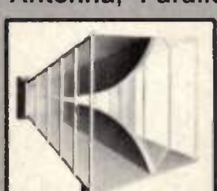
We began with Magnetic Field Instruments and Radio Frequency Antennas for the military. Since the mid-sixties we have been working closely with the military and industry standard setting groups, and EMCO now has one of the broadest lines of Test Antennas and EMI/RFI Test Accessories in the World.

What exactly is your major product line?

EMCO's primary business is Test Antennas for use in Emissions and Immunity (Susceptibility) Testing as required for MIL Standard, FCC, VDE, and CISPR Test Procedures.

Typical Military Antennas for Radiated Immunity (RS) and Emissions (RE) Testing cover the frequency ranges from **30 Hz to 18 GHz**, and are noted in MIL STD 462, Notice 3, Table 1. EMCO currently manufactures **Magnetic Field Loops**, the 41" **Rod Antenna, Parallel Strip Line**, both



Biconical Antennas, the **Conical Log Spirals** and the **Double Ridged Guide Antennas** shown on this table.

Antennas which are currently acceptable for use in FCC Volume II, Part 15 Emissions Testing include, **Adjustable Element Dipole Sets**, Broadband **Biconical Antennas** and Broadband **Log Periodic Antennas**. EMCO manufactures all of these separately or can include them as part of an FCC "Class A" and "Class B" **Antenna Test System**.

What differentiates your antennas from your competitors?

One major difference is Calibration. Each Antenna is calibrated using NBS Traceable Testing Equipment, on our own FCC open field test site. Calibration data includes Antenna Factor, Numeric Power Gain, and dBi Gain for each individual Antenna. For Immunity Testing Antennas we include Field Strength measurements in Volts Per Meter, and Radiation Patterns where applicable.

Another difference is Design and Construction. Each Antenna is designed to be durable and long-lasting, yet functional in varied applications, such as in Anechoic Chambers or Outside Test Sites. Antennas and accessories are machined and constructed "in-house" for Optimum Quality Control.

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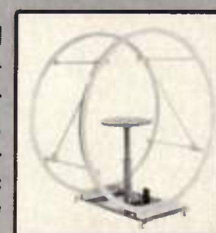
EMCO adds efficiency to EMI Testing with an **Antenna Positioning Tower** (1-6 meters) and an **Equipment Testing Turntable**. Both are suitable for outside or indoor use, come with a standard Digital Readout Controller and are available with **IEEE-488 Bus** Option.

For Conducted Emissions Testing, EMCO manufactures **Line Impedance Stabilization Networks** to satisfy FCC and VDE requirements. Our unique design allows production of as many as 4 separate lines (three phase) in one unit.



Other Related Equipment include: **Signal Rejection Networks, Acceptance Networks, Magnetic Field Intensity Meters, Magnetometers** and **Helmholtz Coil Systems.**

Why should my company buy your EMI/RFI Test Equipment?

The Electro-Mechanics Company is more than just another manufacturer. We realize that in order to grow and help improve EMI/RFI Testing we must constantly forge ahead . . . not live in the past.

As the FCC moves toward better and more Standardized Test Procedures, EMCO is staying close to ANSI (American National Standards Institute), NBS (National Bureau of Standards) and other standards groups so we can keep improving our equipment. Involvement with current and future industry needs also helps us plan for design of new equipment . . . an ongoing process at EMCO.

EMCO is committed to offering Technical Assistance, as well as Test Accessories, to help solve EMI Testing Problems. Part of that Technical Assistance is advice on purchasing only the equipment needed, not kits or systems with unnecessary items. We can also advise on various manufacturers of other complimentary test equipment.

If you have more questions and are looking for Helpful Answers, Call us at (512) 835-4684.

The Electro-Mechanics Company
P.O. Box 1546/Austin, Texas 78767/Telex 767187

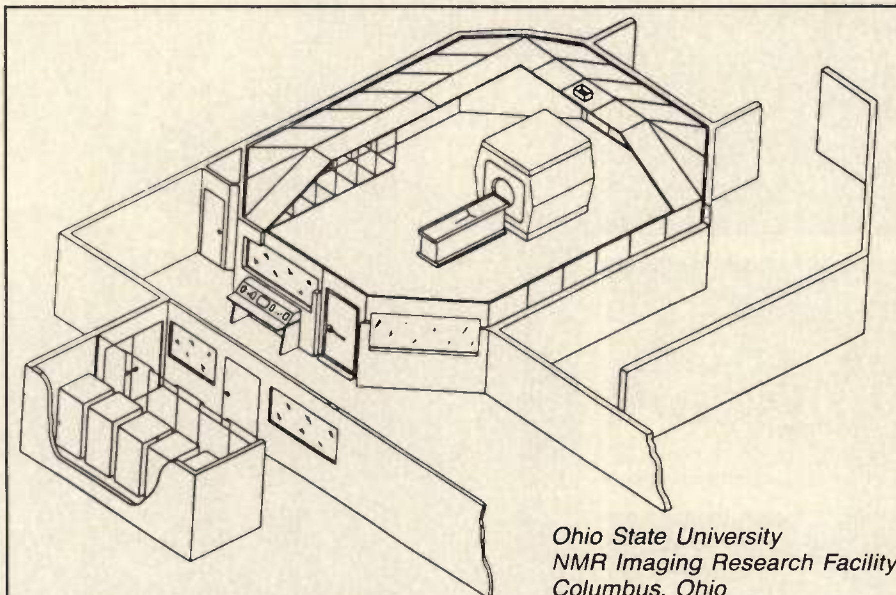
INFO/CARD 29

Medical RF Applications Require Special Shielding Techniques

By Gary A. Breed

In the past few years, hospitals and other medical facilities have been making ever-increasing investments in high-tech equipment to aid in the diagnosis and treatment of patients. From sensitive EEG equipment to powerful MRI (magnetic resonance imaging) units, the peaceful coexistence of the varied types of equipment requires electrical and magnetic shielding techniques unique to the medical environment. Lives depend on it!

Consider for a moment the radiated chaos that would occur if medical electronic shielding requirements were ignored. Can you imagine performing an EEG or EKG in the room next to an X-ray machine pulsing on and off? Could you rely on remote heart rate monitors on the floor directly above an MRI unit generating magnetic and RF fields at kilowatt levels? It does not take much imagination to recognize the problems that result from inadequate isolation between powerful generators of energy and sensitive detectors of physiological electrical currents.



Ohio State University NMR Imaging Research Facility, Columbus, Ohio

The principal difficulty in shielding medical equipment is the extreme diversity of equipment types and the energy radiated and conducted during their use. For example:

X-ray equipment is always shielded for radiation, but uses enough power to generate sizable transients that may propagate through AC power lines.

Hyperthermia equipment, the modern evolution of diathermy technology, uses RF in the MF through VHF range.

MRI systems represent a major challenge in shielding design, as they generate high magnetic fields as well as high RF fields (HF and VHF range). The sensitive detection circuitry requires protection from external fields, as well.

Lithotropy, a new technique for treatment of kidney stones, uses high power ultrasonic transducers.

Measuring equipment, as used for EKG, EEG, fetal monitors, heart monitors, nerve conduction testing, and laboratory analysis all needs to operate without interference from external sources. Most often, it is impractical to operate this equipment in a shielded environment, so the efforts of the shielding engineer are concentrated on the design of enclosures for larger radiating equipment.

Lindgren RF Enclosures, Inc. is a major supplier of shielded enclosures for medical use, and technical information supplied by them outlines the four major shielding materials: bronze screening, copper screening, sheet copper and sheet steel. Bronze screening is very effective for RF between 1 MHz and 1 GHz. Copper screening has somewhat better microwave attenuation characteristics and better magnetic field performance than bronze. Sheet copper offers the best high microwave attenuation and outstanding durability, but like all non-ferrous metals it has limited magnetic field attenuation at lower frequencies (below 1 MHz). Sheet steel provides much better magnetic shielding than copper, and is effective for RF up to the 1 GHz range. Steel has the problem of more difficult fabrication than copper and a greater potential for degradation with time, due to oxidation at joints and seams.

In the medical realm, a hyperthermia treatment room requiring RF shielding at MF through VHF can use bronze or copper screening very effectively. However, for an MRI system, a double electrically isolated shielding system provides the best attenuation of radiated energy, using copper screen for the inner enclosure, and sheet steel for the outer shield.

Lindgren's RF enclosures feature panelized construction, which is essential for medical shielding installations. An enclosure often must be built within an existing structure, requiring modular or knock-down construction. Special resilient fastening techniques developed by Lindgren make it possible to maintain effective shielding in a bolt-together system.

Finally, aesthetics are important in a medical environment. Hospitals are trying to make patients more comfortable by reducing their "antiseptic" appearance. Pleasant surroundings are very important to the use of new high-tech equipment, where a high level of patient cooperation is required for successful use. Shielding systems which can be made attractive are an asset to their users.

The work hasn't ended yet, as new concepts are being developed for future use. Every new device will have its own requirement for shielding, whether it is radiating energy, or protection from outside interference.

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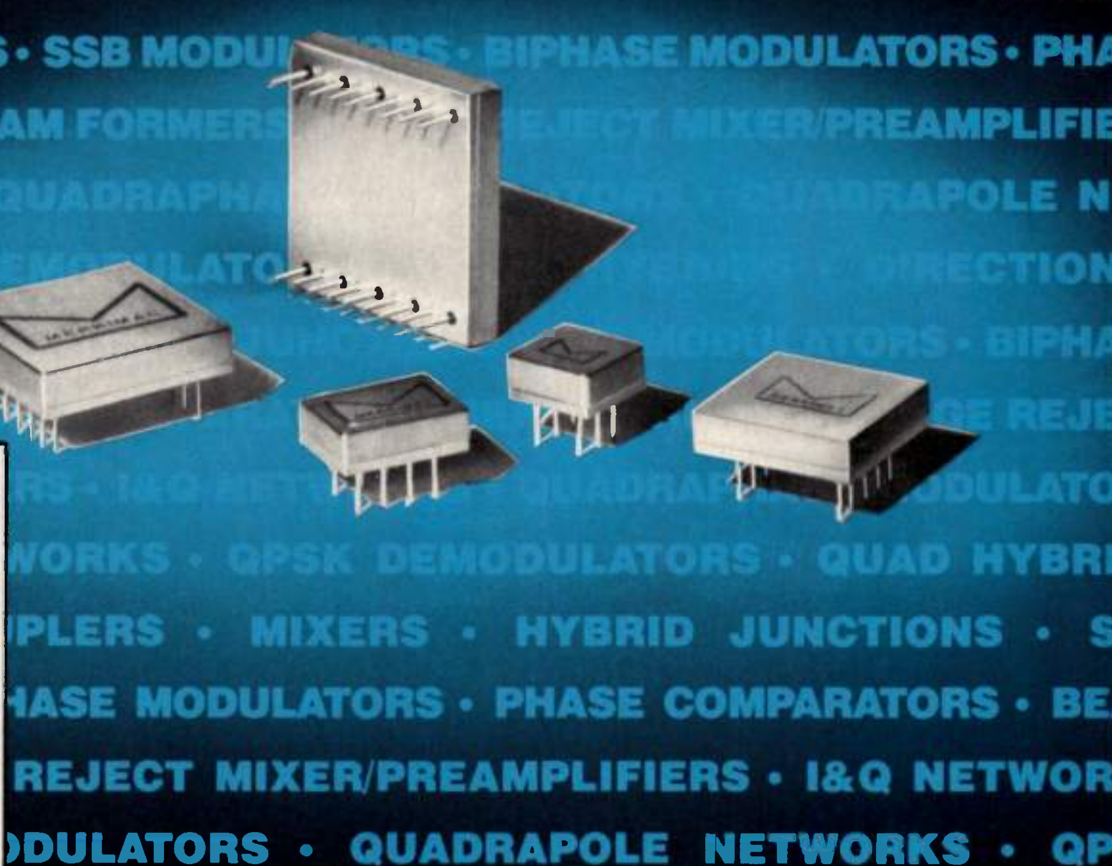
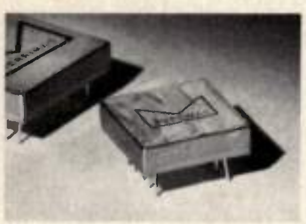
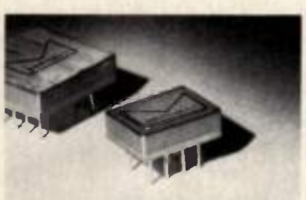


1″ sq. Mixer with Pre-Amp

8/10″ sq. Phase Comparator



5/8″ sq. Complex Weight Network



½″ sq. Phase Shifter

3/8″ sq. Broadband Mixers

High Performance IF Signal Processing Networks in up to 50% less space

- **Save on real estate and also obtain low profile 0.20″ height package**
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Merrimac's Meri-pac provides you with a new way to save space in dense PCB requirements for all your IF signal processing needs *up to 3.5 GHz*. **When you have flat packs on your mind — consider Meri-pacs instead** — you'll eliminate wasted space and lead breakage problems. Plus you have the advantage of a package which permits direct insertion into PCB by computer control parts placement.

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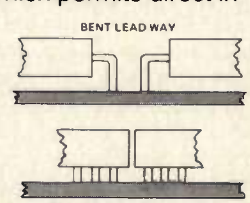

Merrimac's extensive Hi-Rel product experience in RF and IF signal processing is available in every configuration; flat pack, low profile TO cans, relay packages, discrete connectorized SMA or OSP low profile packages, and NOW in new Meri-pac.

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INFO/CARD 30

ESD Sensitivity Of A Diode Mixer

By David T. Geiser
General Electric Company

Assemblies of mixers may cost hundreds of dollars each, so the cause of occasional burn-out is important. ESD sensitivity is a frequent suspicion, particularly in light of the fact that Schottky Barrier semiconductor diodes are commonly used.

Experiencing burn-out of complex mixers using the double-balanced diode-ring configuration, the author decided to investigate the possibility of ESD damage. This article describes the test procedure and results.

The basic mixer is made up of two transformers and four diodes. Figure 1 shows how T1 and T2 are shunted (in the presence of only one signal) with two series-connected forward diodes for either polarity. The circuit also shows that DC and very low frequencies cannot reach the diodes via the radio frequency (RF) or local oscillator (LO) ports.

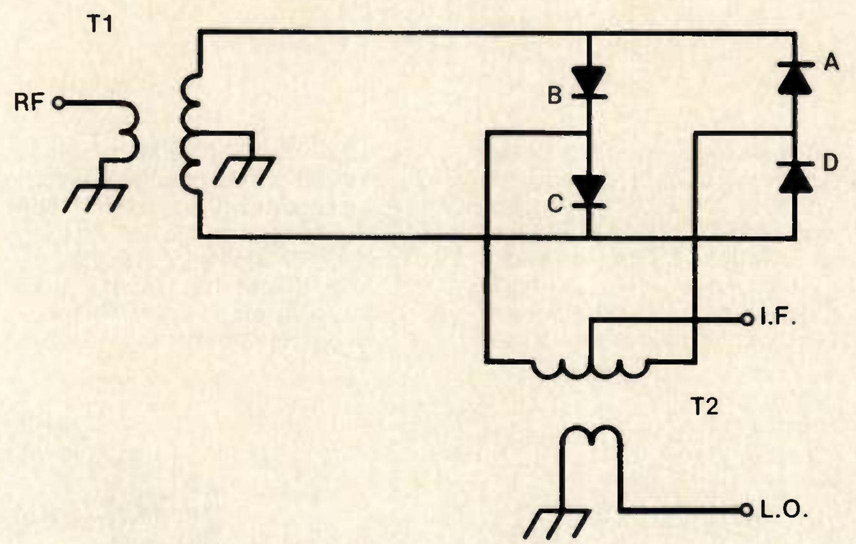


Fig. 1. Two Series — Connected Diodes

Direct current can reach the diodes via the intermediate frequency (IF) port (Fig. 2). The basic circuit (a) is approximated by its DC equivalent, (b). This implies that the diodes with lower forward conduction voltages will divert current from those having higher conduction voltages. Thus diode A might draw more than C, and B more than D.

However, transformers T1 and T2 cannot be ignored at high frequencies or for short pulses. The combined effect of the two transformers (Fig. 2c) shows that the result is the so-called "current-equalizer tap," raising the voltage (and therefore the current) of the diode that tended to draw the lower current.

Power applied to any port therefore tends first to be divided between two diodes, and then to have reverse voltages limited to the order of a single diode forward voltage drop. Failure mode in a diode-ring configuration is usually caused by power or excess forward-current. Other mixer configurations may experience different failure modes and be more susceptible to damage.

The test mixers were two basic Olektron model O-CDB-145, modified so the diode-ring assembly (HP 5082-2831) could be replaced easily. Approximate ratings were:

- Diode ring: 75 mW/junction (4 junctions)
- Mixer:

LO power (nominal)	5 mW
Input power (maximum)	300 mW
Conversion loss	6 dB
Isolation (actual)	65 dB

Conversion loss and isolation were checked in the vicinity of 75 MHz. The diode characteristics as seen through the IF port were monitored with a Tektronix 576 Curve Tracer.

The Electrostatic Discharge Sensitivity Classification Test (MIL-STD-883 Method 3015) consists of charging of 100 pF capacitor to a stated voltage. The capacitor is then discharged by way of a 1500 ohm resistor through the terminals of the device under test, five times with forward and five times with reverse polarity. RF and diode curve characteristics are then measured, the test voltage raised, and the steps repeated (Fig. 3).

Voltage steps in this test were 20, 50, 100, 200, 500, 1000 and 2000 volts. The 2000 V discharge was repeated with a capacitance of 250 pF. Five mixer assemblies passed this last step, while one (B1) failed.

The five mixer assemblies that passed were then given a monitored 60 Hz overstress on the Curve Tracer. They went into the thermal response precursor of failure at the levels of Table I. ("Thermal Precursor" is the tendency for the curve trace to loop rather than retrace, showing that the thermal change of diode electrical characteristics is beginning to lag the application of the 60 Hz sweep source. Experience shows that it first becomes apparent just before obvious damage at slightly higher stress levels.) Two-minute periods of lesser overstress did not cause any apparent damage to the mixers.

It should be noted that the diode-ring assemblies in the mixers as supplied had been epoxy-attached to a fairly good thermal mass. Replacement diode-rings were attached with cyanoacrylate (Eastman 910) adhesive.

TABLE I. Damage to mixer assemblies.

Mixer	Damage at ESD Test Level	Destroyed at Swept Power
A0	None	1200 mW (pk), 2 min.
B0	None	1200 mW (pk), 2 min.
A1	None	800 mW (pk), 2 min.
B1	2000 V, 250 pF	—
A2	None	800 mW (pk), 2 min.
B2	None	800 mW (pk), 2 min.

Other tests

Passing current through the opposite corners of an individual diode-ring approximates currents caused by an input to either the RF or LO ports. A curve-tracer test of unmounted (no heat sink) diode-rings showed that the ring entered the thermal response precursor region at approximately 600 mW peak input.

Passing current through adjacent corners of an individual diode-ring also causes (no heat sink condition) the ring to enter the thermal response precursor region at approximately 600 mW peak.

Conclusions

Electrostatic discharge sensitivity testing and intentional burn-out attempts support the conclusion that double-balanced diode-ring mixers of the types tested merit Category B classification of MIL-STD-883 Method 3015. According to these standards:

"Category B devices may be ESD sensitive to damage in a range above 2000 V, but normal good practice for the handling of semiconductors should suffice. Category B devices are preferred for general use in military equipment because they require no special ESD packaging or handling precautions other than normal good practice for semiconductor devices."[1]

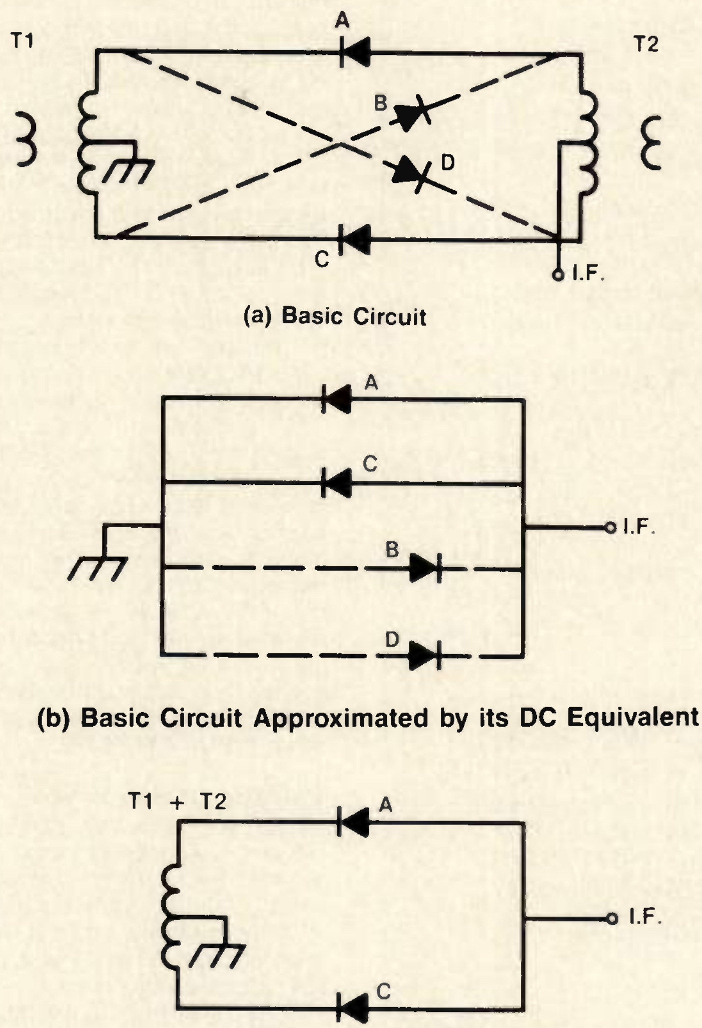


Fig. 2. Direct Current to Diodes

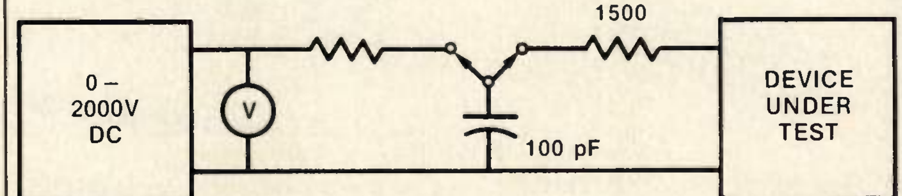


Fig. 3. Basic ESD Test Setup

About the Author

David Geiser has overall responsibility for components at the Aerospace Electronic Systems Department of General Electric, French Road, Utica, NY 13503. A Registered Professional Engineer, Mr. Geiser has 30 years experience in the design, testing and application of mixers.

[1]*Method 3015.2 Figure 3015-3 Note 2, MIL-STD-883C.*

rf products

Gallium Arsenide Digital Cell Array

A gallium arsenide (GaAs) digital macro cell array that offers the fastest speed and greatest circuit complexity of any such cell array on the market has been announced by Harris Microwave Semiconductor, a division of the Semiconductor Sector of Harris Corp. The device, called the HMD-11100 GaAs cell array, features performance up to 3 GHz and a medium-scale integration level of 300 equivalent gates. The cell array is a fixed-location array with 48 AND gates, 8 NOR gates, 88 inverters, 8 master/slave "D" flip-flops, 6 dual-phase clock drivers/differential amplifiers, 16 input buffers, and 8 output buffers. The HMD-11100 features ECL and GaAs compatible I/Os, reliable Ti/Pt/Au metallization, −55 degree to +85°C operating temperature range, and a configurable output that can drive 50 ohm, 1 pF loads at up to 3 GHz. High-speed signal processing markets show the greatest interest in gallium arsenide circuits. Electronic warfare systems, satellite communications networks, fiber-optic communication links and high-speed instrumentation and test all rely on fast response times and high throughput. **Harris Microwave, Milpitas, Calif., please circle INFO/CARD #176.**

150 MHz Oscilloscope

B&K Precision has introduced a quad input, dual independent time base 150 MHz oscilloscope featuring ±2% vertical accuracy, 500 μV/div vertical sensitivity and 20 kV accelerating potential. The Model 1596 features 500 μV/div sensitivity to 70 MHz (cascade channel 1 to channel 2), 1 mV/div sensitivity to 100 MHz and 5 mV/div sensitivity to 150 MHz. In addition

to standard sweep operations, this unit features a DUAL mode whereby the A sweep and B sweep operate independently of each other, allowing two signals to be viewed in different sweep times. Model 1596 features 20 ns/div sweep speed (2 ns/div with X10 magnification); 20 MHz bandwidth limiter to eliminate high frequency noises when viewing low frequency signals; video sync circuitry for viewing video signals; Channel 1 output to hook-up to frequency counter or peripheral equipment; and a beam finder. **B&K-Precision/Dynascan Corporation, Chicago, Ill., INFO/CARD #175.**

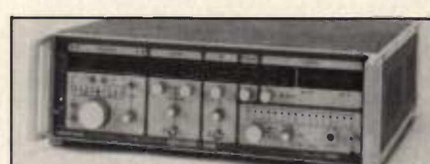
Spectrum Analyzer

Marconi Instruments announces the first in a new series of high-performance spectrum analyzers, the Model 2382. This analyzer system comprises two units, RF Unit 2382 and Display Unit 2380. It covers

frequencies 100 Hz to 400 MHz with a resolution of 1 Hz; a precision tracking generator is integral and the analyzer is keyboard controlled and fully GPIB compatible. The 2382 offers an overall level accuracy of ±1 dB at any frequency and automatic setting of IF gain, RF attenuation and filter bandwidth. The instrument's automatic calibration facility carries out a comprehensive calibration routine in a matter of seconds. The unit has an electronic graticule which offers a variety of axis labels, including linear and logarithmic scales, keyboard-selected, and it features a 50 W overload protection facility. **Marconi Instruments, Allendale, N.J., INFO/CARD #174.**

Synthesized Signal Generator

The Model 7100D Synthesized Generator covers the frequency range of 100 kHz to 1300 MHz with 1 Hz resolution. It offers phase noise performance of −136 dB/Hz at 10 kHz from the carrier. The 7100D's low noise, wide frequency range, wide dynamic range of +20 to −140



dBm, and modulation capability including AM, FM, ϕM, and pulse make it suited for high performance receiver testing. All functions are IEEE programmable. **Comstron Corporation, Freeport, N.Y., please circle INFO/CARD #173.**

Rotary Electronic Switches

A full range of new electronic rotary switches is announced by Electro Switch Corp. Three series are included for applications ranging from low-level to power switching. The interrupt ratings are from .10 to 10 amps and continuous from 6 to 25 amps. All are multi-pole, multi-position with as many as 48 positions and up to 90 poles. They are designed for such typical applications as communications systems, computers & peripherals, test equipment, power supplies, medical electronics, and industrial controls. Most are available in a wide choice of options including special contacting, special terminals, dual concentric shafts, key-operated, spring-returned, and field adjustable stops. **Electro Switch Corp., Weymouth, Mass., INFO/CARD #172.**

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Fixed or Variable Directivity (balance) 40 or 50 dB options.

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INFO/CARD 33

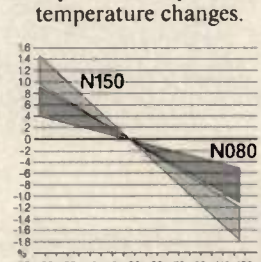
New MLCs with negative TC available from SFE Technologies combine excellent stability and tight tolerances with a wide choice of packaging.

With a temperature coefficient of –80 ppm/°C and –150 ppm/°C, our negative TL MLCs span a capacitance range of 1 pF to .056 uF with tolerances to 1%, working voltages from 25 to 500 VDC, and have all other characteristics of standard NPO series ceramics. Their stable performance compared to plastic film capacitors makes them ideal replacements for polystyrene, polypropylene and polycarbonate components, in filters for modems, cable TV, RF amplifiers and other telecommunication applications. They are unaffected by high production methods of solder attachment such as wave solder. Available in leadless chips, 2-pin DIPs, molded axials and radials, glass encased axials and conformal-coated radials. In all standard packaging methods including bulk, tape-and-reel for pick-and-place and automatic insertion.

Check these additional advantages:

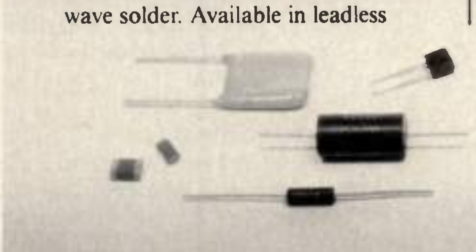
- Cost effective—eliminates multiple capacitor trimming.
- Compensates for positive TC of inductive components, giving superior filter performance over temperature changes.
- Capable of high-density packaging in thick-film hybrid or printed circuits.

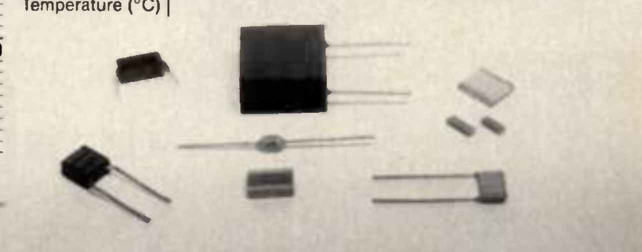
For more information, call Steve Klein at (818) 365-9411. Or write to SFE Technologies, San Fernando Electric Division, 1501 First Street, San Fernando, CA 91340-2793.



N080 & N150 Capacitance Change (%) vs. Temperature (°C)

SFE TECHNOLOGIES
San Fernando Electric Division



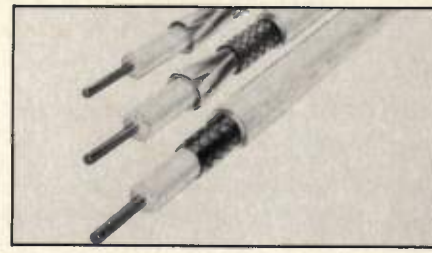


INFO/CARD 34

Program for RF Design

Collected onto a single disk for the IBM PC are a variety of solutions to problems frequently experienced in radio frequency design. RF Notes No. 1 can aid in such activities as passive filter design, resonant circuit design, basic microstrip and stripline design, and mixer cross-product evaluation. Additionally, short programs for dB, dBm, and VSWR conversions are included. **Etron RF Enterprises, Diamond Bar, Calif., INFO/CARD #171.**

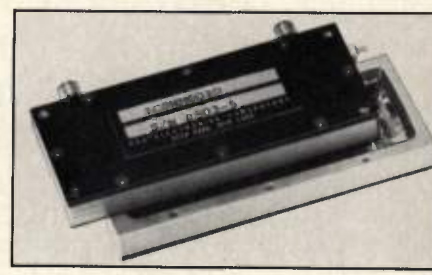
Teflon Coaxial Cable



Habia Cable, Inc. announces the introduction of a new line of Fluorax coaxial cables. The new cable utilizes solid or air spaced Teflon REP dielectric cores over a copper center conductor that closely approximates MIL specified products. 100% fluoropolymer jackets, copper, tinned copper or aluminum braid with aluminum polyester shields are available to enable the use of Fluorax coaxial cables in the quietest offices as well as the noisiest factory environments. Fluorax coaxial cables are available in 50 ohm, 75 ohm and 93 ohm ratings. **Habia Cable, Inc., Ronkonkoma, N.Y., please circle INFO/CARD #170.**

IC IF Limiters with Increased Dynamic Range

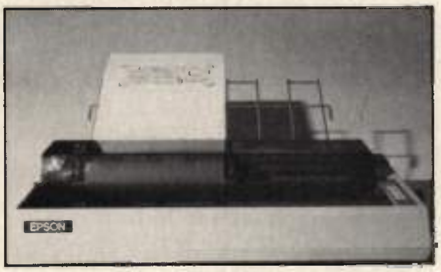
RHG Electronics Laboratory, Inc. announces the addition of two new series with increased dynamic range to their IC IF limiter line. Identified as ICSH for single channel models and ICSHM for matched channel units, the series offer a dynamic



range of −65 to +15 dBm on models from 20 to 70 MHz and −55 to +15 dBm on the 160 MHz models. The RHG limiters utilize hybrid IC construction on alumina substrates for high reliability and are designed to work with CW or pulsed signals. An output buffer stage eliminates load variation errors. The matched channel limiters are particularly useful for high performance monopulse and DF systems. **RGH Electronics Laboratory, Inc., Deer Park, N.Y., INFO/CARD #169.**

CAD System for Printed Circuit-Board Design

Kepro Circuit Systems, has announced the introduction of a new software program for creating circuit-board artwork. The program called smARTWORK™ is designed for engineers and technicians who need fast turn-around on PCB's. The program utilizes an IBM PC and an EPSON MX-100 printer. Paper, vellum or polyester film copies may be created using a pen and ink plotter. The plotter is recommended for large production runs. Multi-color display shows two layers. The screen permits a 2" x 4" close-up view of individual sections of the panel. Maximum panel size is 10" x 16". smART-



WORK requires two 360 Kbyte floppy disk drives or one 360 Kbyte floppy and a hard disk. EPSON MX series printers must have the Graftrax software. **Kepro Circuit Systems, Inc., Fenton, Mo., INFO/CARD #168.**

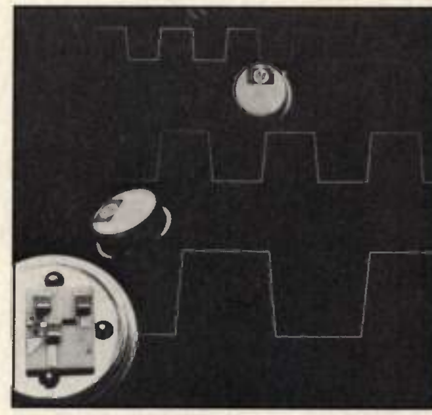
Digitally Compensated Crystal Oscillator

Model D01728, a digitally compensated, high stability crystal oscillator is now available from Murata Erie North America, Inc. A frequency stability factor of 0.1 ppm over a temperature range of −40°C to +85°C is specified, with a frequency range of 2-20 MHz, a warm-up of less than 3 seconds, power consumption of

less than 500 mW with 0.1 ppm stability, square or sine wave outputs, an input voltage of 15 to 28 VDC, and an input current of 20 mA. Available in a standard case size of 1.5" (L) x 1.5" (W) x 3.150" (H), other package sizes are available upon request. **Murata Erie North America, Inc., Marietta, Georgia, please circle INFO/CARD #167.**

Wideband TO-8 Cascadable Amplifiers

A new series of hybrid cascadable amplifiers from Hewlett-Packard Company feature stability over a wide temperature and frequency range in a TO-8 package. The amplifier design uses resistive feedback in a Darlington configuration to deliver gain flatness and phase linearity



over a wide temperature range and broad bandwidth. HP has introduced four members of its amplifier series. The HAMP-1001 medium-output power amplifier provides typical minimum output power at 1 dB compression of 12.5 dBm. The 1 dB bandwidth of this amplifier is from 5 to 2,800 MHz. The HAMP-1002 and HAMP-1003 general-purpose amplifiers offer minimum gain of 9.7 dB. The 1 dB bandwidth of the HAMP-1002 is 5 to 1,900 MHz; that of the HAMP-1003 is 5 to 2,100 MHz. With a 1 dB bandwidth of 5 to 1,650 MHz, the HAMP-1004 has a maximum noise figure of 4.0 dB and a typical minimum gain of 12.5 dB. **Hewlett-Packard Company, Palo Alto, Calif., circle INFO/CARD #166.**

50 Watt Fixed Attenuator

JFW Industries, Inc. introduces their model 50FH-xxx-50, a 50 watt, 50 ohm fixed attenuator. This high power unit is available with attenuation values of 3, 6, 10, 20 and 30 dB. The 50FH-xxx-50 completes JFW's existing high powered fixed attenuator line which includes 5, 10, 30,

and 100 watt pads. The new 50 watt pad has a frequency range of DC-2000 MHz with N connectors standard (BNC available on request). **JFW Industries, Inc., Indianapolis, Ind., INFO/CARD #165.**

Ceramic-to-Metal Power Triode

Varian EIMAC has developed a compact high-mu, ceramic-to-metal power triode designed for use in HF radio transmitters, RF amplifiers for plasma generators, and other linear amplifiers. The EIMAC 3CX1200A7 power triode was developed by Varian EIMAC in Salt Lake City, Utah, to take advantage of the new FCC regulations permitting amateur radio power output of up to 1500 watts PEP. Intended to serve as a zero-bias Class AB2 amplifier for cathode driven circuits, the EIMAC 3CX1200A7 delivers a power gain of up to 20. The 3CX1200A7 is forced-air cooled rated at an anode dissipation of 1200 watts 30 cfm at 0.5 inches of water. **Varian EIMAC, Salt Lake City, Utah, circle INFO/CARD #164.**

Analog Design Tools CAE Software Made Compatible to Apollo Domain Workstations

Analog Design Tools, Inc., has announced it will develop a version of its analog-circuit design software, the Analog Workbench, to run on Apollo Computer's Domain® family of engineering workstations. The software, to be available in third-quarter 1985, will run on all of the Domain family's 32-bit workstation models. Its availability will enable Apollo users to fully automate the analog-circuit design process, emulating the design, breadboarding, analysis and test functions usually performed at a conventional engineering workbench. **Analog Design Tools, Inc., Menlo Park, Calif., please circle INFO/CARD #163.**

Trimmer Capacitors Surface Mount

Mepco/Electra announces the introduction of a series of trimmer capacitors in surface mounted device (SMD®) configuration. Designated Series 2800S, these units consist of brass rotors and stators

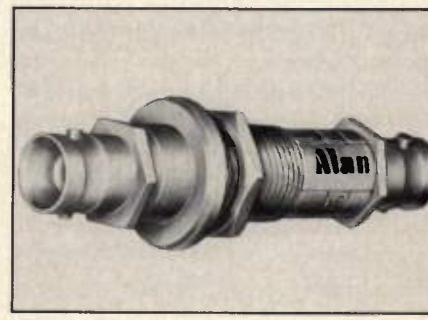
separated by a film dielectric and enclosed in a plastic case. The plastic film dielectric affords excellent long-term stability and a low temperature coefficient of capacitance. The SMD design is suitable for surface mounting with high speed, automatic placement equipment and can be reflow, vapor phase or hand soldered. **Mepco/Electra, Inc., Morristown, N.J., INFO/CARD #162.**

Low Profile Comsec Connector

Breeze-Illinois, Inc. announces a new connector, designed specifically to benefit the tactical and mobile communications environment by T.J. Electronics, Inc. This newly developed 90° angled connector assembly eliminates the protrusion of cable from the face of electronic equipment. Just one inch in length, cable equipped with the Low Profile 90° Comsec connector will not extend beyond the normal handle length of the component. With patents applied for, the T.J.E. Low Profile connector conforms to MIL-C-26482 and all other applicable Military specifications. **Breeze-Illinois, Inc., Wyoming, Ill., INFO/CARD #161.**

Panel Mount RF Fuse

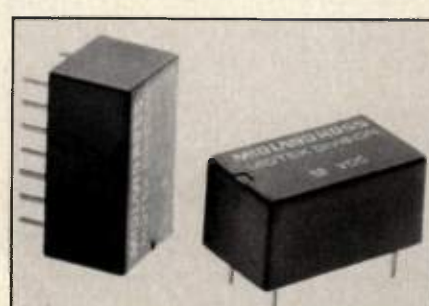
A panel mount precision RF fuse designed for easy replacement of the fuse element has been introduced by Alan Industries, Inc., This RF fuse, Alan's model 50FL( ) 712, protects attenuators and other devices sensitive to DC and RF power from accidental burnout. Should a power surge cause a fuse breakdown the unique construction of this unit allows the fuse element to be replaced from the front



panel without removing the fuse housing. Two fuse amperages are available; the 1/16 amp model 50FL16-712 and the 1/8 amp model 50FL8-712. Electrical specifications are: frequency range, DC to 1,000 MHz; impedance, 50 ohms; VSWR, 1.5:1 MAX; insertion loss, less than 1.2 dB at 1 GHz; connector, BNC or TNC. Breakdown point: 1/16 amp model, +23 dBm (195 mW); 1/8 amp model, +29 dBm (785 mW). **Alan Industries, Inc., Columbus, Ind., INFO/CARD #160.**

Midtex Announces a New RF Relay

The Midtex Division of Midland-Ross Corporation announces a new RF relay in a "Dip" size package. The Midtex type 251 RF relay is a SPDT (14 Pin Dip) relay capable of switching one watt at 900 MHz, 60 dB isolation, 1 dB insertion loss, 1.8 VSWR at 900 MHz. The type 251 has 5



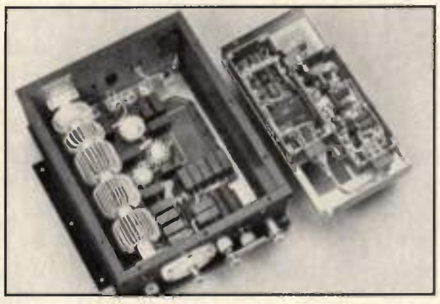
to 24 VDC coils with internal metal shield and printed circuit terminals. **Midland-Ross Corporation, Midtex Division, No. Mankato, Minn., INFO/CARD #159.**

Miniature Rotary Ceramic Switch

ELMA introduces '01 Type' — a new mini rotary switch that is the smallest on the market (0.708" diameter) to use ceramic wafers. The unique construction of ceramic wafers that are further enclosed and environmentally sealed within the switch body makes 01 Type suited for high reliability requirements in the low power and signal switching applications. With three versions of gold plated contacts (1, 3, 5 microns), the '01' switches provide low resistance (10 mΩ max.), while the heavily built bridge type wipers have 2 A (at 2 V) switching, and 5 A (at 20° C) carrying capacity. One, 2 and 4 pole models in shorting and non-shorting mode are available in either PC board or wire terminal versions. **ELMA Switch Corporation, Irvine, Calif., INFO/CARD #158.**

High Speed Automatic HF Antenna Tuner

Trans World Communications, Inc., has announced the release of a high speed HF automatic antenna coupler, the Model RAT100. This unit couples HF transceivers into whip and long wire antennas over 1.6 to 30 MHz. Designed to operate with HF transceivers with power outputs up to 150W, the RAT100 provides high efficiency matching of the antenna to 50 ohms with typical VSWR's of less than 1.5:1. The coupler uses a special wide range impedance transformer with 10 impedance ratios from 3 to 800 ohms. The tuning elements are selected by high speed low loss relays with sealed 5000V vacuum contacts used where the voltage can exceed 500V. The RAT100 is microprocessor controlled and this has permitted the use of an intelligent tuning program, with high speed tuning algorithms to ensure the minimum number of switching operations



to provide a good match. The tune power requirement is 10W and only four connections are required to control the coupler. The RAT100 is contained in a ruggedized, waterproof, aluminum case with a high voltage Teflon insulator and MIL spec connectors. The AT100 is a lower cost model packaged in a waterproof fiberglass box. **Trans World Communications, Inc., Escondido, Cal., please circle INFO/CARD #157.**

Precision Crystal Oscillator

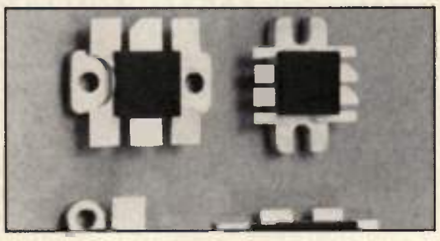
PIEZO Systems announces the availability of a miniature, rugged precision frequency standard. The PIEZO Systems Model 2850038 oscillator combines the latest techniques in SC cut crystal design with a low noise oscillator circuit. The stress compensated (SC cut) crystal offers a long life and low vibrational sensitivity. The oscillator has an aging rate of 5 x 10^{-10} per day, with a noise floor of −153 dBc/Hz. The unit obtains final frequency within 1 x 10^{-7} after 2.5 minutes at 25° C, and within 5 minutes at −40° C. The time domain stability is better than 5 x 10^{-12} per second. The Model 2850038 is available in 10.00 MHz or 10.23 MHz. Frequency stability is 1 x 10^{-8} from −40° C to +70° C. **PIEZO Systems, an affiliate of PIEZO Crystal Company, Carlisle, Penn., INFO/CARD #156.**

UL Listed Foil Tapes

Three new pressure sensitive tapes from Fluorglass Division of the Oak Materials Group have received the Underwriters' Laboratories (UL) recognition for flame retardency. The Fluorglas Division's embossed copper, smooth copper, and embossed aluminum foil tapes received the UL recognition for flame retardency per UL Subject 510. The foil tapes, developed for manufacturers' compliance with FCC Docket 20780 EMI/RFI shielding requirements, can reduce electrostatic coupling in transformer and DC power supply windings, and provide ESD protection in OEM design and field applications. Oak pressure sensitive foil tapes are available in widths from 1/4 inch to 24 inches, and in standard lengths of 18 and 36 yards. All tapes are available with release liners. **Oak Materials Group, Inc., Fluorglas Division, Hoosick Falls, N.Y., INFO/CARD #155.**

Gold Metallized Transistors

Polycore RF Devices has introduced a gold-metallized silicon FET designed as a drop-in replacement for Acrian and Power Hybrid transistors in the VHF and



rf products Continued

UHF frequency bands. In addition to making gold metallization available for the first time for these frequencies, Polycore's "POLYFET" field effect transistors feature infinite VSWR, high Gm, and low interelectrode capacitance. Available for off-the-shelf delivery, the F1000, −2, −3 and −4 POLYFETs replace Acrian 20-120 watt Vmil series FETs, as well as Power Hybrid's 20-120 watt PHI-DV series FETs. **Polycore RF Devices, Newbury Park, Calif., INFO/CARD #154.**

Low Cost Shielded Enclosures

Pacific West Electronics announces the availability of low cost imported shielded enclosures which provide a shielded environment for use by the land mobile radio communication industry. These units range from a 4 x 4 x 6 ft. single shielded enclosure (Model 1-SR-A) to a 20 x 20 x 8 ft. isolated double shielded enclosure (Model CTR-IL). The low cost of these units permit the small shop to purchase their first shielded enclosure or the larger shop to purchase an additional enclosure. **Pacific West Electronics, Costa Mesa, Calif., INFO/CARD #153.**

RF Power Source for Plasma Uses

AMT announces a new FET RF power source for plasma use. The Model 1010 boosts over 600 watts of CW output power from 100 KHz to 400 KHz, and is capable of remote or local operation. The Model 1010 has a bidirectional digital power meter to monitor load and reflected power

and an active power protection system to allow maximum power to be delivered into any load VSWR. System status and control lines can be accessed via rear panel connection. The Model 1010 is available in OEM quantities. The size is 8.75" x 8.5" x 19.5". The weight is 44 lbs. AC power reg. 120 VAC, 1500 Watts. **American Microwave Technology, Inc., Fullerton, Calif., INFO/CARD #152.**

DC to 40 GHz Terminations

With a range of DC to 40 GHz Wiltron's new 50 ohm coaxial K Connector™ terminations offer the broadest frequency range available. Models 28K50 (male) and 28KF50 (female) have a return loss of better than 34 dB (<1.04 SWR) from DC to 18 GHz and better than 24 dB (<1.135 SWR) from DC to 40 GHz. Since the K Connector is compatible with SMA connectors, the 28K50 and 28KF50 can be used for all termination needs up to 40 GHz. Wiltron offers terminations for use with APC-7, Type N, SMA, and K connectors. **Wiltron Company, Morgan Hill, Calif., INFO/CARD #151.**

rf literature

Microwave Filter Catalog

Microwave filters in the frequency range of 0.3-40 GHz are presented in a new 40-page catalog. With graphics for all electrical and mechanical filter characteristics, this catalog serves as a useful tool for design engineers. The SUHNER filter line includes coaxial and waveguide bandpass filters as well as tubular lowpass filters. **Huber & Suhner Ltd., RF and Microwave Division, 9100 Herisau, Switzerland, INFO/CARD #138.**

Frequency Synthesizer Catalog

PTS announces the publication of a new frequency synthesizer catalog. PTS makes one of the most complete lines of direct synthesizers available in the industry today. The applications, properties and specifications of the four models offered (40 MHz, 160 MHz, 250 MHz, 500 MHz) are discussed in this catalog. Pricing and ordering information is included. Reliability and quality; MTBF and life-cycle-cost are discussed, as well as the new two-year warranty and the flat-rate service. **Programmed Test Sources, Inc. Littleton, Mass., INFO/CARD #137.**

Electrically Conductive Compounds Selection Guide

Chomerics, Inc. has published an electrically conductive compounds selection guide, designed to assist engineers in selecting conductive caulks, adhesives, primers and coatings for specific EMI shielding applications. The wall chart provides data for 19 CHO-BOND® and CHO-SHIELD® compounds, including pot life, consistency, use temperature, cure cycle, coverage, max/min thickness, shelf life, and resistivity. **Chomerics, Inc. Woburn, Mass., INFO/CARD #136.**

RLC Electronics Catalog

RLC Electronics has issued their new precision microwave components catalog. This 100 page catalog contains specifications, charts and graphs concerning RLC's complete line of switches, filters, attenuators and terminations. Information on couplers, hybrids, dividers/combiners, detectors, and coaxial connector adapters are also described. **RLC Electronics, Mt. Kisco, N.Y., INFO/CARD #135.**

PC Enhancement Handbook

CyberResearch Inc. announces the publication of the second edition of *The IBM PC Enhancement Handbook for Scientists and Engineers.* This 192-page book is a combination handbook, buyers guide, and catalog for technical hardware and software products for the IBM PC. This book includes applications information on hundreds of PC enhancement products for applications such as computer aided design, data acquisition, instrumentation control, engineering development, presentation graphics, scientific word processing, etc. Complete turn-key systems are listed in this book for applications such as CAD for architectural, mechanical, civil and electrical engineering, presentation graphics, solid modeling, data acquisition, instrumentation control, programming, communication, etc. Systems are supplied with IBM PCs, XTs, or ATs with a wide variety of options selected to match each particular requirement. All systems are available as single workstations, or as a multiple workstations network. Also listed are mass storage and communications products for integration into the systems. **CyberResearch Inc., New Haven, Conn., INFO/CARD #134.**

rf literature *Continued*

Phase-Noise Measurements

Hewlett-Packard Company Product Note 11729C-2, "Phase Noise Characterization of Microwave Oscillators, (Delay Line Discriminator Method)," presents a detailed overview of the frequency discriminator method of measuring single-sideband phase noise. The method is particularly valuable for measuring free-running sources such as Gunn-diode, GasFET, and YIG-tuned oscillators. The 40-page product note, which contains 34 graphs and charts, discusses phase noise and its effect on the signal performance of modern microwave systems, and provides considerable detail on the theory and practice of the frequency discriminator method. **Hewlett-Packard Company, Palo Alto, Calif., INFO/CARD #133.**

Semiconductor Chip Catalog

Solitron Devices, Inc., Semiconductor Group, has announced the publication of a new semiconductor chip and wafer catalog covering a partial line of silicon wafers and chips for transistors, rectifiers, FETs and linear ICs. The 110 page book provides a comprehensive listing of power transistors, Darlington transistors, planar diodes, Schottky diodes, GaAs diodes, Gunn diodes, thin film resistor chips, resistor chips on sapphire and resistor networks. Included in the catalog are power chips, junction field effect transistors, MOS and MOSFETs, rectifier dice, quartz crystals and crystal oscillators produced by Solitron along with selected types from affiliated companies. **Solitron Devices, Inc., Riviera Beach, Fla., INFO/CARD #132.**

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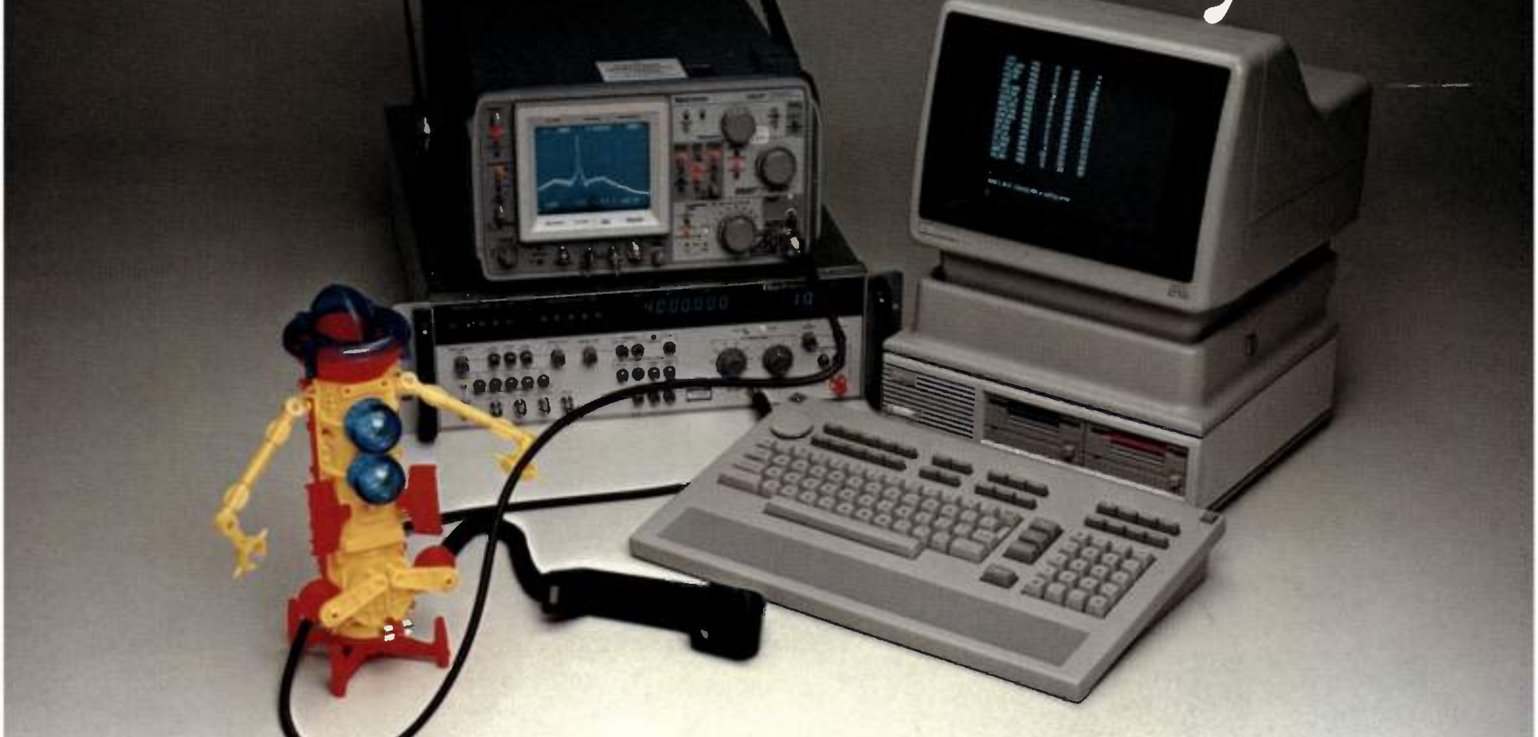
From Test to Toys



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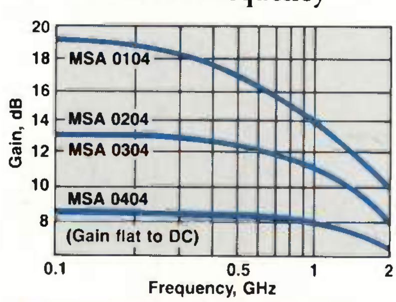

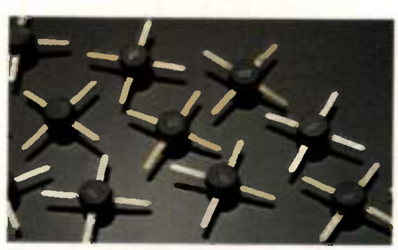

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