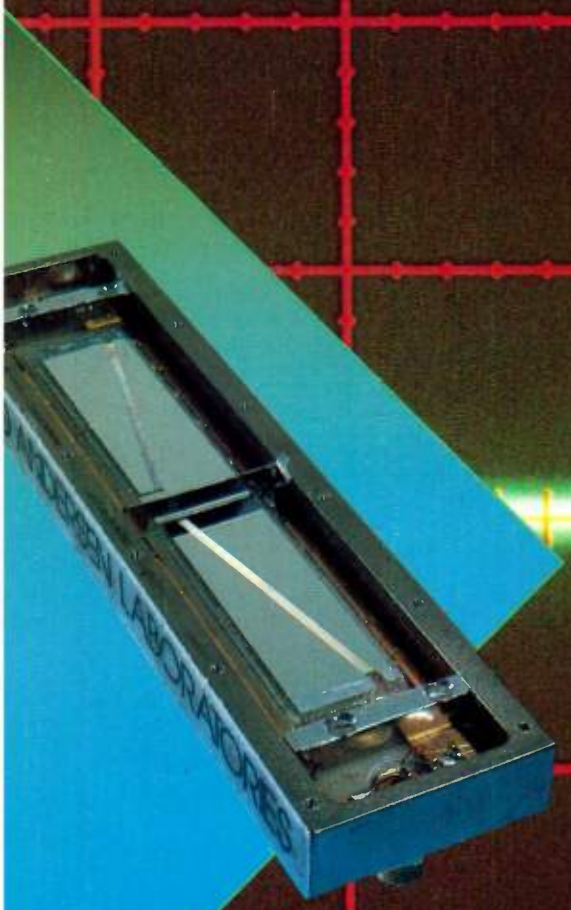
rfdesign

ideas for engineers

June 1986



Special Report — Military SAW Applications

Special products section features products on display at Military Microwaves '86

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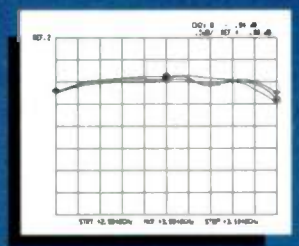

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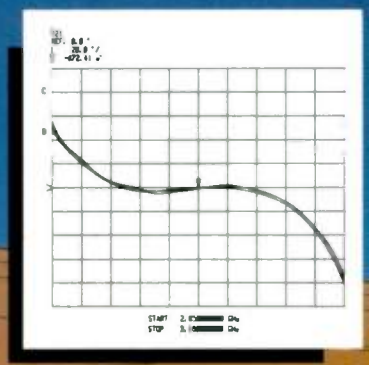

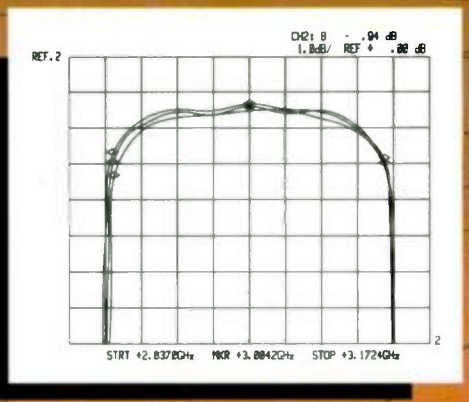

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Motorola has expanded its line of hermetically sealed oscillators with the MDO-2 and MDO-3.

These latest additions offer systems engineers significantly improved performance, reduced size, and lower cost compared to other designs.

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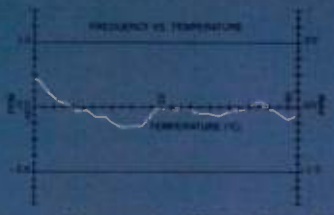

The effects of extreme temperature variations on frequency is one way to compare the stability of a TCXO. And the new Motorola MDO-2 and MDO-3 offer impressive performance, as shown in the graphic at left.

But that's not the only measure.

	MDO-2	MDO-3
PACKAGE SIZE (inches)	0.8 x 0.8 x .455	.82 x .52 x .245
FREQ. RANGE (MHz)	10 to 20	10 to 20
FREQ. STABILITY (ppm) (ppm over temp., humidity, and voltage)	±2.0 −35°C to +85°C	±5.0 −30°C to +70°C
SUPPLY VOLTAGE (Vdc)	5.0 to 16.0	5.0 ± 0.1
CURRENT DRAIN (mA)	4.0	2.0
AGING (ppm/1 yr. typical)	±1.0	±1.0

Also, consider the stability demonstrated in humidity, shock, vibration, and aging tests. Then, you can get a better overall picture of how much better these Motorola oscillators perform in severe environmental conditions.

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Both MDO Series oscillators benefit from proprietary thick film hybrid design, automated manufacturing, and reduced discrete component counts.

This achieves not only smaller size and lower cost, but also improved field reliability, as documented in longer MTBF.

These devices can be tuned using an external potentiometer or electronically tuned for AFC capability. And the all-metal welded packages with full hermetic seals minimize RF radiation.

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INFO/CARD 2

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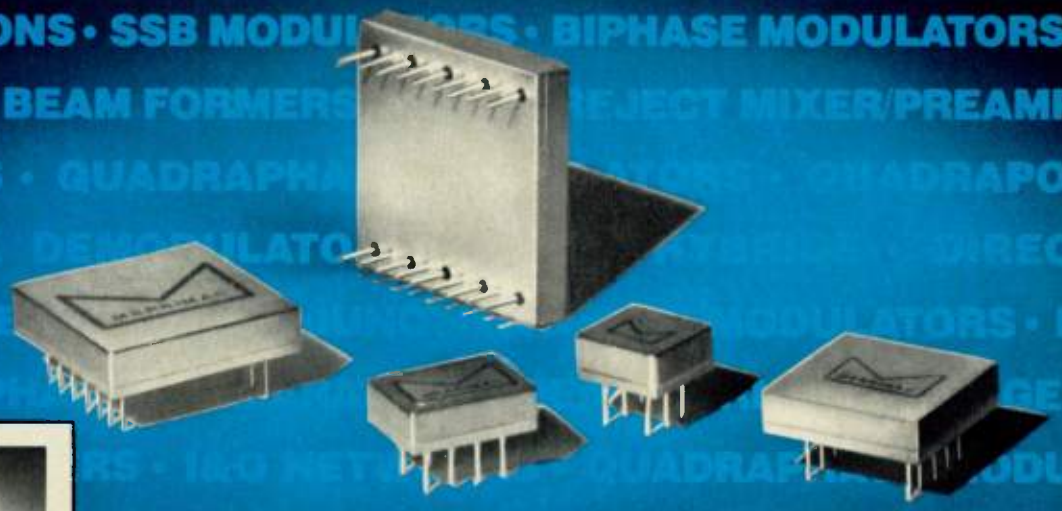
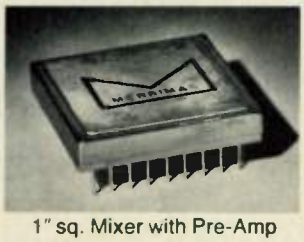
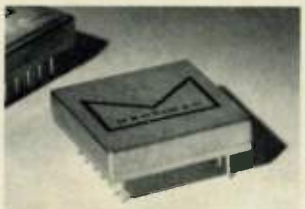


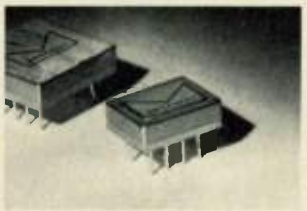


1" sq. Mixer with Pre-Amp

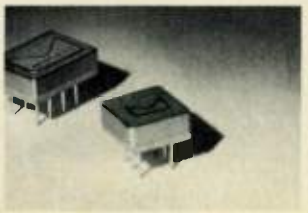


8/10" sq. Phase Comparator

⅝" sq. Complex Weight Network



½" sq. Phase Shifter



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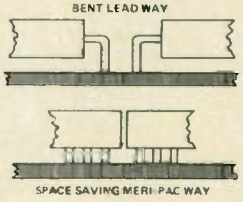

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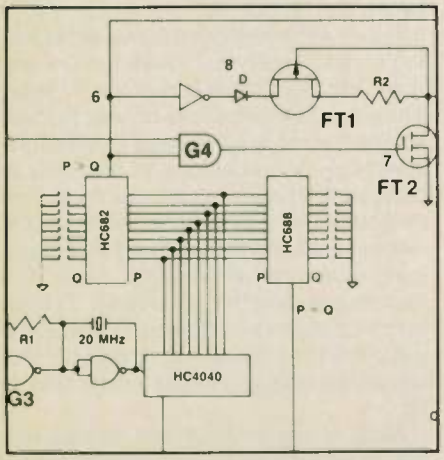
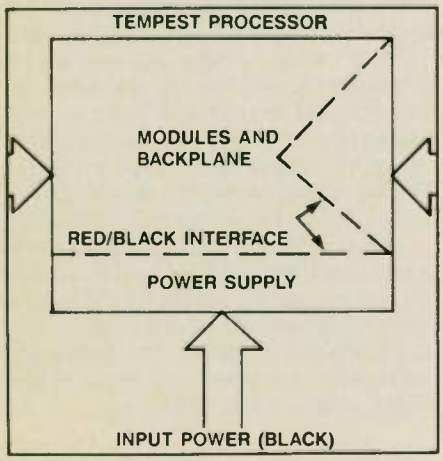
rfdesign

June 1986

Page 32 — SAW Technology



Page 57 — Precision Demodulator



Page 69 — TEMPEST Requirements

Cover

This month's issue discusses Surface Acoustic Wave (SAW) devices and their uses in military and communication systems. The cover depicts a SAW Dispersive Delay Line, manufactured by Andersen Laboratories, which is used for matched filtering in pulse expansion/compression systems. A typical compressed output pulse is shown.

Features

Departments

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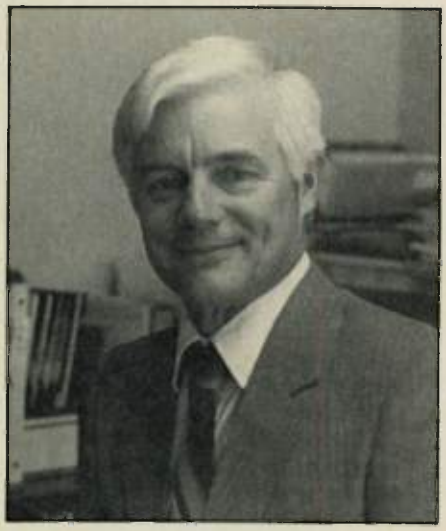
rf editorial

The Communications Privacy Act



By James N. MacDonald
Editor

There is a bill making its way through the legislative process that alarms some people familiar with radio transmission technology. It is an attempt to protect the interests of some by controlling the private behavior of others, something that immediately arouses emotions in a free society.

The Electronics Communications Privacy Act of 1985 (S.1667) is a proposed amendment to title 18, United States Code "with respect to the interception of certain communications, other forms of surveillance, and other purposes." It seems like a reasonable attempt to update the earlier law to cover modern technology. For example, it seeks to change the old definition of electronic communications by striking out paragraph (1) of Section 2510 and substituting the following:

"(1) 'electronic communication' means any transmission of signs, signals, writing, images, sounds, data, or intelligence of any nature in whole or in part by a wire, radio, electromagnetic, or photoelectric system that affects interstate or foreign commerce."

Section 2510(4) would be amended by substituting "interception" for "aural acquisition."

Originally intended to protect against unauthorized wiretapping, the amended law would forbid unauthorized reception of mobile telephone transmissions and electronic mail, as well as any other electronic communication. It is deliberately vague enough to cover future technology not yet known. To ensure the privacy of such communications is a laudable goal, but it cannot be done the way the amendment proposes. It is like forbidding people to listen to the conversation at the next table in a restaurant.

There is a significant difference between the active act of tapping into a telephone line and the passive act of tuning a radio receiver. Unless the government installs listening devices in every American home, there is no way to know whether someone is tuning in to cellular telephone conversations in their city or portable telephone conversations in their neighborhood. People who use these devices should understand that their conversation can be overheard, even if it becomes against the law to listen. The law may actually be a challenge to those who get a thrill from listening to others' conversations, adding an extra incentive to do so.

Most of the original law forbids disclosure of information overheard by a third party or use of the information to the detriment of the parties overheard. Updating this part of the law is an important step. In fact, most of the amendment is praiseworthy, and the Senate should be commended for trying to keep up with changing technology. It is the impossible attempt to control radio reception that the Senate should reconsider. Even totalitarian countries cannot do this completely.

The technology is readily available to alter radio transmissions so they cannot be understood by unintended listeners. Manufacturers should use this technology to provide true privacy for their customers, and not rely on federal legislation to give users a false sense of privacy.

James N. MacDonald

Worldwide Market Opportunities for U.S. RF Power Technology

By Daniel R. Mazziota, President, M/A-Com Microwave Power Devices, Inc.

One of the few solid state technologies in the area of international defense preparedness that has escaped significant domination by Japan is the RF power silicon bipolar transistor and resulting solid state RF power amplifiers. These technologies provide the high power signal for all military RF communications, radar and EW systems, and even the neutral particle beam RF drivers for the Strategic Defense Initiative (SDI).

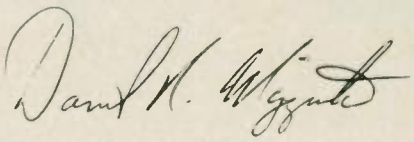
The pulse performance of silicon bipolar transistors has allowed realization of UHF, L-band and S-band radars with peak power outputs of 250 kW, 80 kW and 60 kW, respectively. On a CW basis, a 200 kW CW radar at HF is being fielded, while communication jammers are routinely operational at one kilowatt and above. Most of these applications have been initiated and achieved primarily with U.S. semiconductor devices and, recently, with European transistors in L-band radars.

The U.S. defense market for silicon bipolar devices is estimated at $50-60 million per year, resulting in amplifier equipment sales of $200-300 million. OEM systems sales to the worldwide defense market are estimated to be well over several billion dollars per year. The worldwide export market is clearly a target of opportunity for U.S. defense manufacturers.

One of the most promising markets involves those areas where U.S. companies possess a technological lead, such as state-of-the-art silicon bipolar RF power amplifiers. A prime factor driving exports of this technology is that as one foreign country deploys defensive electronics, its neighbors tend to follow suit. On the other hand, one of the concerns of foreign countries is dependence on imports. To a large extent this can be overcome by local manufacture or joint ventures involving technology transfer or co-production.

Significant export opportunities exist for products and technologies with competitive edges. We have taken advantage of M/A-Com's vertically integrated power generation capability (semiconductors through subsystem) to develop high power amplifiers for various frequency bands from 2 MHz to 3.5 GHz, directed toward both domestic and export military customers, for communication jammer and radar applications. These have included the first solid state Over-The-Horizon-Radar amplifiers operating up to 20 kW CW over the HF band, 1 kW UHF airborne jammers, and L-band pulsed radar transmitters at 80 kW.

It is our responsibility, within the U.S. RF electronics community, to examine and recognize the product developments and business strategies that can take advantage of export opportunities.



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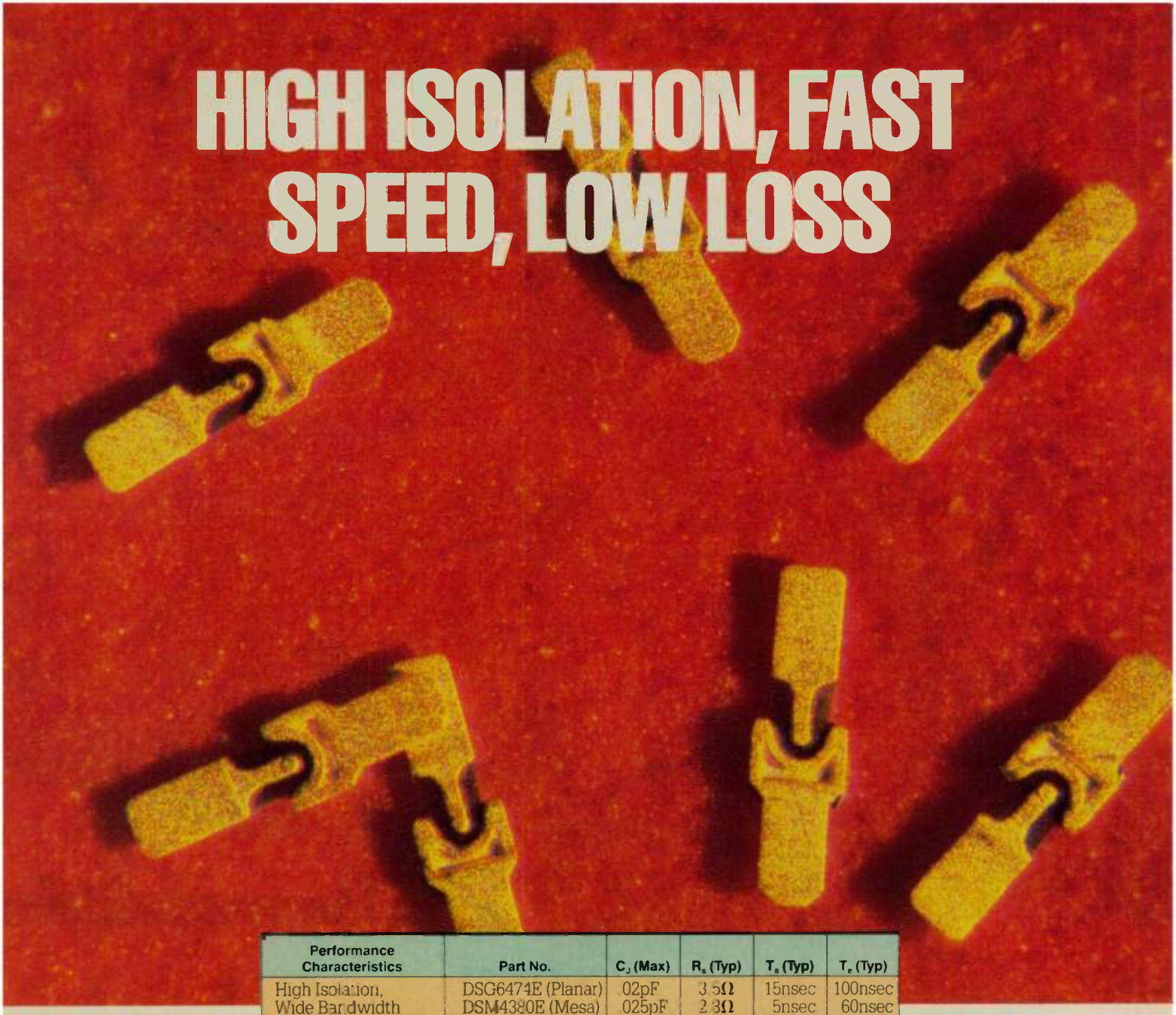

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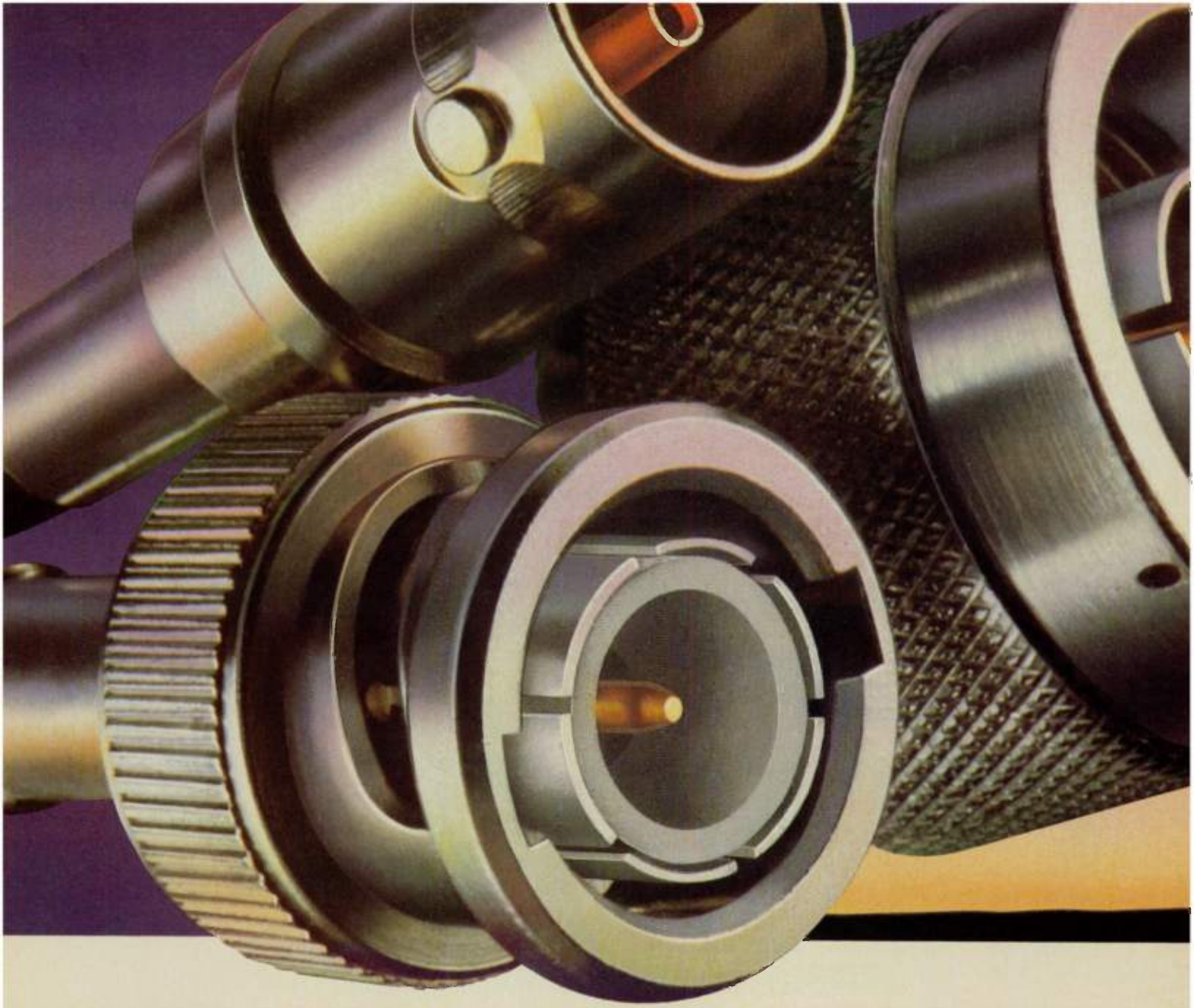

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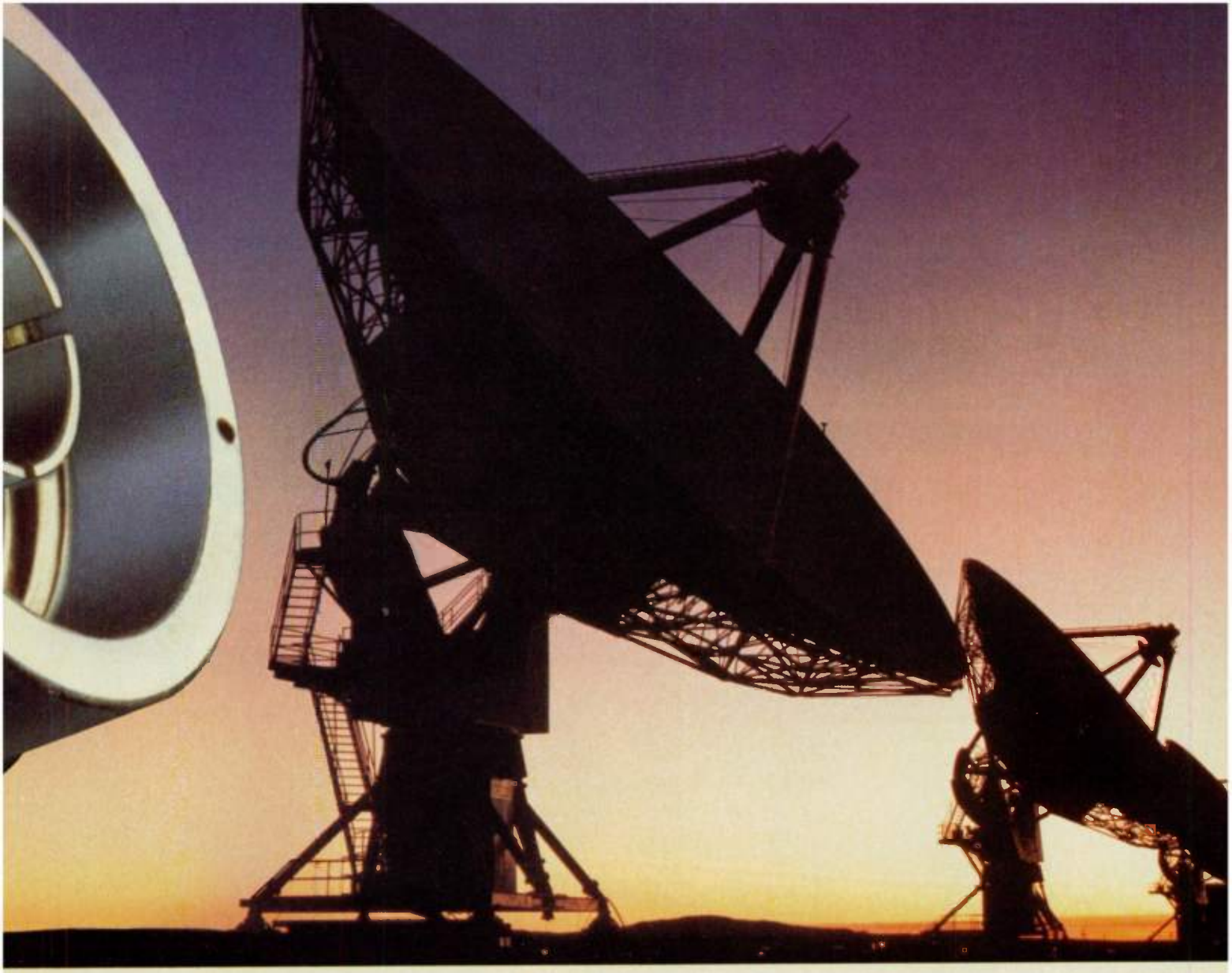

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Editor:

I wish to respond to "A Varactorless VCO" (April 86, p.41) and share my own experience with this circuit. I consider the explanation offered to be inadequate and offer a different modulation mechanism as the primary mode involved. Communication passed on to your submitters would be welcome.

This circuit (Colpitts variation with emitter current modulation of 2N3663) was used in a prototype PAM-FM telemetry system developed here at M.I.T. for use in an instrumented Moore hip prosthesis. Several unacceptable instabilities were observed: 1) Spurious output was difficult to control, 2) Deviation sensitivity was found to be nonlinear, 3) Deviation sensitivity and linearity were very sensitive to RF loading. These forced us to resort to conventional discrete varactor modulation, padded for linearity. A prosthesis was then able to be implanted in a patient two years ago, and it has been giving excellent performance leading to a better understanding of articular-joint physics by monitoring pressure distribution on the ball surface *in vivo* as the patient exercised the joint in various maneuvers.

The circuit and prototype were passed on to me by my predecessor who described the modulation as via the C_{cb} varactor. He did not analyze the circuit he developed, and did not notice that the modulation sense was reverse.

Although compatible with C_{eb} varactor sense, the behavior is much better explained by saturation storage-time modulation, which gives a good explanation of the instabilities observed. This mode is not addressed in the article, but very likely is what is really happening as the primary modulation mechanism. The article is devoid of any quantitive description of the claimed C_{eb} behavior.

Ralph Burgess
Research Engineer
Massachusetts Institute of Technology
Cambridge, Massachusetts

Editor:

The article "Coordinate Conversion and SWR Nomogram" (April '86) had an error. The calculated SWR of 2.33 was wrong. The wrong result was caused by using the formula SWR = Zo/Z.
The correct formula for VSWR is:

$$T = \frac{Z - Ro}{Z + Ro}$$

$$S = \frac{[T] + 1}{[T] - 1}$$

S: Voltage-standing wave ratio

Comp.	Type	Value	Node	Node
1	Generator	5.0000E+001	0	1
2	Resistor	5.0000E+001	1	0
3	Capacitor	8.0000E−007	1	0
4	Inductor	2.0000E−003	1	0

Frequency	Atten S21 in dB	Return Loss in dB	Phase deg.	Delay μsec	Z (in) R +/−J	
1000.0 Hz	6.507	1.099	61.78		3.357	+j 12.51
2000.0 Hz	1.911	4.486	36.63	69.882	15.57	+j 23.15
3000.0 Hz	0.342	11.210	15.97	57.383	37.66	+j 21.56
4000.0 Hz	0.000	45.522	−0.30	45.200	49.99	−j 0.530
5000.0 Hz	0.225	12.974	−12.98	35.202	41.24	−j 19.01
6000.0 Hz	0.713	8.198	−22.90	27.565	29.18	−j 24.65
7000.0 Hz	1.318	5.821	−30.77	21.866	20.68	−j 24.62
8000.0 Hz	1.966	4.388	−37.11	17.614	15.20	−j 23.00
9000.0 Hz	2.620	3.440	−42.30	14.410	11.60	−j 21.10
10.000 kHz	3.261	2.774	−46.61	11.962	9.133	−j 19.32

T: Reflection coefficient

I wouldn't have found the error if I hadn't decided to check the accuracy of the nomogram, with a circuit analysis program. It is surprising that many design engineers still use nomograms, now that an IBM-PC type computer can be purchased for $1,495 and a linear circuits analysis program can be had for $500.

It took only 30 seconds to enter Mr. Martin's example circuit into the analysis program and only 2.6 seconds for the IBM-PC to run a 10 frequency sweep analysis. The results showed a return loss of 2.774 dB (VSWR of about 6), not the 2.33 SWR from the nomogram.

I think it is time design engineers put nomograms up on the shelf with the old slide rules.

Robert Stanton
President
RF Engineering
Norwich, New York

Editor:

I have just read the April 1986 article "Composite EMI/RFI Shielding," and would like the author to explain the following:

1. Figure 1 shows graphs of FCC radiated emission limits, which are supposed to be expressed in dB above 1 microvolt per metre (and which, in this instance, appear to have been normalized to a measuring distance of 10 metres, and which are not quite correct anyway because the first break point is at 88 MHz, not 100 MHz. as shown), compared to graphs of attenuation of copper foil and aluminum foil, expressed in dB, which is just a ratio. What is the graph supposed to be telling the reader?

2. The statement "Theoretically, a consistent uninterrupted layer one atom thick would fulfill the electrical function" does not address the issue of skin depth. If the thickness of a shield is considerably less than one skin depth (skin depth is about 0.012 millimetres at 30 MHz for copper) its shielding effectiveness will be poor. The approximate diameter of an atom is about 1×10^{-5} millimetres or more than 1000 times thinner than one skin depth of copper at 30 MHz.

3. Figure 2 says that lower magnetic permeability is better, and the text says that nickel and steel have poor magnetic permeability. This is clearly incorrect, because high permeability materials make the best shields for low frequency magnetic fields. For example, mu-metal, which has a very high permeability, is frequently used for shielding against low frequency magnetic fields. Just ask one of your own advertisers (Ad-Vance Magnetics, Inc.)

I believe that publishing an article with this kind of misinformation does a disservice to your readers.

B. Cooperstein
Manager, EMC Unit
Xerox Corp.
El Segundo, Calif.

Editor:

I just received the February issue of *RF Design* and I want to express my agreement with the letter from Mr. Terry White. It seems to me that it is not in the best

interests of your readers to reject an article if the program that accompanies it is written for the HP-41 or another handheld computer. This seems particularly true with the article written by Professors Feeney and Hertling when you printed their original articles with the HP-41 code.

I should also like to recommend that whenever a program is provided, regardless of the language, you include a sample run with the inputs and the results. This would be of benefit to all of us so that we could check that the program we have written for our machines works correctly. Without this, it is sometimes difficult to detect an error, or to find it if one is detected.

I realize that space is a premium in your publication, but the addition of this sample run is well worth the additional space it would require. I would also like to express to you the help that your publication has been to me. In agreement with Mr. White I can add, "but don't let your HP-41 (or other handheld) readers down."

Charles L. Fruchter
Senior Mem. of the Exec. Staff
Computer Sciences Corp.
Vienna, Virginia

Editor:

I guess it's just human nature for people to draw circles with "me" inside and "other people" outside in our various pursuits of excellence, but, if anything, my observation at RF Expo '86 was that there is great *diversity* in our profession. Please don't narrow your magazine's perspective to include only a small group of "professionals" like so many others have done.

True, some larger companies define professional as at least an MSEE and probably a Ph.D. plus 5-10 years experience in some "spook house" and some engineers don't think anyone could possibly be "professional" unless they have access to $150,000 of test equipment and a $3,000+ IBM PC.

On the other hand, I wouldn't bet on *some* of those professionals being able to get a broadcast or two-way radio station back on the air in less than two hours for less than $25 parts cost, complete!

I'm not suggesting here that one is better than the other. Just that they are different parts of a complex field called "RF Engineering."

It may be a requirement in MIL/Gov't work to have a $3,000 IBM with $2-10K bucks of CAE/CAD software. It is way over the *yearly* budget of many of us, however.

Even those of us having access to both a mainframe and IBM PCs often find our calculator or Commodore more attractive. After all, *the boss* has the IBM on *his* desk, not me. He is usually using it for reports, pert-charts, correspondence, business plans, and electronic memos . . . not CAE, of course.

Sometimes we wait for time on the mainframe . . . time to get a terminal, then time to get an answer when sharing the machine with Accounting, Stock, Receiving, Shipping, Production, and Documentation. The VAX can be fun, but . . .

So we then tend to use the calculator for immediate needs and the Commodore, TRS-80, Apple II, or whatever else we might have picked up for $200-$300 at the flea market, including the "slightly damaged" printer for anything more complex.

Unfortunately, aside from *RF Design* and, yes, *ham radio,* the software is sometimes hard to come by to use these machines to their best potential. Don't fade out on us. Give us programs that can be entered into *any* machine. We can, and *do* use them! Just make sure that you don't cut out so many REMs that we can't figure out what the author is trying to do when we make our conversions.

We may not set up the "toy" computer at work so that the VIPs don't look askance when they tour the place, but we do use it for work even though "that Commodore is at home!"

James Eagleson
B&B Electronics
Watsonville, Calif.

P.S. I'd hate to see *RF Design* become merely another "professional journal." Most of those I scan briefly for gossip about my competitors, check out relevant ads, wonder a few minutes about the relevancy of the article "A 264 GHz Integrated Substrate Oscillator" someone has developed for the government at a cost of 264 Kilobucks of my tax money so that some bureaucrat feels more secure that we can actually hit that tank with our "tactical" nuclear weapon, then toss into the trash can.

RF Design on the other hand, distracts me for a much longer period of time. It doesn't get thrown away!

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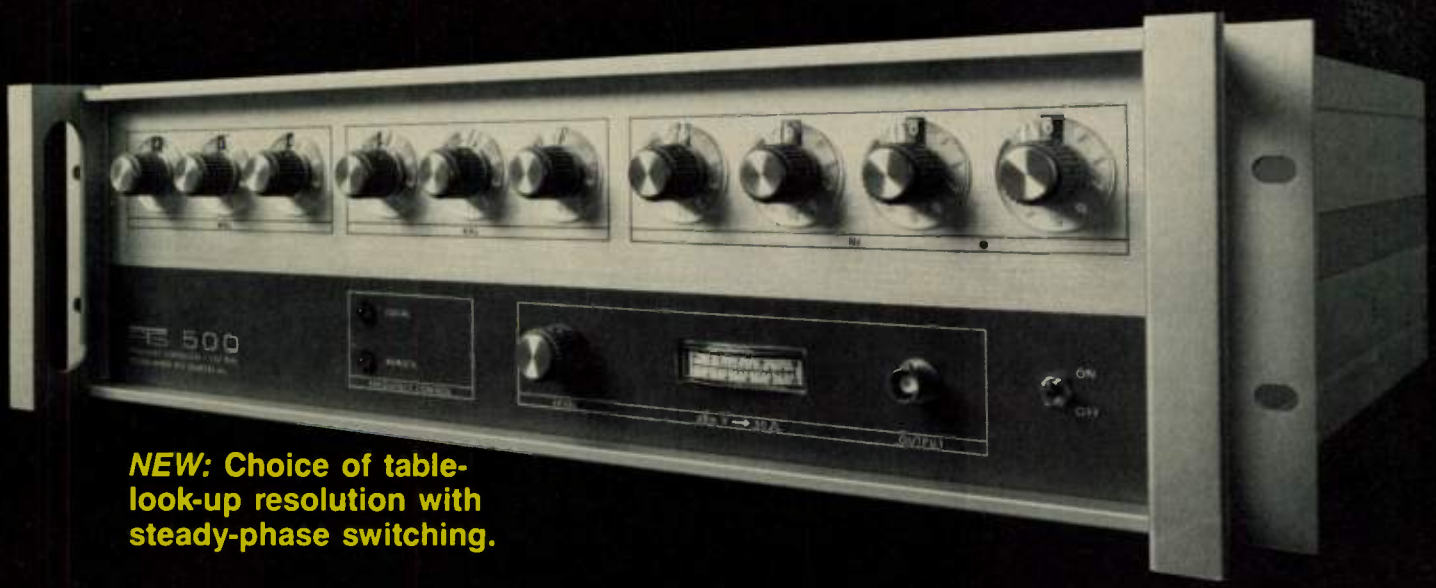

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August 18-21, 1986, Washington, DC

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Information: Merril Ann Ferber, Assistant Director, Continuing Education Engineering Program, The George Washington University, Washington, DC 20052; Tel: (800) 424-9773

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Information: Greg Gore, Director of Training, R & B Enterprises, 20 Clipper Road, West Conshohocken, PA 19428; Tel: (215) 825-1960

Besser Associates, Inc.

Principles of RF and Microwave Circuits: Theory and Applications
July 21-23, 1986, Santa Clara University, Santa Clara, California

Information: Ron Rose, Besser Associates, Inc., 3975 East Bayshore Road, Palo Alto, CA 94303; Tel: (416) 969-3400

Georgia Institute of Technology

Microwave Antenna Measurements
July 21-25, 1986, Atlanta, Georgia

Information: Diedre Mercer, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332; Tel: (404) 894-2547

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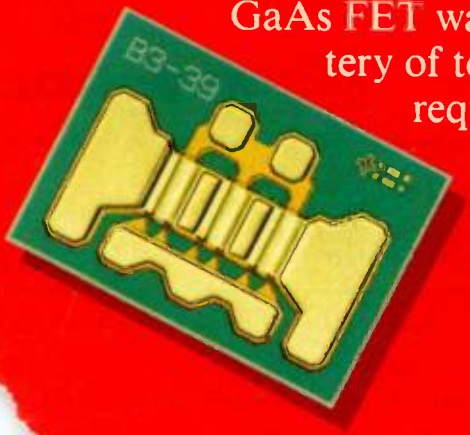

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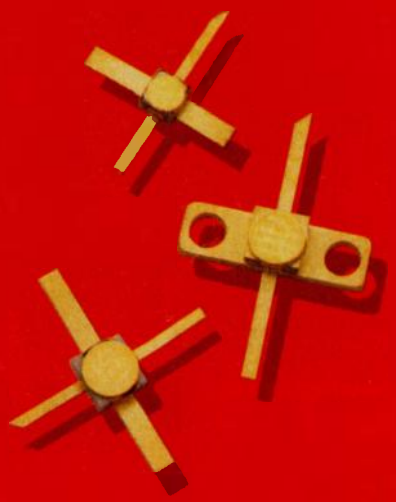

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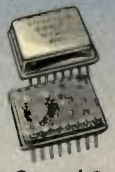

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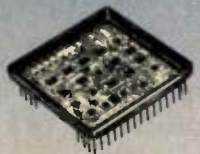

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Thomson Concentrates Discrete Manufacturing in U.S.

Thomson CSF, the French corporation that recently surprised the electronics world with its acquisition of Mostek, has made its Montgomeryville, Penn., plant worldwide headquarters for RF and discrete component manufacturing. The move partly reflects the growing U.S. military interest in RF technology. The French parent company is a leading worldwide OEM for professional and military products.

Don Kupinewicz, marketing manager for RF products at Thompson Montgomeryville, said the company had spent the last few years developing a full line of products in the UHF (300-500 MHz), L-Band (1200-1400 MHz) and S-Band area (2.8-3.5 GHz).

"We have been developing high power pulsed products for use in phased-array radars," Kupinewicz said. "In the UHF area our intent is to pursue shipboard Over-The-Horizon radar. We have had very serious penetration with some key military sub-contractors and, I think, have one of the broadest product lines in the business.

"This year we will be introducing our S-Band product line, which initially will be up to the 45 watt level, but we hope will be up to the 60 watt level by the end of the year. Our product line differs from the competition in that our products have better gain at the highest frequency, allowing the design engineers to design systems with fewer products."

Part of the reason Thomson has concentrated RF production and design in Montgomeryville is probably the increasing U.S. military market for such products.

"Our total sales for RF products is about 60 percent military and high-rel now and 40 percent commercial, just about the reverse of what it was in 1985," Kupinewicz said.

He said the primary reason for the move was to guarantee a reliable source of supply of RF components for the parent corporation.

"Thomson CSF — France recognizes their internal need for RF power transistors for their own equipment division. It is very, very important to Thomson to have an internal source that is very strong in the marketplace. There is still a facility in Tours manufacturing RF power transistors, but it is in the process of being phased out, and all that technology and products are being transferred to Montgomeryville. There have been technology developments both here and in Tours. In France, the primary design expertise has been in MOSFETs. They have been designed primarily for the military market in that they employ gold metallization.

"We feel TMOS is the MOSFET technology which will eventually lead the market. We stepped back for a number of years and looked at the MOSFET marketplace and the technology available and tried to figure out which technology was more productionable and reproducible than the others, and we've keyed on the TMOS technology, as it is called now. That is what we feel is going to win."

Mark O'Molesky, vice president and general manager of Discrete Operations for Thomson-Montgomeryville, believes the synergy between the Mostek operation and Montgomeryville gives them a significant advantage in military RF product development, such as avionics.

"The avionics field is mirroring the development in a lot of the RF areas today," O'Molesky said. "People in avionics are looking for higher power and wider bandwidths and some flexibility against electronic countermeasures. Our developments in avionics are structured around getting higher power while maintaining junction temperature, which is really a key in the industry. In the DME areas we probably have the highest power devices around — 1.2 kW. We are also looking into the possibilities of getting into S-Band and beyond for avionics as well as for other aircraft system demands."

O'Molesky said Thomson MGV will benefit from Mostek's experience with IC manufacturing for the government under MIL/STD 883C. He thinks the RF standard is due for revision and Thomson will have an edge in meeting the stricter standard.

"In order to get zero defects, most manufacturers of high volume parts have learned that it takes more statistical process control than screening and testing. There has been a trend in the IC industry to move toward control on the chip level to guarantee reliability. Discrete people haven't seen that, but because we have a window on that wall and share the same quality groups and go to the same meetings, we're beginning to see that and are moving in that direction.

"Mostek has a substantial expertise in military/governmental product controls, the right environmental screenings to meet specs — they've passed audits, they have line clearances. We have an organization that is used to dealing with military establishments, and because of that they know how to do the job correctly, design it in at the front and do all the right things. They feel free to send one of their inspectors up to look at our line and give us a critique before inviting the government up. These are people who have passed audit after audit by some of the toughest people in the government, so it helps us fashion a plan to really move our wafer fab and assembly technology.

"There is a smart power product base in Carrolton, as well. They're doing some high power MOS and we do high frequency MOS for RF, and I think the military could use a real good high frequency, high power, wideband RF MOSFET. It is our intention to go after one," O'Molesky said.

RF Component/Test Equipment Expo Debuts in Midwest

More than 200 engineers, most from Ft. Wayne, Ind., companies, mingled with personnel of 20 RF and microwave exhibitors April 16 and 17 in the Ft. Wayne Sheraton Inn for the first RF Components and Test Equipment Expo.

The new event was deemed enough of a success, according to show manager Jim Leach, RF Management, Inc., to be held in Ft. Wayne in the same season next year, upgrading to a larger facility. Leach said that while technical sessions were not part of the program this year, they will be added next year.

"Discussions are underway," Leach said, "to have a program developed and directed by Besser Associates, Inc."

The Besser company is a Bay Area specialist in RF and microwave instruction. A high point of the opening show was

an exhibit by Besser Associates introducing courses available on videotape. A TV monitor in the exhibit area was kept busy during most exhibit hours, as engineers and training managers viewed the new material.

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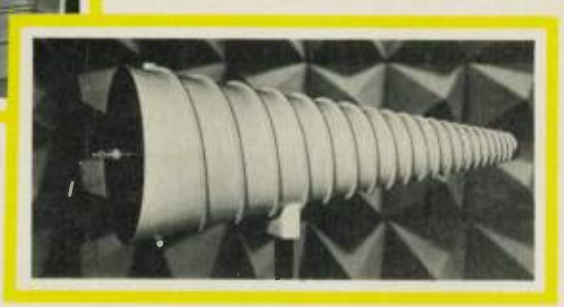

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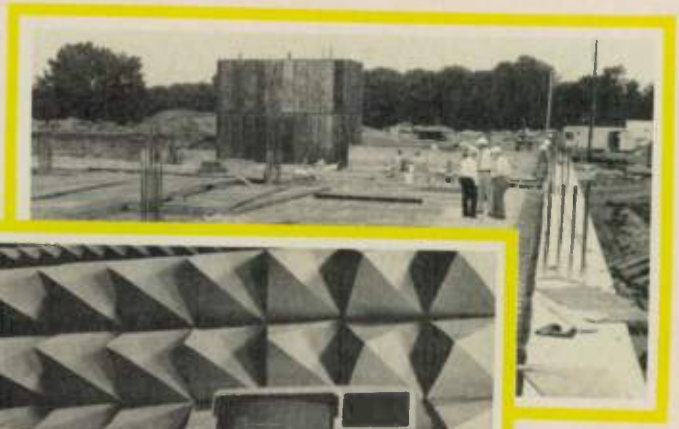
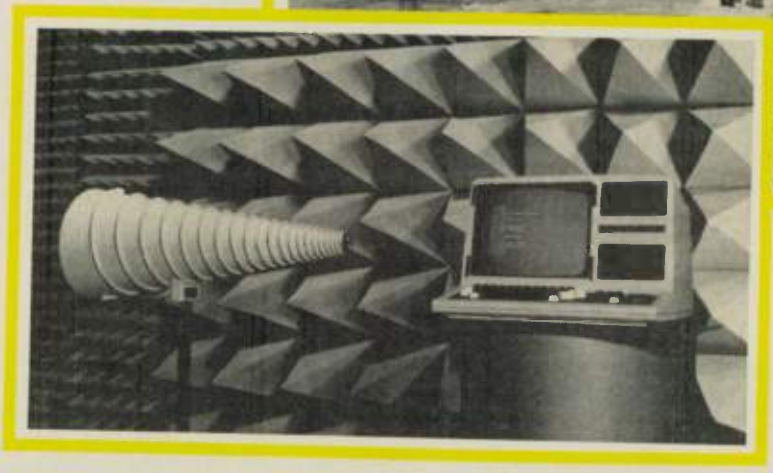
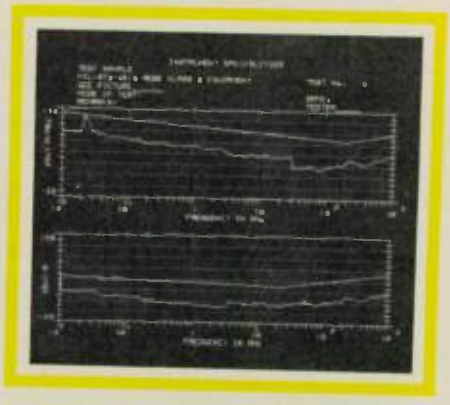




What do you get?



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INFO/CARD 97

Dr. Vorhaus Winner of MTT-S 1986 Microwave Award

The Administrative Committee of the IEEE Microwave Theory and Techniques Society unanimously awarded it's 1986 microwave prize to Dr. James L. Vorhaus and his co-authors for their paper "2-20 GHz GaAs Traveling-Wave Amplifier." The prize is awarded annually to the author(s) of that paper published the preceding year in an official IEEE publication which is judged to be the most signficant contribution in a field of interest to the society. The paper was published in the *IEEE Transactions on Microwave Theory and Techniques*, Volume 32, No. 1, January 1984, pp. 71-78.

Dr. Vorhaus is Director of Solid State Operations for the Microwave Division of EPSCO, Inc.

NAB Show Highlights Solid State Power and New Technologies

The National Association of Broadcasters 40th Annual Convention, held April 12-16 in Dallas, featured the latest developments in broadcast technology, techniques and regulations.

On the trade show floor a dramatic increase in solid-state transmitting equipment was evident. Thomson-LGT exhibited a 30 kW VHF television transmitter of modular, all solid-state design. Thomson expects to have the first unit in operation around the end of this year. Nautel showed their 50 kW AM transmitter, top of their product line. Since the first showing at last year's NAB, several of these transmitters have been put into operation in Canada and the United States.

CSI had a 3.5 kW FM transmitter using the power amplifier made by Microwave Modules and Devices (February 1986 *RF Design*, pp.36-38). Other FM manufacturers noted that they are developing solid state designs for the near future. Larcan showed a 1.2 kW solid state VHF-TV transmitter and a 3 kW aural amplifier for VHF. The rapid movement toward solid state power by many transmitter manufacturers was very striking, given the slow acceptance of previous solid state equipment by broadcasters.

In contrast to the rise of the transistor, progress in the area of UHF-TV klystron amplifiers is always of interest to broadcasters using this power-hungry medium. Updates on high efficiency klystrode and depressed-collector klystron technology presented at the Engineering Conference promise demonstration models by the end of 1986.

Other new technologies demonstrated in Dallas included High Definition TV (HDTV), with many manufacturers exhibiting prototype equipment for use with this ultra-high quality television medium (HDTV has picture quality roughly equal to 35mm film). The major concern of broadcasters is how to get this medium to an audience, since HDTV requires 25 MHz bandwidth, compared to current 6 MHz TV channels. Considerable technical and political discussion continues surrounding the broadcast possibilities of HDTV. In the meantime, HDTV presents opportunities for closed-circuit applications in medicine, flight simulation and motion picture production.

The improvement of AM (540-1600 kHz) broadcasting has been actively pursued in the last few years as radio listeners rely more and more on FM as their primary reception choice. Included in reports on AM improvement reseach were anti-sky-

wave antenna systems to reduce interference levels; efforts to determine uniform performance standards for AM receivers; exploration of multiple transmitters on the same frequency, operating synchronously, to increase the station coverage area; appropriate performance of AM stereo; and study of the problems of interference from power lines and electrical appliances.

Noise Com Prevails In Lawsuit

The New Jersey Superior Court completely exonerated all defendents — Noise Com, Inc., Karabet Simonyan, Joanne Abrams Simonyan, Kurt Stern and Jerome Callahan from all liability in connection with its business efforts in competition with Micronetics. In particular, the court refused to enter any form of injunction against any defendant, and rejected the claims of Micronetics that any of the defendants had appropriated any trade secrets or any other proprietary information, had engaged in any conduct amounting to unfair competition, or had tortiously interfered with the business of Micronetics. Rather, the court ruled that each of the individual defendants, former employees of Micronetics, were free to terminate that employment and form Noise Com, Inc., a company which competes in some areas with Micronetics, and that no proof had been presented which would indicate that Noise Com was competing unfairly with Micronetics.

EEsof Software To Be Offered by HP

EEsof, Inc. has entered into a joint sales agreement with Hewlett-Packard Company under which Hewlett-Packard will sell EEsof integrated workstation software packages for use on the HP Vectra PC and the HP 9000 series 300 desktop computers.

The integrated software packages consist of EEsof's Touchstone®, a program for the design, analysis, and optimization of linear RF/microwave circuits; Touchstone Sr.™, for modeling custom or proprietary elements and incorporating them into Touchstone's element library; LineCalc™, a transmission line analysis and synthesis program; and Touchstone Monte Carlo™, an analysis and yield prediction tool. The individual software programs, along with EEsof's full line of products, will continue to be available directly from EEsof.

HP Network Measurements Division general manager Wilhelm L. (Bill) Wurst, noted the significance of the agreement in light of CAE engineering productivity: "We feel we can help microwave engineers increase their productivity through integration of the simulation and optimization processes in EEsof software with the RF and microwave measurement and computational processes afforded by HP instrumentation and computers." Wurst concluded, "We are pleased to have this association with EEsof. It allows us to offer to our customers what we think are simply the best engineering programs available today for the microwave designer."

Charles Abronson, president of EEsof, said, "EEsof's joint agreement with Hewlett-Packard opens new opportunities for the sales and applications of our software products in the microwave and RF industry. The increased availability of the packages on HP workstations extends the software's applicability to the HP 8510A and 8753A Network Analyzers, making it easier for engineers to utilize our software on these instruments."

Abronson pointed out the enhanced productivity the HP/EEsof workstations will guarantee to microwave and RF circuit designers "by offering the integration of EEsof's design, simulation and analysis software capabilities with Hewlett-Packard's advanced computer instrumentation and test products. The agreement with Hewlett-Packard to distribute our microwave engineering programs for use on HP computers will provide industry engineers with fully integrated microwave CAE workstations, and we are pleased to include the HP packages in our expanding marketing plans and anticipate a long and rewarding working relationship with Hewlett-Packard."

The integrated Touchstone software package for the HP workstation is available from Hewlett-Packard. Software for the 9000 series computers will be available only from Hewlett-Packard; software for the HP Vectra PC will be sold by both EEsof and HP. Customers who purchase the workstations from Hewlett-Packard will have the hardware and software installed by HP and will also receive a 90-day on-site warranty for both hardware and software. HP is recommending that its customers enroll in EEsof's support program thereafter for continued software program support.

Software purchased directly from EEsof includes a full one-year support and upgrade service. In addition, customers who wish to license Touchstone, Touchstone Sr., LineCalc, Monte Carlo, or other EEsof products for use on IBM and IBM-compatible computers, including the HP Vectra PC and DEC VAX computers, can do so by contacting their local EEsof sales representative directly, said Jim Landauer, vice president of marketing and sales. EEsof, Inc. is located at 31194 La Baya Dr., Westlake Village, CA 91362. Phone (818) 991-7530.

Klystrode™ Amplifier Tube to Power UHF-TV Transmissions

Comark Communications is incorporating Varian EIMAC's Klystrode power amplifier tube in a new series of highly efficient UHF-TV transmitters. Recent transmitter tests conducted by Varian EIMAC and Comark indicate that Comark's new SK Series 60 kW transmitters could reach an efficiency level 50 percent greater than currently available klystron systems. With this efficiency, a typical UHF station could realize a 40 to 50 percent energy cost savings, or as much as $100,000 over a five-year period at the 60 kW level. Higher transmitting levels would realize further savings.

Details of the Comark SK Series transmitters and test results were presented at the 1986 NAB Convention in a paper entitled, "Using Klystrode Technology to Create a New Generation of High Efficiency UHF-TV Transmitters." The paper was authored by N. Ostroff and A. Whiteside, Comark Communications.

According to George Badger, marketing manager of Varian EIMAC, the klystrode originally was developed to bring UHF transmitter efficiency up to a level approaching the operating economy of a VHF transmitter. Nat Ostroff, Comark president, noted that Varian EIMAC and Comark began to develop a transmitter around the klystrode after the 1985 NAB Convention. "The resulting SK Series transmitters deliver a 100 percent or better figure of merit. This major jump in transmitter efficiency will have a signifi-

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INFO/CARD 20

cant impact on the world of UHF TV transmission."

The klystrode combines the high reliability and power handling features of a klystron with the grid-cathode components of a tetrode. This combination cuts the high power consumption required to make UHF systems competitive with VHF and offers users additional cost savings through the tube's long life expectancy. The klystrode derives its efficiency through its ability to operate in Class B service. Typical klystron-based UHF systems operate in Class A service in which a tube draws a continuous beam current equal to the highest value necessary to meet instantaneous RF requirements. Conversely, in Class B service the RF drive power automatically controls the beam current. Therefore, Class B operation gives the broadcaster a power cost based on actual transmitted power output, not on fixed DC tube power consumption.

Initial test results also demonstrate the klystrode's particular applicability for stereo TV service due to its attractively low incidental carrier phase modulation (ICPM). Its ICPM of less than three degrees make the klystrode very similar to the VHF tetrode. This low ICPM contrasts greatly with the 45 degrees or more of ICPM generated by UHF klystrons.

For additional information and literature, circle INFO/CARD #102.

Nurad Secures General Dynamics Contract

Nurad, Inc., Baltimore, Md., recently secured a $7 million defense contract with General Dynamics, Fort Worth, Texas, to supply an airborne self-protection jammer system. The system will include radomes and antennas for the forward and aft sections of F-16 aircraft.

Nurad manufactures electronic countermeasure/electronic warfare equipment for U.S. and NATO aircraft including the A-6 Prowler, A-7 Corsair II, F-8 Intruder, F-14 Tomcat and F-16 Fighting Falcon.

TRW's Solomon Receives Goddard Award

Dr. George E. Solomon, executive vice president and general manager of TRW Electronics & Defense Sector, has received the 1986 Robert H. Goddard Astronautics Award of the American Institute of Aeronautics and Astronautics (AIAA). Solomon received the award May 1 during the honors banquet of the 1986 AIAA Annual Meeting held at the Hyatt Regency Hotel, Crystal City, Virginia.

The Goddard Astronautics Award is given annually for notable achievement in the field of astronautics in honor of American rocket pioneer Robert H. Goddard. Previous recipients include Wernher von Braun and Theodore von Karman. Solomon was named the 1986 Goddard award recipient for "outstanding contributions to aeronautics and astronautics programs and reentry system development."

A graduate of the University of Washington and California Institute of Technology, Solomon holds an M.S. in Aeronautics and a Ph.D. in Aeronautics and Physics. Solomon joined the Guided Missile Research Division of the Ramo-Wooldridge Corporation in May 1954 as a member of the technical staff.

He worked for several years studying the dynamic motion of reentry vehicles and their protection from atmospheric friction and heat during reentry. This research contributed to the successful design of first and second generation ICBM reentry vehicles for the U.S. Air Force. With the advent of the U.S. space program, Solomon directed functional engineering management of the first spacecraft to be built for NASA, Pioneer I. He also supervised the system design of the Pioneer interplanetary spacecraft and the VELA Nuclear Detection Satellite.

As vice president and general manager of TRW Defense and Space Systems Group, Solomon directed major spacecraft satellite programs. These include Pioneer 10, which in 1983 became the first man-made object to leave the solar system, the Viking Mars Biology Instrument, the Navy's Fleet Satellite Communications System and the Tracking and Data Relay Satellite. In March 1981, Solomon was elected an executive vice president of TRW Inc. and appointed general manager of the Electronics & Defense Sector, which employs 38,500 people in six major operating organizations.

Solomon is a Fellow of the American Institute of Aeronautics & Astronautics and the American Astronautical Society. He is member of the National Academy of Engineering and a member of the Board of Governors and the Executive Committee, Aerospace Industries Association.

Surface Component Availability Grows

The availability of surface mountable active component part numbers has increased dramatically since 1984, reflecting the continued growth of SM technology throughout the electronics industry, and the trend toward SMT is likely to continue.

According to Don Brown, president of D. Brown Associates, Inc. (DBA), the number of MOS IC part numbers, in particular, has nearly doubled in the last two years, from approximately 2,800 in '84 to some 5,000 at present. Brown said the increasing popularity of CMOS technology in surface mountable packages can be attributed to its low power consumption.

"Bipolar technology is by far the most widely available surface mounting technology, particularly the low pin-count 'glue' logic devices," Brown said.

Currently, 70 to 80 percent of all commercial device functions are available in at least one form of surface mountable package, although not all such devices are available in all package configurations. This information was obtained by DBA in preparation for the 1986 Surface Mounting Directory, the cornerstone of the Surface Mounting Technology Information Service. The 1986 Directory's 1,500 hardbound pages feature more than 30,000 active and passive component listings, divided into 24 separate component types, and sorted by company, description and generic numbers. The directory also includes: more than 600 equipment listings, divided into 10 separate subsections and sorted by company and product type; more than 600 surface mounting package outline drawings which provide detailed information about component package configurations, physical dimensions and specifications; more than 100 contract service houses, sorted by service and company; and over 90 part ordering information illustrations supplied by surface mounting component vendors.

Also included in the Directory are a master index of surface mounting Generic Part Numbers, and a roster of companies providing surface mounting contract services, sorted by company and type of service. According to DBA, the 1986 Surface Mounting Directory contains nearly 45 percent more data than last year's directory, reflecting the growth of surface mounting technology.

The 1986 Surface Mounting Technology Information Service encompasses the Surface Mounting Directory, published in March 1986, the Surface Mounting Directory Mid-Term Update, published in September 1986, and the Person-to-Person Inquiry Service, which enables subscribers to update directory data via direct contact with DBA engineers. Investment in the 1986 Surface Mounting Technology Information Service is $634 for a one-year subscription.

For details about the 1986 Surface Mounting Technology Information Service, or other DBA products and services, contact James Wallace, Sales Manager, DBA, P.O. Box 43, Warrington, PA 18976; (215) 343-0123, ITT Telex: 4990935 (DONBA), or circle INFO/CARD #103.

VHSIC Program Moves Into Phase II

This High-Speed Signal Processing and Computing IC Program is the Foundation for Future Weapons and Avionics Systems.

By Gary A. Breed
Technical Editor

In fiscal 1980, the VHSIC program was conceived in order to provide the military with advanced-technology ICs that have been specifically designed with military requirements in mind. One goal of the program is to close the gap between current state-of-the-art, developed primarily for commercial applications, and the high reliability needs of the military. This gap has often meant that military components are two or more generations behind current technology.

What does VHSIC mean to RF engineers? It means digital signal processing, *plus an integrated approach to systems of computation, communications, avionics and weapons. Recent military policy emphasizes communications and information for battle management, and high speed circuits are a necessity for these goals.*

In 1980, the VHSIC program began with a Phase I goal of 1.25-micron technology, 70,000 device density and 25 MHz clock rate. Although work has been done in bipolar technology, CMOS is the preferred architecture. Phase I development is now virtually complete, with Honeywell and TRW already marketing products using VHSIC technology to military contractors. The other Phase I contractors, IBM, Hughes, Texas Instruments and Westinghouse, are expected to either market products or use their expertise in-house for their own military products.

Military planners have established a program to upgrade existing electronic systems with Phase I VHSIC-based replacements. Not only will this mean higher electrical performance, but improved radiation and EMP resistance, since these factors were included by design. New systems are being planned on the assumption that Phase II VHSIC will develop on schedule. If certain aircraft (such as the new LHX helicopter program) follow the prescribed schedule, it is possible that electronic systems may not be ready.

In one sense, this is not so serious. After all, the main idea behind VHSIC is to get *current technology* into military systems. The inevitable result of this philosophy is that some systems will not develop as fast as others, causing delays in the final product. This is the cost of pursuing the leading edge.

Phase II VHSIC

Honeywell, IBM and TRW are the prime contractors for Phase II of the program, which has $194 million budgeted for FY-86 (for both Phase I and II). The Phase II goal is an order of magnitude increase in performance over Phase I: 0.7-micron geometries, 300,000 device complexity and higher speed. Increasing performance to this extent will create some new challenges, particularly in testing.

High speed, highly complex logic circuits are very difficult to test thoroughly. MIL-STD screening will place a heavy burden on both military and industry personnel to establish testing programs which will provide assurance of the quality and reliability of VHSIC components. The timetable of implementation of VHSIC allows little room for a major snag in testing equipment or procedures.

The VHSIC program has projected Phase II technology to reach the prototype stage in mid-1987, with demonstration hardware following thereafter. By FY-89, Phase II designs should begin to be implemented into operational systems. Phase I is presently in the early stages of demonstration equipment, with integration into operational equipment coming very soon, as VHSIC chip makers are able to deliver the devices to defense contractors.

System Applications

The first application of VHSIC is a central processing unit (CPU) to implement MIL-STD-1750A computations at 3 million instructions per second. TI has demonstrated a brassboard containing a vector arithmetic logic unit, part of an integrated communications, navigation, identification and avionics (ICNIA) system to be implemented in the Army's "fire-and-forget" missile seeker.

Electronic countermeasures and counter-countermeasures (ECM and ECCM) will be recipients of high-speed signal processing, as will ultra-reliable radar systems. Integration of computation and processing functions required in a total avionics package is another goal, saving valuable space by providing common processing for different weapons, radar, and communications equipment on board.

There is a question whether the electronics of VHSIC will develop fast enough to keep pace with weapons, aircraft, communications and radar systems currently being developed. These new systems simply cannot be completed without the speed of the VHSIC-developed computers and processors that are required to make them operational. rf

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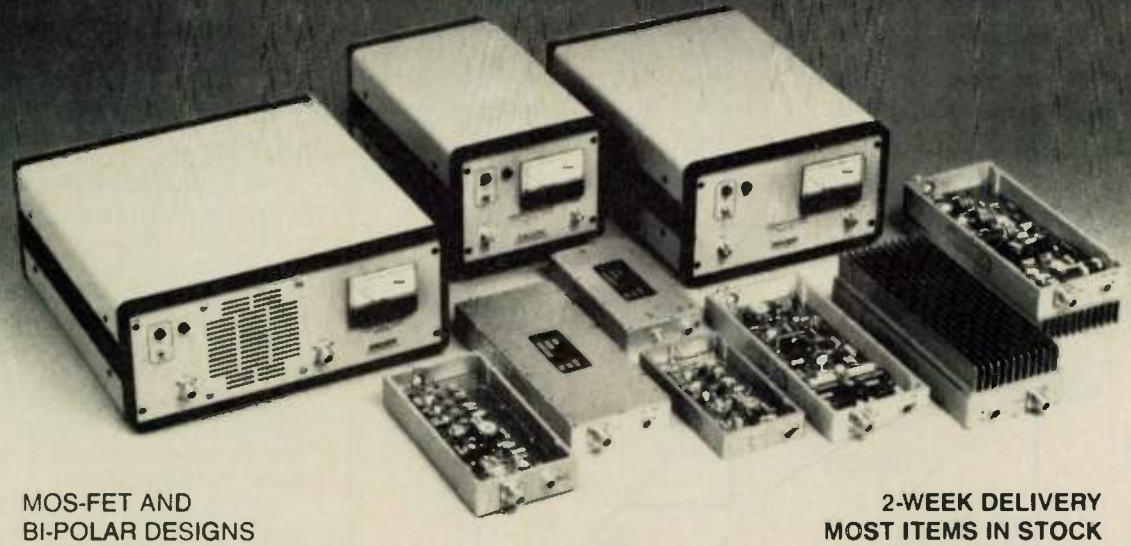

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INFO/CARD 22

SAW Technology for Radar and Communications Systems

By Robert King
Andersen Laboratories, Inc.

SAW devices have been used in both military and commercial applications since the technology emerged in the 1960s. As the field matured, continued developmental work yielded new techniques, resulting in many new uses for SAW technology in signal processing applications. As a result, SAWs have now become the preferred technology for many applications.

SAW devices have played a major role in modern radar and communication systems. The inherent small size and high reliability of these devices have made SAWs a natural choice for the design engineer of modern hi-rel military systems. SAWs are used for critical filtering applications, precise time-delay requirements, pulse compression techniques, as stable frequency sources, and for various coding techniques.

A particularly interesting and established device is the dispersive delay line, or chirp filter. The most common use of dispersive delay lines is as matched filters for pulse expansion-compression techniques. Many modern radars employ the use of pulse-compression to enhance the performance capabilities of the system. Use of a dispersive delay line allows the transmitted energy to be spread out in time over a wide frequency range, thus reducing the peak power requirements for radar transmitters. Furthermore, this spread spectrum technique allows use of wider bandwidths to be contained in the transmitted pulse, which improves the radar resolution capability. Pulse compression employs the use of matched filter waveform correlation and as a result, a processing gain is realized in the receiver proportional to the time-bandwidth product. By prudently specifying these parameters and sufficient sidelobe performance at the receiver, system sensitivity and dynamic range capabilities can be in the range of 30 to 40 dB.

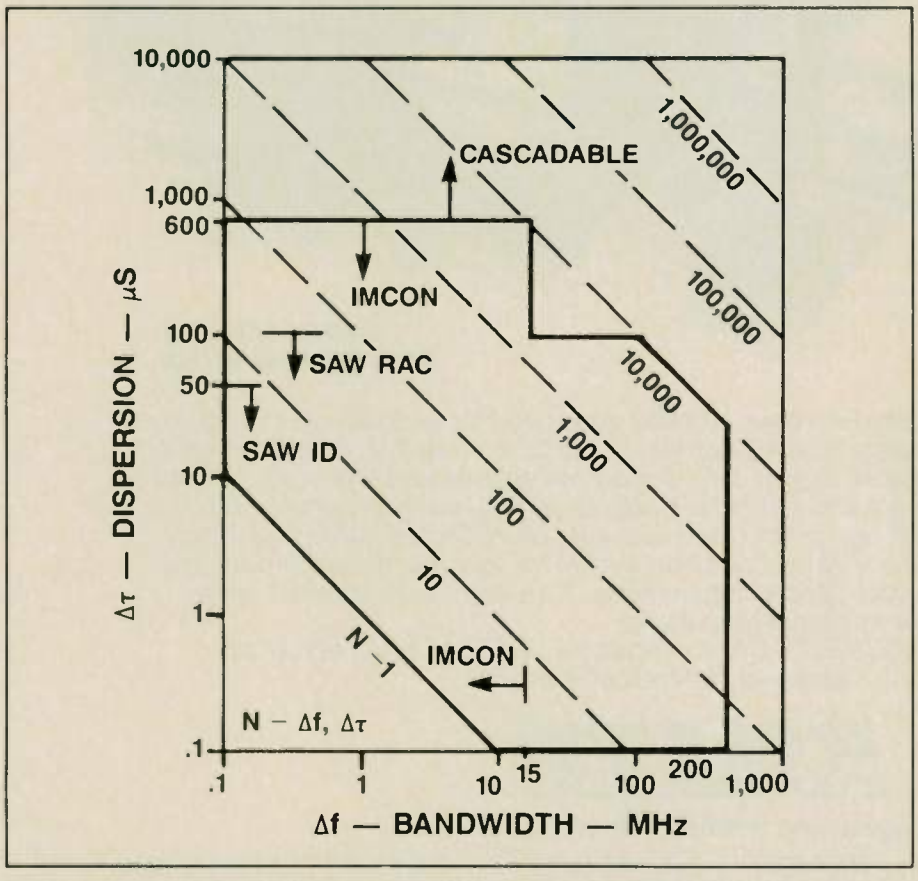

Figure 1. Range of performance for SAW and IMCON Dispersive Delay Lines.

Generally, linear frequency modulation (LFM) is used in pulse-compression techniques, but other forms of modulation are also used for specific applications. Nonlinear FM (NLFM) and pseudo-random binary sequence waveforms have also been employed with good results. For proper performance optimization, various forms of weightings must be utilized in the dispersive elements. SAW and related IMCON designs are unique in that both phase and amplitude characteristics can be individually controlled on the device substrates to achieve various results. As shown in Figure 1, SAW and IMCON products cover a broad spectrum of performance characteristics.

SAW devices are especially useful for wide bandwidth applications. In excess of 500 MHz of bandwidth is realizable, as are time dispersions of up to about 100 microseconds. As an example, a matched chirp filter with 500 MHz of bandwidth and 3 microsecond dispersion will yield a compressed time pulse width of 3 nanoseconds; a compression ratio of 1000. Typical sidelobe performance is −35 dB or better.

IMCON devices on the other hand are suited for long pulse, narrow bandwidth applications. Time dispersions of up to 600 microseconds are available or a single device and devices have been cascaded to up to 10 milliseconds. Bandwidths can be up to 12 MHz. Matched filters employing the IMCON have been supplied with close-in sidelobe levels in excess of −48 dB.

Both SAW and IMCON devices have played a major role for many years in

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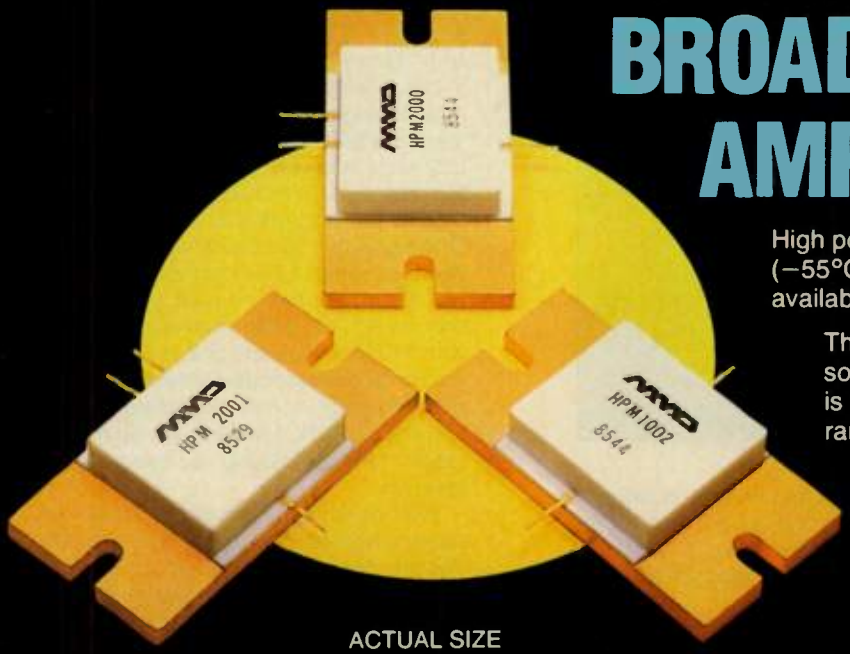

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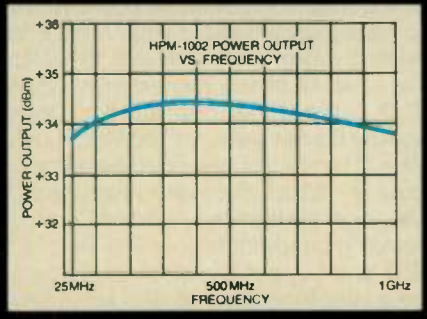

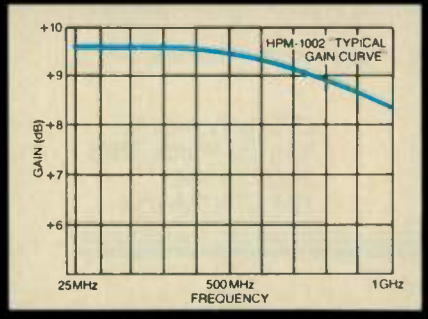

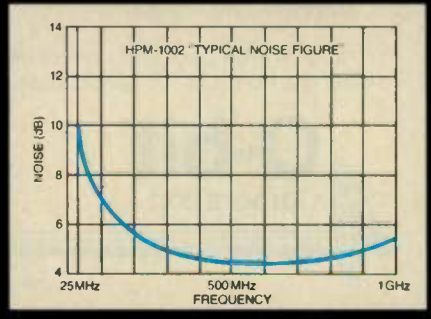

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pulse compression applications, and continue to be a natural choice for the chirp filters due to their performance characteristics. Military radar programs such as SPS-49, AWACS, Patriot and the Shuttle Imaging Radar (SIR) presently use SAW/IMCON devices, with many other proposed programs intending their usage.

Compressive IF Receivers

Compressive IF receivers, or Microscan receivers, are finding increasing application in military surveillance systems for high speed wideband data acquisition, emitter sensing, and various forms of signal identification. Compressive receivers provide real time spectrum analysis for both radar and communication equipment including early warning radar receivers, missile seekers, as well as set-on jammers, and ELINT/ESM intelligence receivers. They are particularly useful for analyzing complex signal waveforms and multi-signal environments, while providing 100% POI (Probability of Intercept).

Utilizing dispersive delay lines (DDLs) the compressive receiver performs a real tiime Fourier analysis of the signals at the input. A basic design usually employs two dispersive elements, one as a linear FM generator to scan the input spectrum and a second as the compression processor. The output is then an instantaneous time display of the Fourier transform of the input frequency spectrum. Each frequency is represented by a compressed output pulse in time. The location of the pulse in time is proportional to the input frequency and the magnitude of the pulse is proportional to the frequency's magnitude. This output can then be detected for further processing, or with additional transformation can be used to analyze both amplitude and phase characteristic of the input signals.

SAW and IMCON technologies combined offer a wide range of performance possibilities for configuring compressive receivers. SAW DDLs can be designed with bandwidths in excess of 500 MHz allowing wide spectra to be scanned for establishing active frequency cells. For instance, a SAW compressive receiver with 250 MHz analysis bandwidth can scan this range in .5 microsecond processing time with a resolution of 3 MHz. IMCON DDLs are able to achieve long time dispersions which further improves spectral resolution. For fine frequency identification, an IMCON design can scan 2.5 MHz with 150 Hz resolution and a processing time of 10 milliseconds. Depending on the required resolution and bandwidth, SAW and IMCON DDLs provide a wide design range for configuring a compressive receiver.

SAW devices are inherently small and easily integrated into a hybrid circuit, producing compact, lightweight receiver packages. A 500 MHz bandwidth receiver with 4 MHz resolution measures 4" × 4" × 1", ideal for airborne application.

Due to the many different requirements for bandwidth and resolution in radar and spectral analysis systems, requirements for the dispersive devices are quite varied. To meet this demand, a large number of existing designs are available for selection, and Andersen has extensive SAW CAD programs for new designs. Years ago the demand was for 100 MHz or 200 MHz of bandwidth and sidelobe performance of −25 dB, but today's high resolution, high performance systems are demanding bandwidths from 500 MHz to 1 GHz and beyond and sidelobe performance as stringent as −45 dB. Use of SAW

Profiles of SAW Device Manufacturers

Six companies are the major commercial participants in the manufacturing of SAW components and subsystems. A brief outline of the products, history and direction of each company is presented here, with INFO/CARD numbers provided for the reader to obtain more information from each company.

Tektronix

SAW technology at Tektronix began in 1975, with bandpass filters designed for television test equipment. The specific requirements for television passband shape and time delay characteristics created the need for high performance filters, with SAW devices providing the best fulfillment. Further developments included SAW resonators for their frequency domain instruments, with ranges from 400 MHz up to about 1 GHz. More recent work has involved wide range VCOs using transversal delay lines for frequency control.

Recent divisionalization of Tektronix has allowed development in areas not within the captive market of instrumentation, and TEK has been pursuing high volume commercial and consumer applications, including such areas as high performance television, local area network modems, and security devices. **Tektronix, Inc., Beaverton, Ore. INFO/CARD #104.**

Sawtek

Since its founding in 1979, Sawtek has been a major supplier of SAW products, including bandpass filters, delay lines, resonators and oscillator hybrids. Specialty areas include low-loss filters with only 4 to 10 dB insertion loss, and resonator filters for narrowband low-loss applications. A full range of fixed and tapped delay lines, dispersive and compressive products for EW and radar, as well as transversal filters for TVRO and CATV are available for applications where the SAWs have clear advantage over other filter techniques.

Recent product introductions include very high performance system B/G filters featuring ±0.2 dB in-band ripple, extremely sharp skirts, and excellent out-of-band rejection. Sawtek has also announced a new line of L-band hybrid oscillators for IFF (Identify Friend or Foe) systems in the 1030-1090 MHz range. **Sawtek Incorporated, Orlando, Fla. Please circle INFO/CARD #109.**

RF Monolithics

The UHF spectrum is the specialty of RF Monolithics, where their SAW FSK transmitter and receiver hybrid modules have recently generated much interest. The range of products is from 121 MHz (Emergency Locator Transmitter products) to 1500 MHz fundamental frequencies (6 GHz with multipliers). IFF oscillators, ECM products, and oscillators for Global Positioning System (GPS) receivers are areas of current activity. Although gaining the greatest attention in resonator products, RFM also has unique developments in low insertion loss filters using coupled-mode technology.

The company operates at two levels, components and subsystems. Individual SAW devices are manufactured and marketed, while the production of subsystems incorporating SAW devices has been a natural outgrowth from RFM's knowledge of the devices and their application. **RF Monolithics, Inc., Dallas, Tex. INFO/CARD #108.**

Phonon

Subsystems for military and other high performance applications is the major position Phonon has taken in the SAW market. Devices for spectrum analysis and laser radar are among Phonon's products. Subsystems including pulse compression devices and their peripheral circuitry are another active area. Emphasis is strong in physically small integrated subsystems with very low power consumption. Smaller portions of Phonon's production include high performance SAW filters and custom components.

There are two sides to Phonon, the manufacturer and the distributor. Not only does the company make SAW devices and subsystems, but they market SAW products from Thomson-CSF for spectrum analysis, doppler analysis and other applications. **Phonon Corporation, Simsbury, Conn. INFO/CARD #107.**

Crystal Technology

With its purchase by Siemens several years ago, Crystal Technology began its role in SAW technology. Initial products included high quantity manufacturing of television IF filters and 70 MHz IF filters for satellite receiving equipment. With the softening of these markets, other areas of expertise have come to the fore, such as phase-tracking filter sets for military applications. Crystal Technology has prototype development and initial production under way for 16 military programs, and has developed products for filter, resonator, and non-dispersive delay applications.

Noting the differences between SAW technology and the alternate LC, cavity, and transmission line techniques, the company has begun to supply subsystems to customers who prefer completed assemblies over the re-training of their own engineers. **Crystal Technology, Inc., Palo Alto, Calif. INFO/CARD #106.**

Andersen Laboratories

High quality filters, oscillators, dispersive and non-dispersive delay lines are all part of Anderson's line of SAW devices. High performance, matched products for pulse compression/expansion systems are currently "hot items" in military systems for radar and EW applications. Other products include accelerometers and convolvers.

Hybrid modules integrating SAW components and associated circuitry are a growing area, and production has expanded from what was primarily oscillator modules into filter banks, multiple-oscillator systems, and pulse compression subsystems. Also part of Anderson's expertise is vestigal sideband (VSB) filters used in the transmission and reception of television signals. Products for all television systems are available. **Andersen Laboratories, Bloomfield, Conn. INFO/CARD #105.**

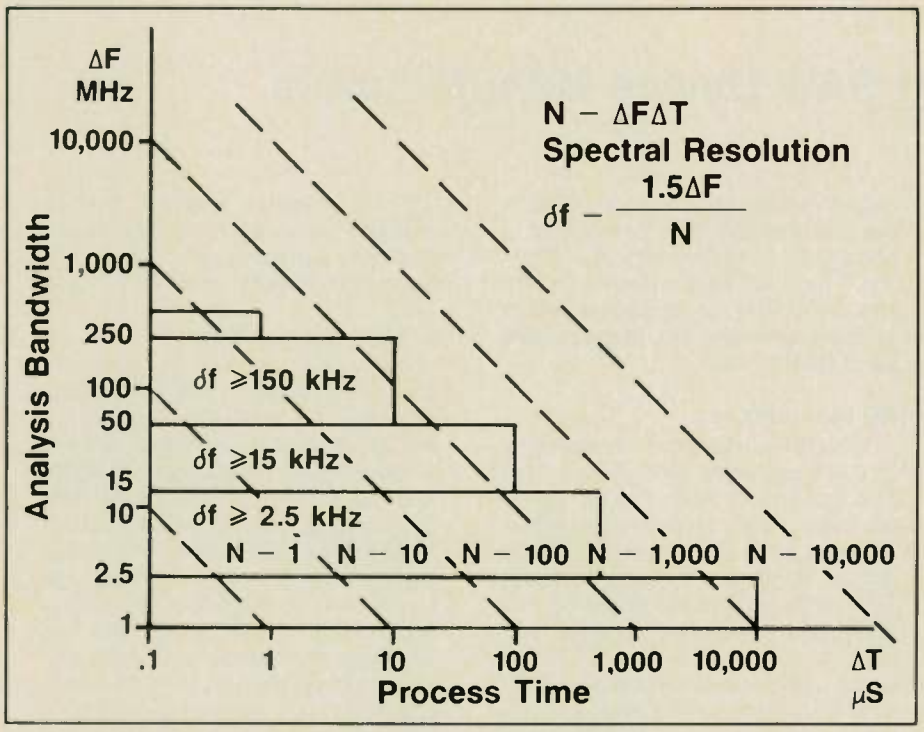
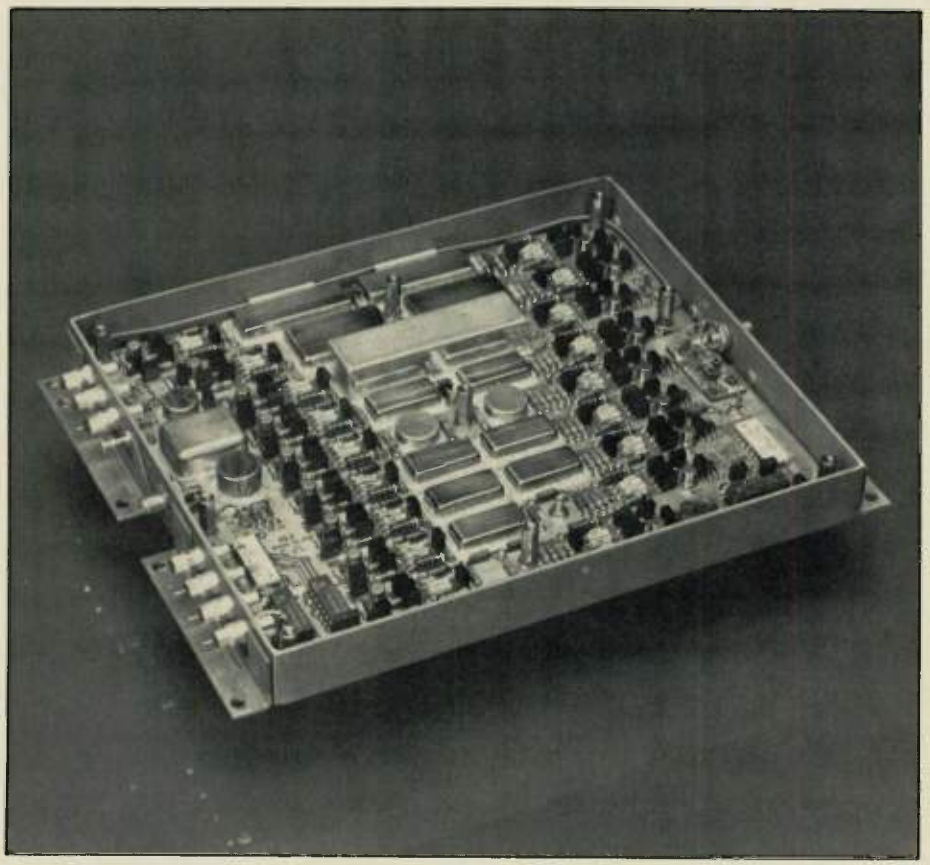


Figure 2. Compressive receiver performance range.



Subsystems, such as this SAW filter bank, are a growing part of the SAW manufacturers' business.

reflective array compressors (RACs) which utilize grooved reflective gratings instead of IDT type, are much more prevalent now for achieving the larger time-bandwidth products.

Oscillators

SAW oscillators have made great strides in the past few years and are now readily available. Designs for fixed frequency or voltage controlled SAW oscillators can be supplied for use as clock references, local oscillators, stable frequency sources, and various VCO applications. SAW oscillators are finding increasing usage in military equipment for radar, communication receivers, frequency hopping transmitters, IFF, telemetry and ranging.

SAW oscillators (SAWOs) are commonly available up to 1.2 GHz, greatly reducing the need for frequency multiplier stages. They are available in both resonator-based or delay-line based configurations. Resonators are useful for high Q fixed-frequency requirements requiring stringent phase noise requirements. Delay lines are excellent choices for VCOs, as well as fixed-frequency applications, and phase noise is generally much better than conventional multiplied crystal oscillators.

Some SAW suppliers have matured to the point of offering a standard line of SAW oscillators. Andersen, for instance, offers a standard delay line oscillator product line from 100 MHz to 1.1 GHz, with standard P.C. mount packaging. The output frequency is selected by the user from standard catalog specifications. The units can be fixed frequency or voltage-controlled, and the VCOs can be frequency modulated at rates of up to 1 MHz.

SAW VCOs have grown into a major product line. Used in phase locked loop (PLL) applications they can be pulled as much as 1 MHz to track to system requirements. One design now in production is in timing recovery circuits for receiver terminals at the end of fiber optic transmit links. The available frequency range is expected to be soon extended to 2 GHz without the use of doublers. This will allow fundamental oscillator outputs for use in L-band radar systems, military communications equipment, troposcatter, telemetry and GPS systems.

Filters/Filter Banks

SAW filters have been widely used for IF signal processing in communication systems, radars, telecommunications, ECM and a variety of other equipment. SAW filters and delay lines are found not only in ground based equipment, but in aircraft, missiles, satellites, etc. Over the

years and through many programs, SAW suppliers have accumulated impressive inventories of standard filter designs at IF frequencies, principally below 500 MHz. For instance, a good selection of bandwidths and shape factors can be found at standard IF frequencies such as 70 MHz or 150 MHz.

But there is increasing demand for filter requirements in both the military and commercial markets for frequencies of 700 MHz, 900 MHz and over 1 GHz. Thus, there has been an increasing demand on the photolithographic techniques presently in use, which limit designs to .5 micron linewidths or approximately 700 MHz. Beyond 700 MHz, direct-write E-Beam techniques as opposed to conventional photo exposure techniques can achieve the smaller linewidths necessary. This, of course, means capital investments, increased processing time and higher filter costs. At times, harmonic designs are used to overcome processing limitations.

A more dramatic increase in demand has been filter bank requirements for multichannel applications. Use of more complex waveforms in modern military equipment and associated signal processing has led to multichannel processing. SAW filters have veen specified for use in a SAW multiplexer for a frequency-modulated continuous wave (FMCW) millimeter radar for establishing ranging cells. Filter banks may be required for basic IF filtering, for use in transmit generators, or as matched filters for waveforms such as MSK. The filter channels must be switchable for selection of different data rates in communications systems and different pulse widths in radar. Channel rejection levels and channel-to-channel isolation specifications often exceed −80 dB. SAW matched filter banks find use for encoding/decoding in communication links requiring low error rate in the presence of noise, and excellent immunity to adjacent channel interference.

In addition, there is a demand for highly compact packaging not practically achieved with conventional discrete circuit designs. To meet this challenge suppliers have had to look beyond the SAW component level and consider hybridized electronic packages which include amplifiers, switches power regulators, filters and channel equalization circuits. Andersen's hybrid facility presently used for the production of SAW/hybrid oscillators has been expanded for such integrated assemblies as filter banks and pulse compression subsystems.

Other SAW Devices

In addition to the devices described, many other SAW components are available for military systems. Non-dispersive delay lines have been extensively used over the years in the military for radar MTI, altimeters, fusing, recirculators and coherent memories. Tapped delay lines have been used for phase coding techniques (such as Barker coding) for secure communications, either for generating codes or correlating them in a receiver. Other SAW products useful to the military are accelerometers for various sensing applications, and programmable convolvers for secure multicode communication requirements.

About the Author

Robert King is an applications engineer at Andersen Laboratories, Inc., 1280 Blue Hills Avenue, Bloomfield, CT 06002. His telephone number is (203) 242-0761.

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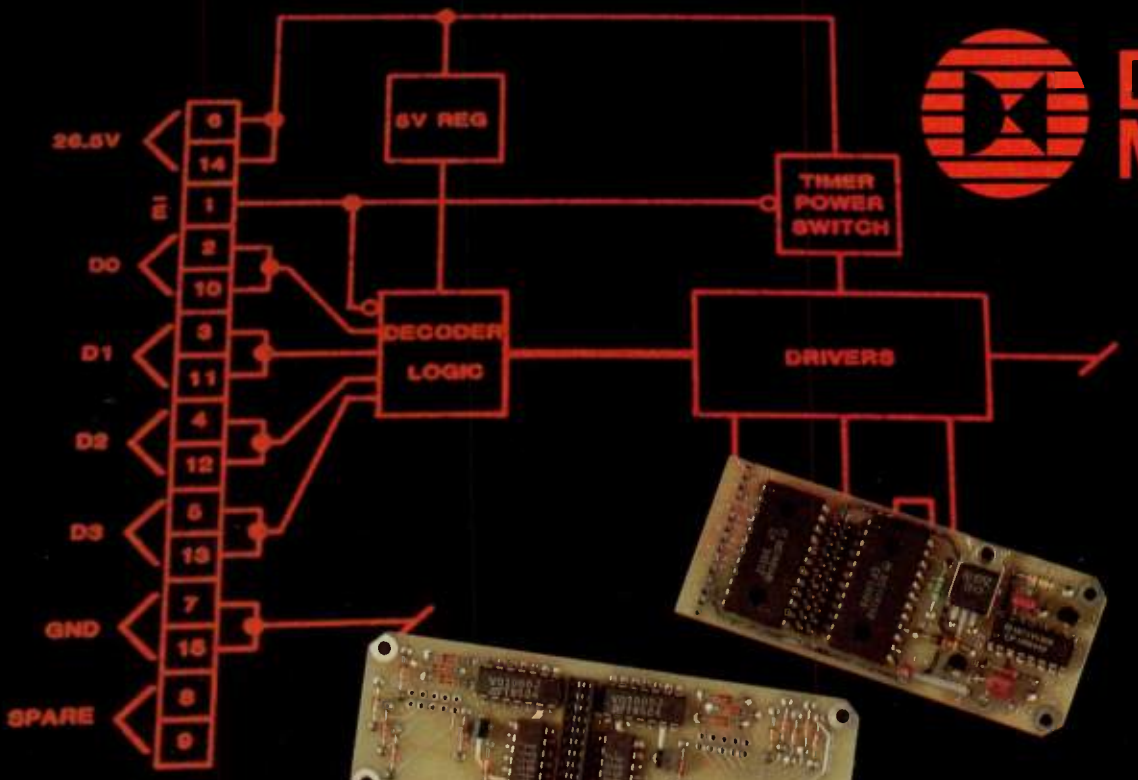
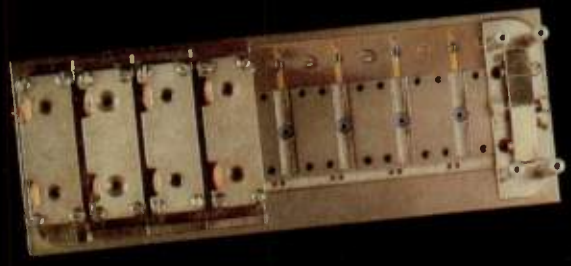
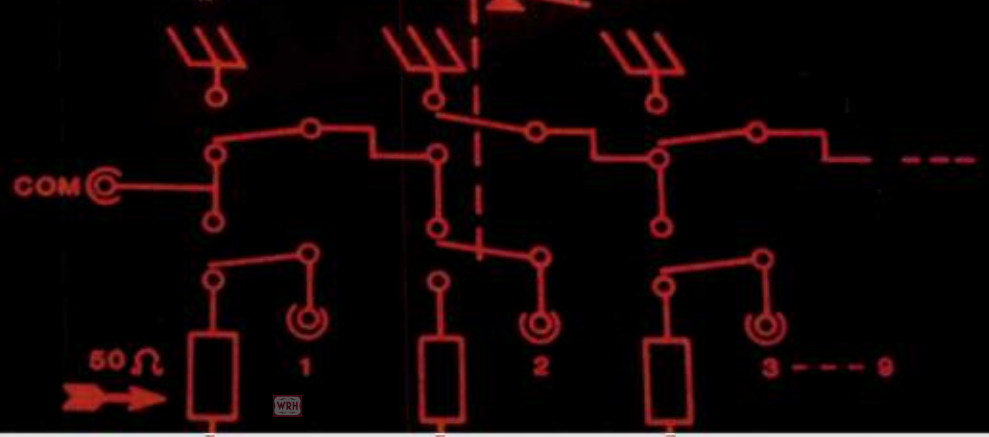


TRUTH TABLE

INPUT SELECT LINES			
D3	D2	D1	D0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1
X	X	X	X





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60	SPDT	BNC N UHF C	50	2000 MHz	0.1	50	1000W	200W
260	DPDT	BNC N UHF	50	2000 MHz	0.1	50	1000W	200W
61	SPDT	BNC	50	2000 MHz	0.1	50	150W	50W
66	SPDT	F	75	1000 MHz	0.1	70	100W	20W
77	SPDT	F BNC	75 50	2000 MHz	0.1	40	100W	20W
54	SPDT	BNC TNC	50	4000 MHz	0.1	70	100W	50W
55	SPDT	BNC TNC	50	4000 MHz	0.1	70	100W	50W
56	SPDT	BNC TNC	50	4000 MHz	0.1	70	100W	50W
62	SPDT	BNC TNC	50	4000 MHz	0.1	70	100W	50W
46 164	DPDT SPDT	BNC SMB SMA	50	4000 MHz	0.1	50	125W	50W
74	SP6T SP7T SP8T	BNC N TNC SMA	50	2500 MHz	0.1	50	100W	20W
78	MULTI-THROW MANUAL	BNC UHF	50	2500 MHz	0.1	50	1000W	200W
115 116	SP3T SP4T	BNC SMA	50	3500 MHz	0.1	50	200W	50W
167	TRANSFER	N UHF	50	1000 MHz	0.1	40	1000W	100W
169	SPDT	BNC	50	1000 MHz	0.1	50	100W	20W

60 SERIES

260 SERIES

61 SERIES

66 SERIES

77 SERIES

54 SERIES

55 SERIES

56 SERIES

62 SERIES

46/164 SERIES

74 SERIES

78 SERIES

115/116 SERIES

167 SERIES

169 SERIES

HIGH POWER SWITCHES

310	SPDT	SC N HN	50	1000 MHz	0.1	30	2000W	500W
312	BYPASS	SC N HN	50	1000 MHz	0.1	30	2000W	500W
313	TRANSFER	SC N HN	50	1000 MHz	0.1	30	2000W	500W

310 SERIES

312 SERIES

313 SERIES

MICROWAVE SWITCHES

401	SPDT	SMA	50	26.5 GHz	.1 TO .5	70	200W	25W
403	SPDT	SMA	50	26.5 GHz	.1 TO .5	70	200W	25W
411	TRANSFER	SMA	50	26.5 GHz	.1 TO .5	70	200W	25W
402	SPDT	BNC N TNC	50	16.0 GHz	.1 TO .5	70	1000W	100W
412	TRANSFER	BNC N TNC	50	16.0 GHz	.1 TO .5	70	1000W	100W

401 SERIES

403 SERIES

411 SERIES

402 SERIES

412 SERIES

IN-LINE SERIES OF MULTITHROW SWITCHES

443	SP4T	SMA	50	18.0 GHz	0.4	60	100W	10W
453	SP5T	SMA	50	18.0 GHz	0.5	60	100W	10W
463	SP6T	SMA	50	18.0 GHz	0.6	60	100W	10W
473	SP7T	SMA	50	18.0 GHz	0.7	60	100W	10W
483	SP8T	SMA	50	18.0 GHz	0.8	60	100W	10W
493	SP9T	SMA	50	18.0 GHz	1.0	60	100W	10W
4A3	SP10T	SMA	50	18.0 GHz	1.0	60	100W	10W
4B3	SP11T	SMA	50	18.0 GHz	1.0	60	100W	10W
4C3	SP12T	SMA	50	18.0 GHz	1.0	60	100W	10W

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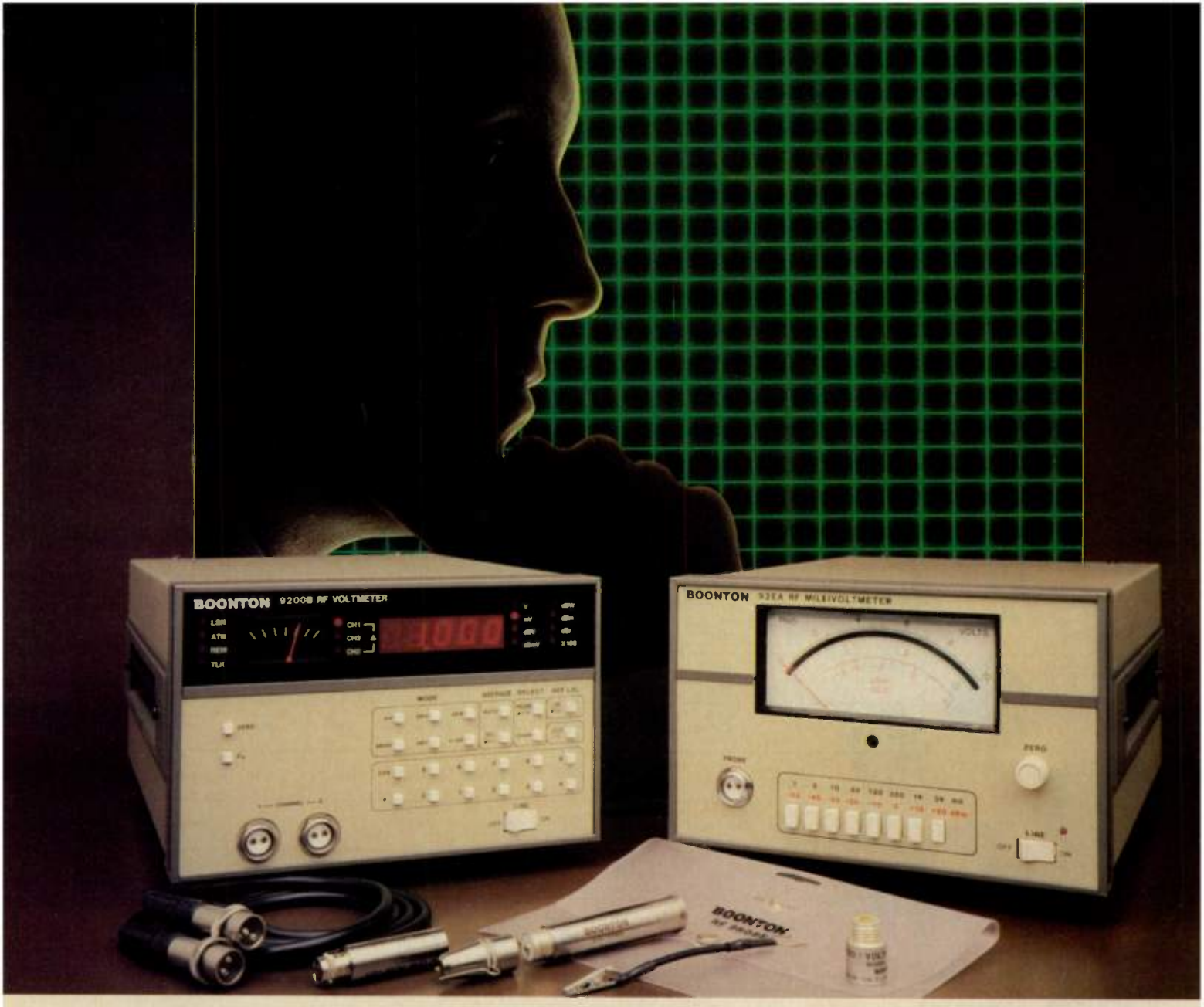

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INFO/CARD 27

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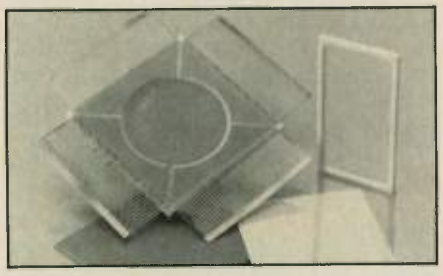
Products on Display at Military Microwaves '86

Plessey: Communications and GaAs ICs

Plessey Three-Five Group introduces a line of GaAs switch products covering 10 MHz to 12 GHz. In the near future, TO5 and plastic SMD switches will be introduced for the lower RF frequencies (up to 1 GHz). Plessey Semiconductors is showing the SL2521 monolithic logarithmic amplifier, successor to the SL521, and a new bipolar 1 GHz limiting amplifier, the SL2532, which features very low phase shift through the limiter. A 110 MHz analog-to-digital converter (ADC) is also introduced, the 6-bit SP9756-6. This high-speed device will soon be complemented by the SP9756-8, with the added logic and accuracy for stacking to 8-bits. **The Plessey Company, Cheney Manor, Swindon, U.K. INFO/CARD #158.**

Morgan Matroc/Anderman Div.: Ceramic Components

Deranox 995F and 999F are new materials developed to offer the benefits of fine grain structure, consistent dielectric constant and excellent surface quality. Metallized components for tubes feature molybdenum manganese and pure molybdenum materials. Special alumina products are also produced for microwave radome use and for use in laser construction. **Morgan Matroc Ltd., Anderman Division, East Molesey, Surrey, U.K. INFO/CARD #157.**



Andersen Laboratories: SAW/Hybrid Oscillator

A SAW oscillator for use in a 565 megabit optical fiber link is introduced by Andersen Laboratories. Operating at a fundamental frequency of 600 MHz, the oscillator will be used for the main timing function at repeater stations in a network that will link cities in the eastern U.S. through long-haul links (30-40 km each). To achieve the required voltage-tuned range, a SAW delay line is used rather than a SAW resonator. **Andersen Laboratories, Inc., Bloomfield, Conn. INFO/CARD #156.**

SDI Microwave: Diodes and Capacitors

SDI is exhibiting its line of microwave semiconductor devices featuring beam lead PINs and a new line of hyperabrupt glass tuning diodes. Also available are Schottky barrier mixer diodes supplied in a beam lead configuration. Its regular line of PIN diodes, harmonic generating (SRD and multiplier) diodes, tuning diodes and limiters will be exhibited. A complete line of MOS chip capacitors will also be featured. **SDI Microwave, N. Billerica, Mass. INFO/CARD #155.**

Maury Microwave: Components and Instruments

New products being exhibited include Maury's line of devices utilizing the new coaxial "Q" connector (2.4 mm), which is rated over the full range of DC-50 GHz. Other featured products include new inserts for the Universal Transistor Test Fixture (TTF), Coaxial and Waveguide calibration kits for the HP8510 automatic network analyzer, new mm waveguide devices, and 1.05 maximum VSWR waveguide to coaxial end launch adapters. **Maury Microwave Corp., Cucamonga, Calif. INFO/CARD #154.**

Oakbury Components: SAW, Radar and Test Products

A representative for a number of major electronics companies, Oakbury features SAW products from Siemens, emphasizing their pulse compression subsystems. Radar Technology, Inc. hybrid log amplifiers are also on display, along with Berkshire Technologies' LNAs and amplifier test equipment. Oakbury has announced the introduction of cost effective microwave amplifiers for 2 to 18 GHz, to be made at MM '86. **Oakbury Components, Newbury, Berkshire, U.K. Please circle INFO/CARD #151.**

Chase Electronics: Low Cost Spectrum Analyzer

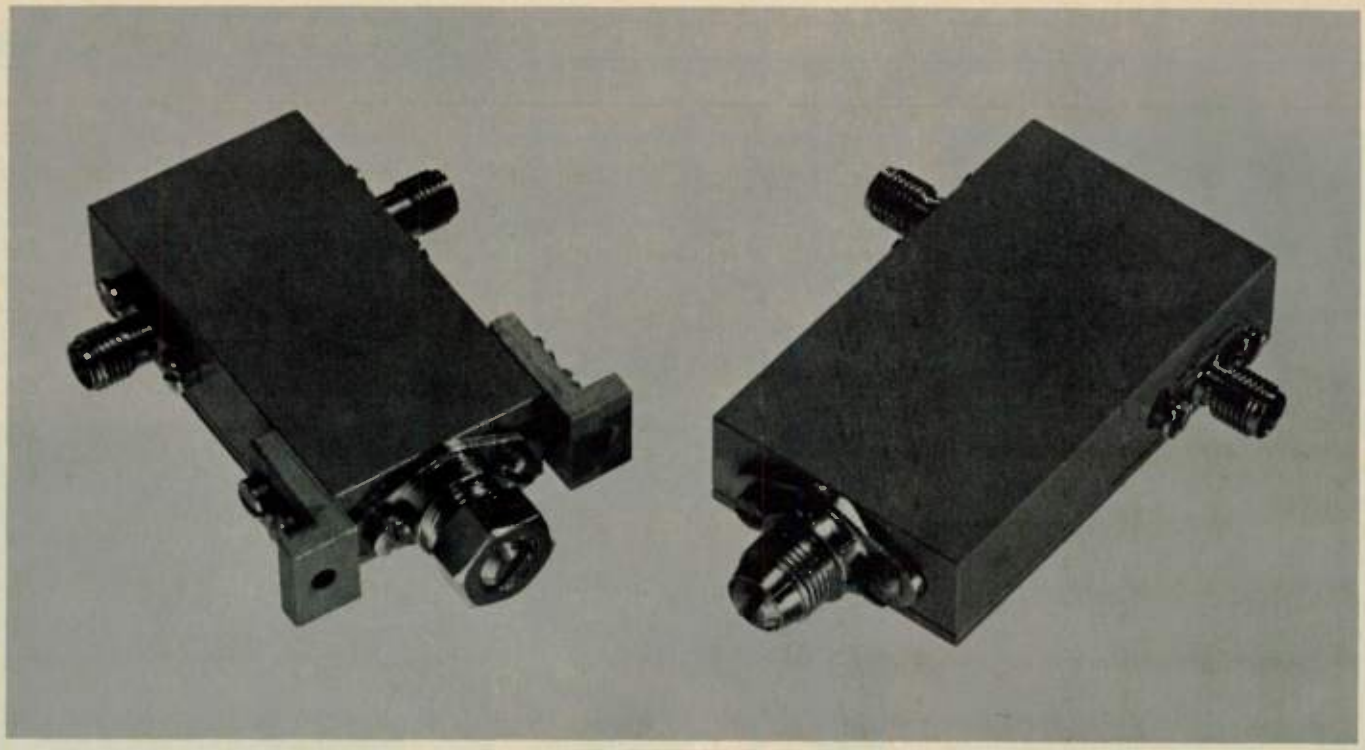
The new Advantest model TR4131 spectrum analyzer covers 10 kHz to 3.5 GHz in a low cost, portable model. Formerly Takeda Riken, Advantest introduces other test instruments at the Chase display, including the TR4133A 100 kHz to 20 GHz portable spectrum analyzer, the TR4173 100 Hz to 5 GHz spectrum/network analyzer, and the TR5214 90 GHz microwave counter. Also on display is the TR4511 combined signal source, synthesizer and sweeper which has exceptionally wide (>25 MHz) FM modulation capability. **Chase Electronics, Mortlake, London, U.K. INFO/CARD #153.**

Watkins-Johnson: Microwave Systems and Devices

Watkins-Johnson spotlights their latest products in microwave electronics systems and components for military applications involving reconnaissance, surveillance, communications, countermeasures and testing. **Watkins-Johnson Company, Palo Alto, Calif. INFO/CARD #152.**

Castle Microwave: VCOs, GaAs FETs, Log Amps

Magnum Microwave's expanded line of VCOs and communications mixers are featured at the exhibit of microwave distributor Castle Microwave, along with NEC's new series of internally matched power FETs with up to 6 watts output. Planar Microwave (a division of Raytheon) has a new hybridized detector log video amplifier (DLVA), and Ferretec introduces



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INFO/CARD 30

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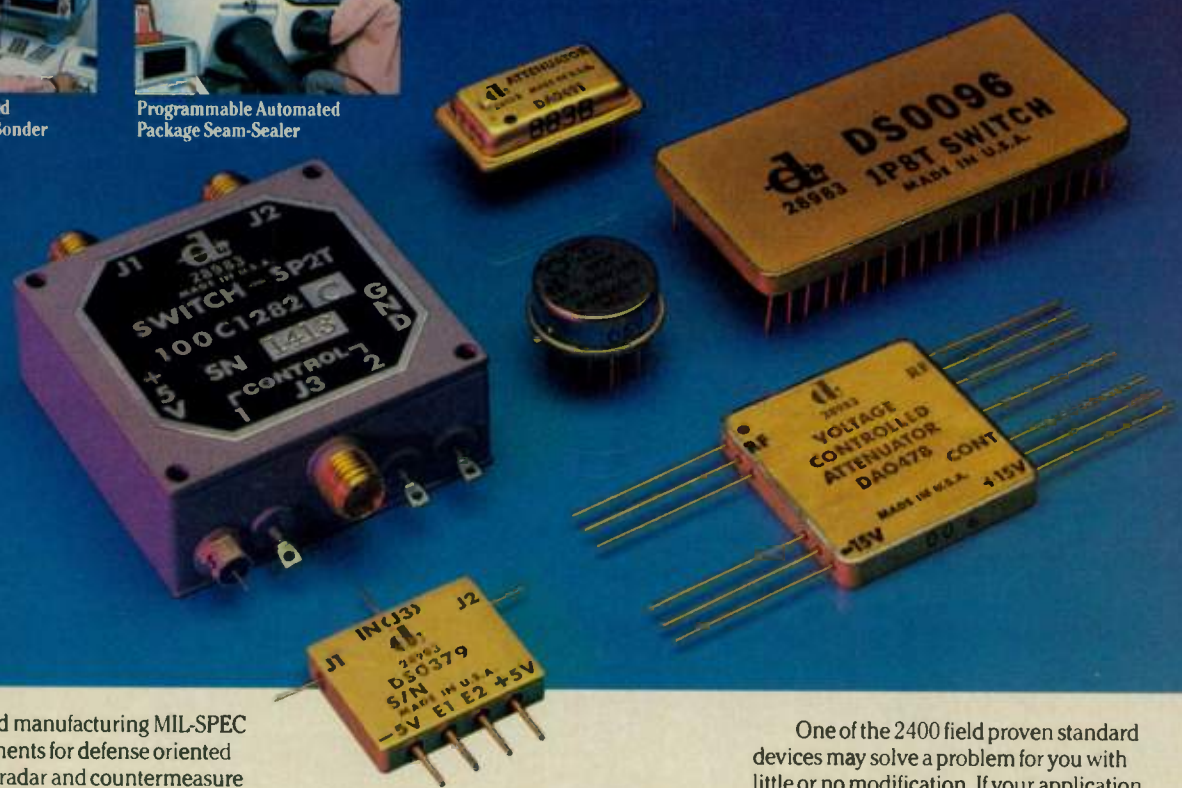

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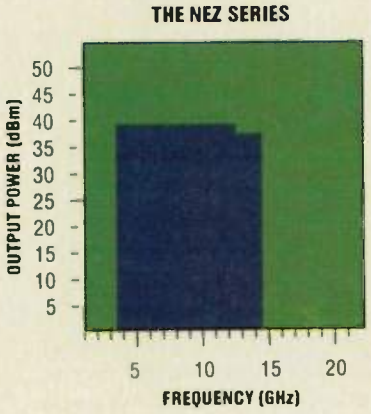
INFO/CARD 32

LINEARITY IN POWER GaAs FETs



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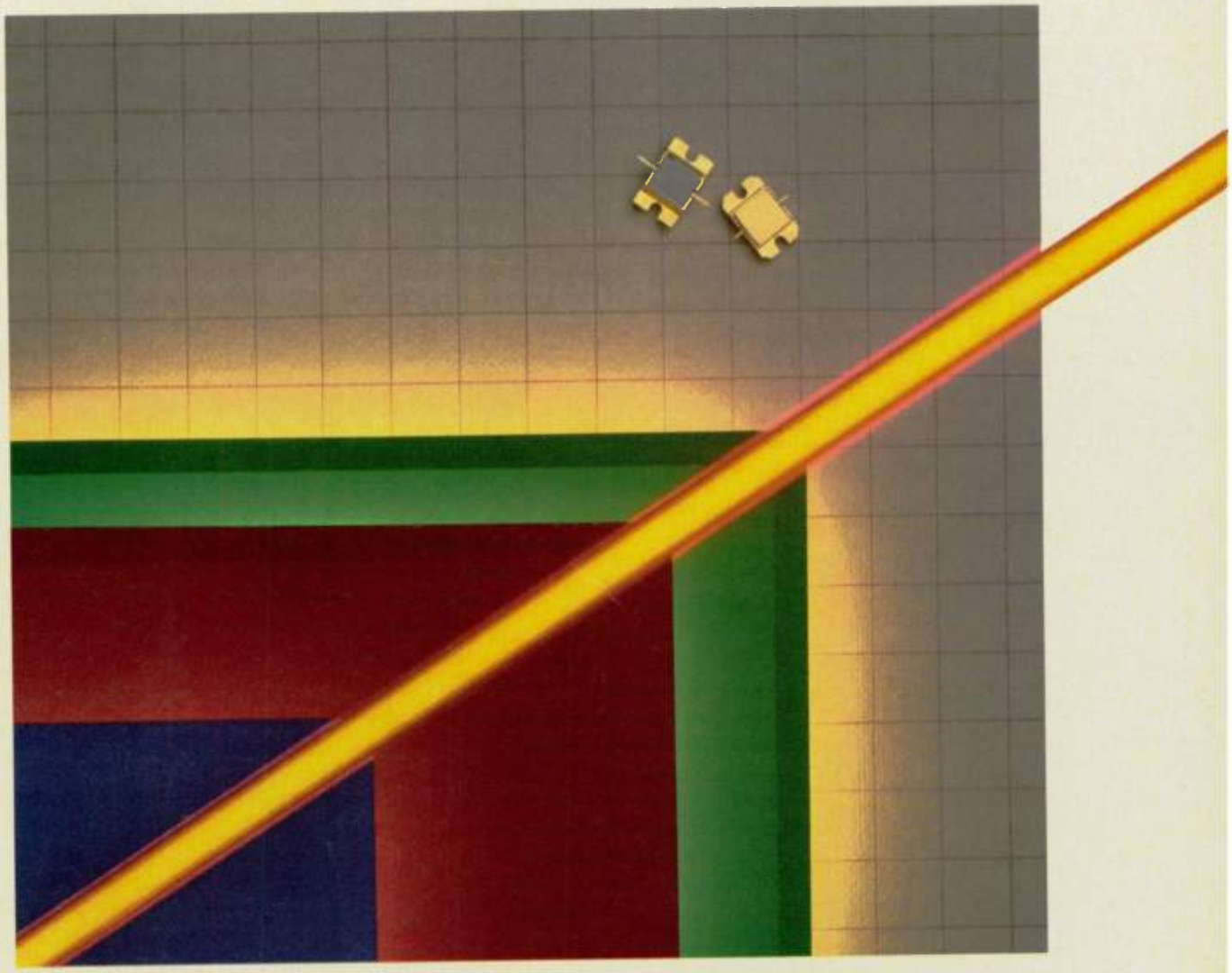

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INFO/CARD 33

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For complete information about this product, contact: W.L. Coyle, Locus, Inc., P.O. Box 740, State College, PA 16804, or call (814) 466-6275.

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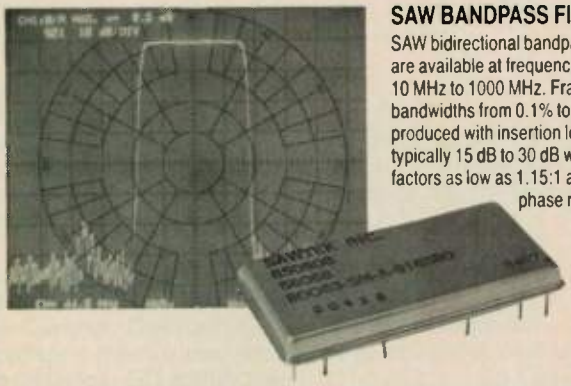

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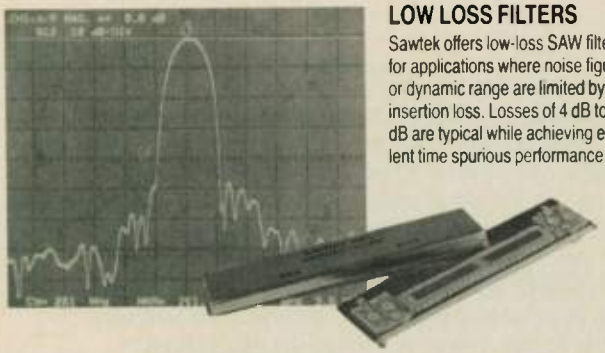

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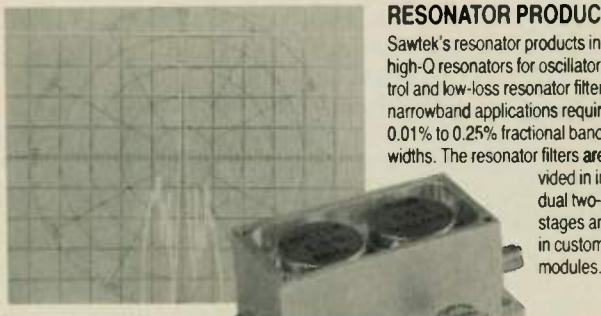
Sawtek offers low-loss SAW filters for applications where noise figure or dynamic range are limited by filter insertion loss. Losses of 4 dB to 10 dB are typical while achieving excellent time spurious performance.



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Sawtek's resonator products include high-Q resonators for oscillator control and low-loss resonator filters for narrowband applications requiring 0.01% to 0.25% fractional bandwidths. The resonator filters are provided in individual two-pole stages and in custom modules.

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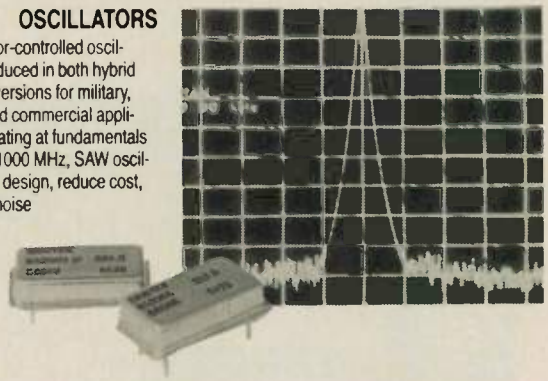

DELAY LINES

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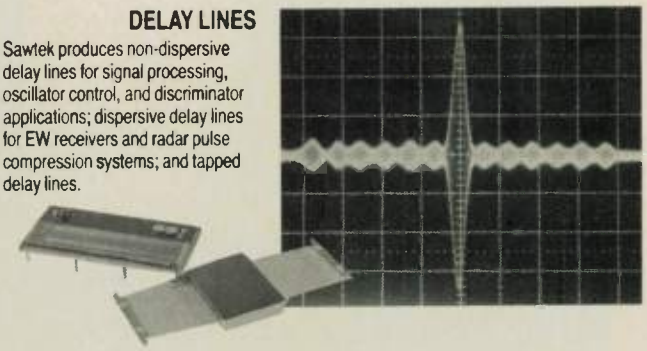

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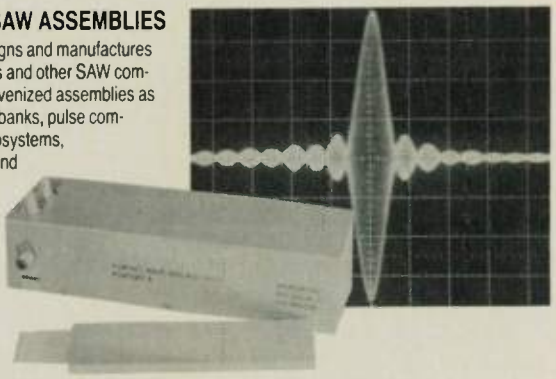

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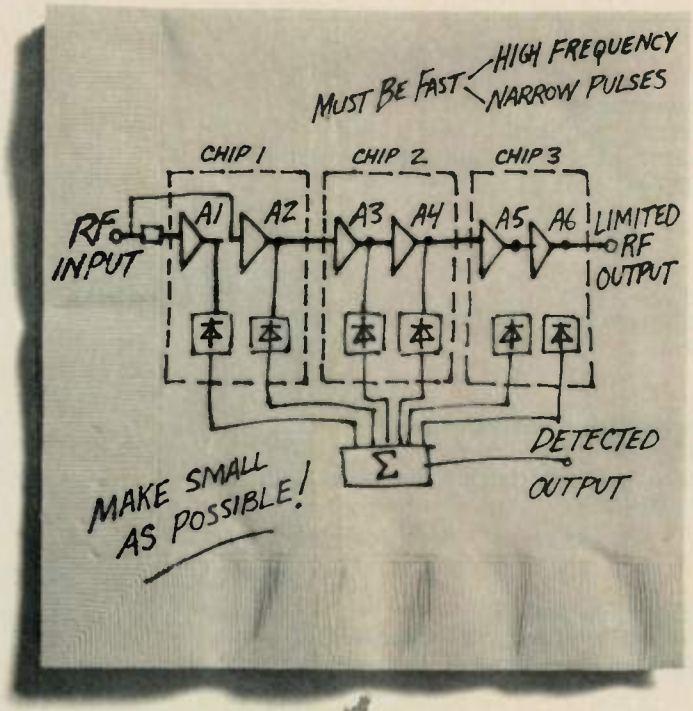

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PLESSEY

INFO/CARD 38

Simple Technique Speeds PLL Lock-in Time

By Daniel Marz
General Instrument, Jerrold Division

This note describes a method by which PLLs using the 4046 phase detector can easily be modified to speed up the lock-in process. Although the technique can be used with nearly any PLL design, this implementation for the 4046 uses a minimum of additional components (and cost).

A well known technique to reduce the lock-in time of PLLs consists of increasing the natural frequency of the loop during acquisition. This is usually accomplished using additional circuitry (several ICs) that detects the unlocked condition and changes the value of the integrator resistor (R1 in Figure 1).

A novel technique can be used when the 4046 is chosen for the phase detector. This IC has a pseudo unlocked condition detector that is accessible to the designer through pin 1. We can connect pin 1 to the control pin of an analog switch, paralleling a small resistor (R2) with R1 during acquisition.

Those that know the 4046 will object that the output of pin 1 is a pulsing signal, not a logic 0 or 1! That's right, and the consequence is that R2 will be in the circuit only part of the cycle (when pin 1 is low), so its effective value will be:

$$R_{eff} = [(R1||R2)\ t1 + R1\ (T - t1)]/T \quad (1)$$

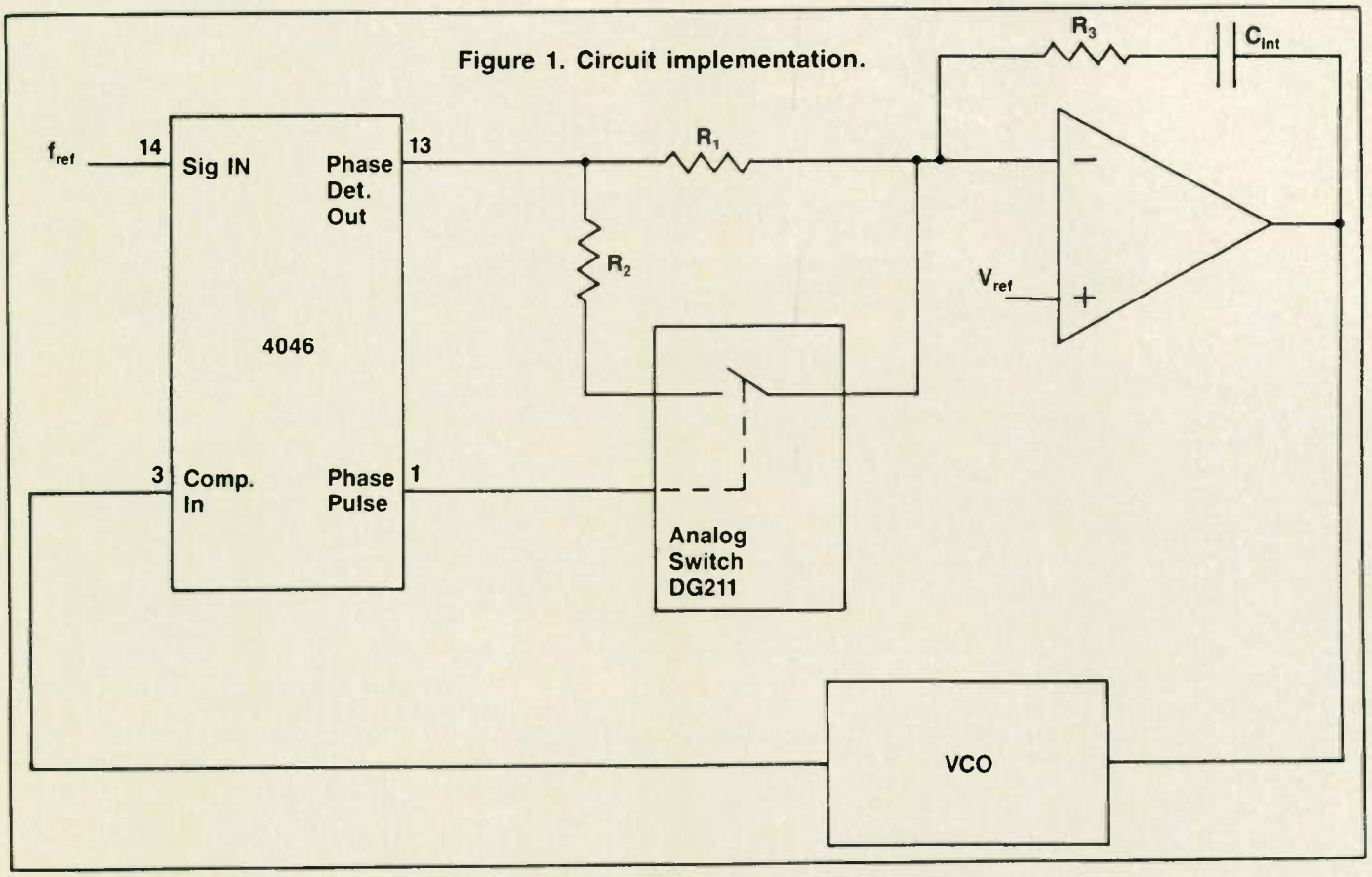
where,
R_{eff} = the averaged integrator resistor.
t1 = the time that pin 1 is low.
T = the reference period.

Remember that the duty cycle (t1/T) of the pulse stream at pin 1 is an inverse function of the difference between the input (reference) and VCO frequency. The result is that the integrator's time constant is a function of time and tends towards its "normal" value (R1C1) as long as the loop is acquiring lock. When t1 is not wide enough to toggle the switch ON, the loop will proceed normally to lock.

About the Author

Daniel Marz is a Project Engineer with the Jerrold Subscriber Systems Division of General Instrument Corp., 2200 Byberry Road, Hatboro, PA 19040.

Figure 1. Circuit implementation.



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JET	ICH*	25–50	1.5 MW	20 seconds
JT-60	ICH*	110–130	750 kW	10 seconds
JFT-2M	ICH*	10–40	1.5 MW	300 milliseconds
KFA-Textor	ICH*	29–59	1.5 MW	3 seconds

*ICH = Ion cyclotron heating

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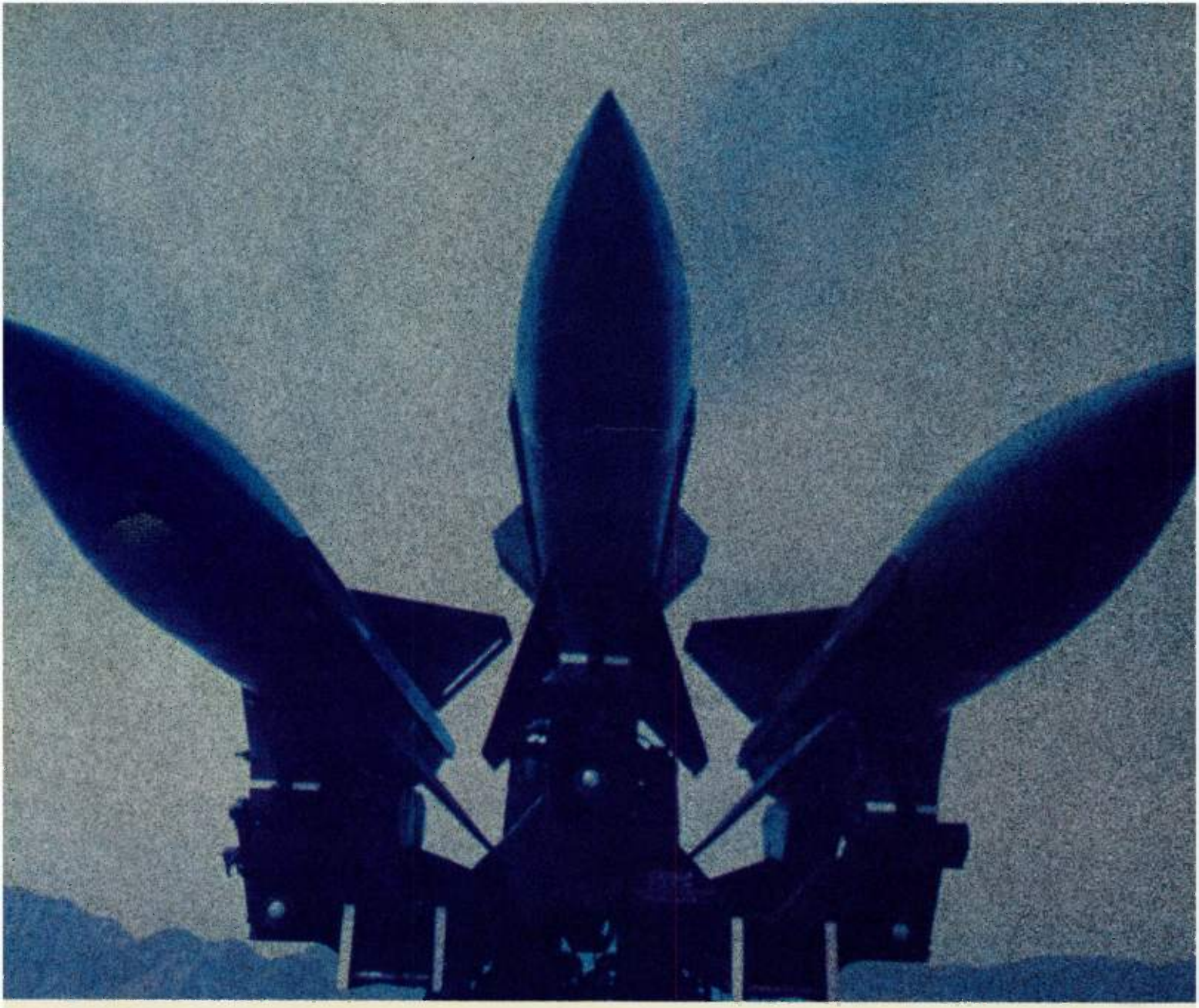
INFO/CARD 177 LITERATURE

INFO/CARD 178 DEMONSTRATION



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INFO/CARD 44

A Precision Frequency-to-Voltage Converter/Demodulator

By Vladimir Shvartsman
Electronic Design & Research Co., Inc.

This article describes a new (patent pending) method which digitally converts frequency to voltage. Originally developed as part of the author's biomedical research, this precision demodulator has many applications where wide-band, low noise and high resolution frequency-to-voltage conversion is advantageous, including FM demodulation and phase locked loop (PLL) phase detection.

The circuit operates by examining (discriminating) each individual pulse applied to it, passing only those whose duration falls into a predetermined "window." With a zero crossing detector used to generate the pulses from the incoming signal, the usual limiting amplifier is unnecessary. A high quality IF filter is also unnecessary, since the circuit acts as an "ideal" filter, giving it a high level of noise immunity.

Additional applications in the RF realm include using the demodulator in rapid scanning emitter identification systems or in FM-based spread-spectrum schemes. With operating parameters determined by an oscillator and frequency divider, programmable operation of the demodulator is quite straightforward.

This recently developed unique circuit (1, 2) for precise pulse-width discrimination has opened a wide field of applications. It works by comparing the duration of an input pulse width to a time interval developed by a precision oscillator in combination with a counter (3). (Figure 1.) An input signal enables a train of clock pulses within its duration to be applied to the resettable up counter (C). If the number of clock pulses are greater than or equal to the number set by the counter, its ripple clock output produces an output pulse which initiates the monovibrator (M2). A negative-going transition of an in-

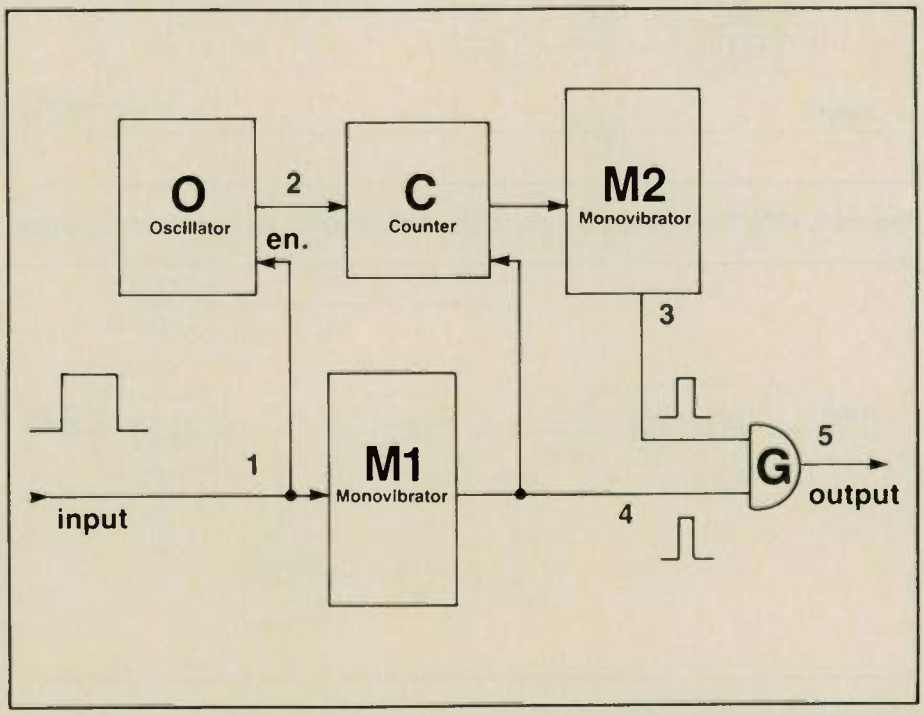

Figure 1. Block diagram of the perpetual pulse-width discriminator (PPWD).

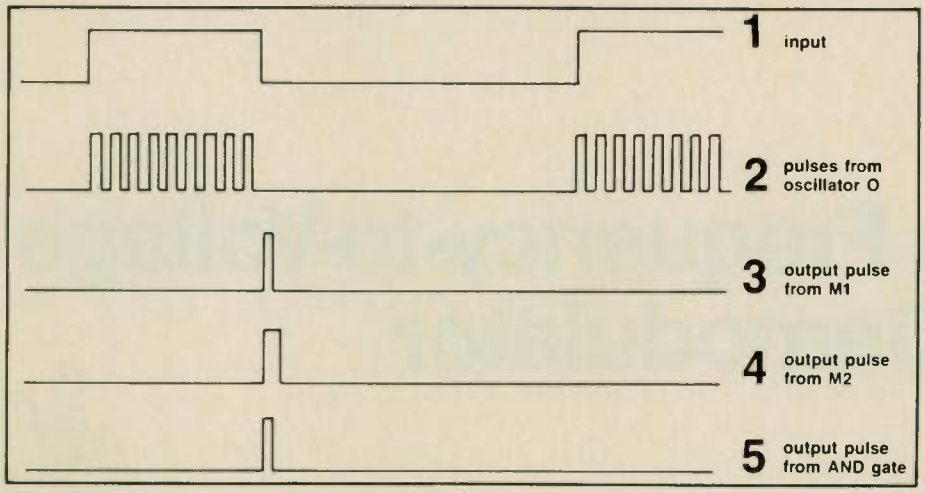

Figure 2. Time diagram of the PPWD.

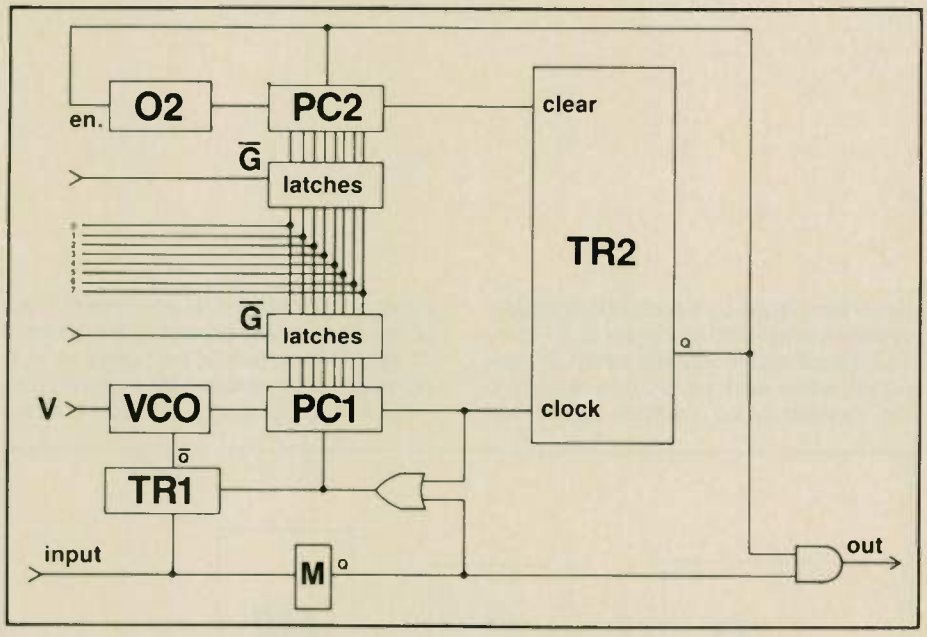

Figure 3. PPWD with digitally-controlled bandwidth and center frequency.

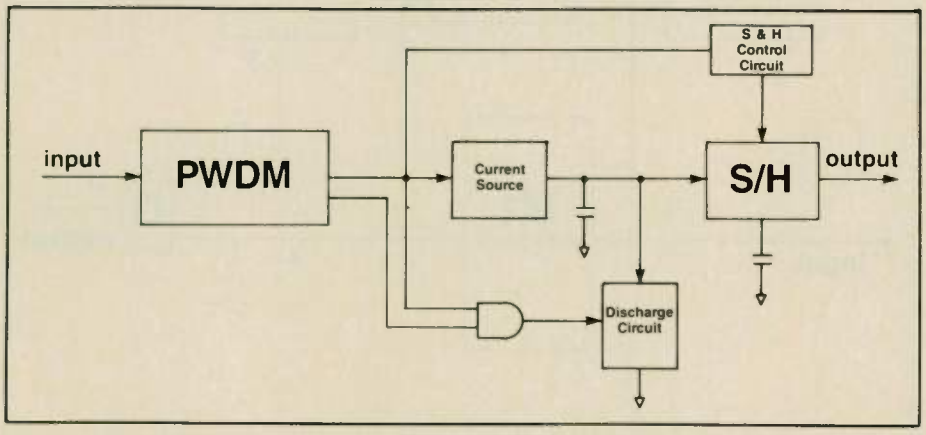

Figure 4. Functional diagram of frequency-to-voltage converter/demodulator (FVCD).

put pulse causes the monovibrator M1 to produce a very short pulse. As shown in Figure 2, the output pulse of the AND gate (line 5) will exist only when the output pulse from M1 (line 4) and M2 (line 3) coincide. This basic diagram will make it possible to detect a predetermined (basic) duration input signal and multiples of a basic duration. This configuration was explored for pulse sorting applications.

Figure 3 shows a pulse width discriminator with a digitally controlled bandwidth and a middle frequency. This is a modification of the original circuit, adding a second oscillator (O2), programmable counters (PC1 and PC2), latches and a flip-flop (TR1). The PC1 output pulse on the input of the TR1 causes the level of the Q output of TR1 to change from LOW to HIGH. During the HIGH time the clock pulses from O2 are applied to the input PC2. When a number of pulses reaches a preset value, the PC2 generates an output pulse. This output pulse will change the output level of the flip-flop (TR2) from HIGH to LOW. These transactions form a tolerance of window (bandwidth). This circuit has a unique, dual way to adjust its discrimination for a specific frequency or duration of an input signal, accomplished by changing the frequency of the voltage control oscillator (VCO) or counting mode of the PC1. The borders of detected durations can be calculated as follows:

shortest duration: $T_s = T_{O1} \times C_{mod1}$ (1)

longest duration: $T_1 = T_s + T_{O2} \times C_{mod2}$ (2)

where:

T_{O1} = period of the oscillator, O1
T_{O2} = period of the oscillator, O2
C_{mod1} = counting mode of the counter, PC1
C_{mod2} = counting mode of the counter, PC2

Frequency to Voltage Converter/Demodulator (FVCD)

The pulse width discrimination principle described above is simple, yet very precise. Based on this design, several uses have been developed. One of its applications is the development of a variable-band FVCD. The FVCD consists of two major blocks: (1) A Pulse Width Discriminator/Modulator (PWDM) and (2) A Pulse Width Demodulator/Integrator (PWDI). This device produces a DC output in direct proportion to a frequency (pulse duration) of an input signal. This applies only to the input signal which is a limited frequency band (4).

The input signal is pre-filtered (within a frequency band) and converted into a

square waveform signal, which is applied to the PWDM. The PWDM performs two functions: discriminates input pulses by their duration and, if the duration of an input signal falls within a predetermined interval, converts it into an output pulse with a duration varying from 0 (zero) to C (some constant), as follows:

$PWM_O = 0$	for $P_{w.in} = < T_s$
$0 < PWM_O < C$	for range of duration $T_s < P_{w.in} < T_1$ (3)
$PWM_O = C$	for $P_{w.in} > = T_1$
where PWM_O	= duration of output pulse
$P_{w.in}$	= duration of input pulse
T_s and T_1	from (1) and (2)
C	= some constant

Generally speaking, the PWMD presents a non-uniform sampling, trailing-edge modulation. In this case, the information is encoded into the width of the pulse with the pulse amplitude held constant. To demodulate PWM each pulse was integrated and the maximum value sampled, held and low-pass filtered, as shown in Figure 4.

Figures 5 and 6 show a simplified circuit diagram of the FVCD and its time diagram. In the following description, refer to both figures. A line number (Figure 6) represents a voltage condition at the point marked in Figure 7. To simplify the description and to decrease a number of illustrations, Figure 6 depicts three input signals with a different duration. The operation of the circuit is as follows: the input signal, with "any" duration (short, normal and long) due to different frequencies, as shown in Figure 6 (line 1), triggers the flip-flop HC107. The Q output of the flip-flop enables an oscillator for the duration it stays HIGH (line 9). The oscillator was built to ensure reliable starting without the use of critical components, using an AND-Gate high-speed CMOS crystal oscillator. Frequency depends on the crystal and has an upper frequency limited to about 30 MHz. Temperature stability is adequate for crystal clocks and other digital-system applications.

A train of pulses from the oscillator is applied on the clock input of the up-counter HC4040. This device is an asynchronous 12-stage binary counter with the outputs of all stages available externally. Figure 5 shows that only eight outputs were used to discriminate the frequency band in this application. Of course, it should be

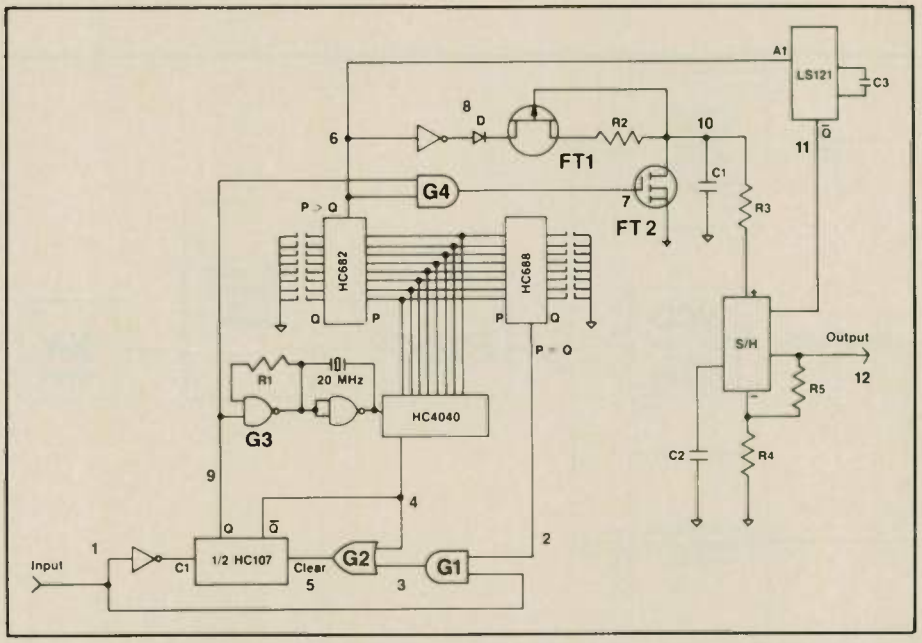

Figure 5. Simplified circuit diagram of FVCD.

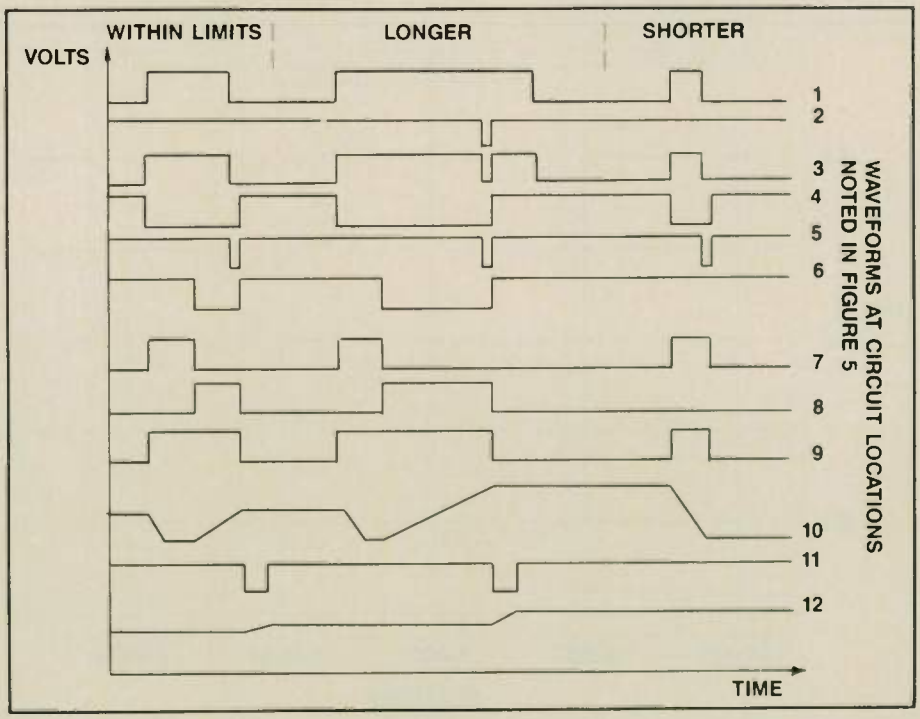

Figure 6. Time diagram of the FVCD.

understood that all of the parameters mentioned here are illustrative and provided for the purpose of explanation and not a limitation of the resolution (setting of a bandwidth and middle frequency). The circuit has the ability to discriminate an incoming signal with a theoretically unlimited resolution. The counter is reset by the Q (HIGH) output of the flip-flop (line 4). The P=Q output pulse (line 2), in combination with the input signal and the Q output, are used through AND and OR gates to clear the flip-flop (line 5). The flip-flop can be cleared either by the trailing edge of the input pulse or the P=Q output pulse. Only one enabled pulse (the Q output of the flip-flop) can be generated during these transactions, though the length of the input signal could be much longer.

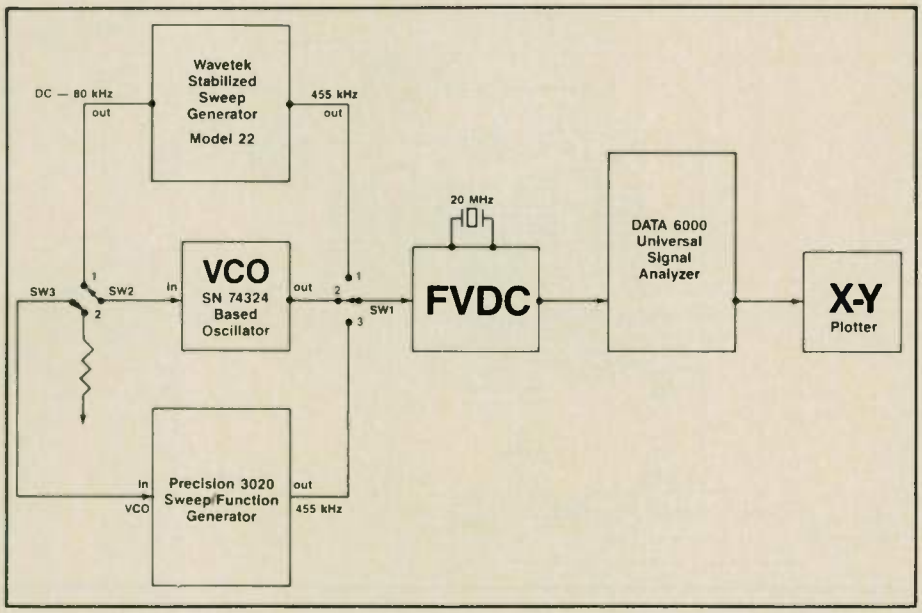

Figure 7. Experimental setup.

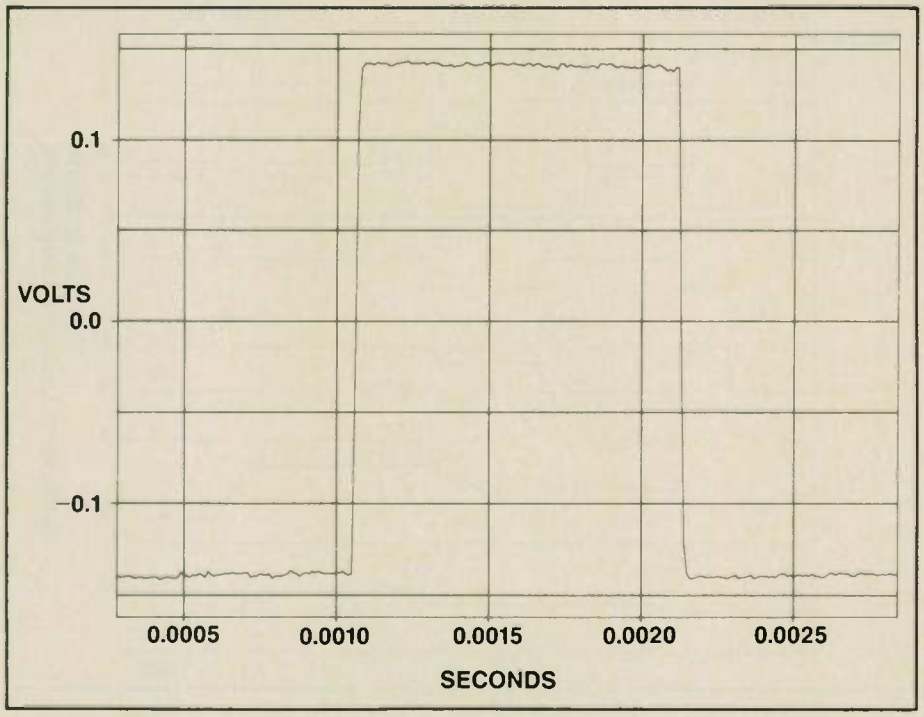

Figure 8. Small-signal stop response of FVCD.

An 8-bit magnitude comparator (HC682) and an 8-bit identity comparator (HC688) perform comparisons of an 8-bit output of the counter. These two comparators are set to detect the two extreme limits (bandwidth) of the duration of an input signal. The P=Q (identity comparator) output (line 2) generates a pulse when two eight-bit binary words (P input and Q input) become equal. The P>Q (magnitude comparator) output will change its status (from HIGH to LOW) after an eight-bit binary word on input P becomes larger than on input Q (line 6). The inverted P>Q output pulse (line 8) is applied on the input of the PWDI.

The discrimination ranges are simple to set. There are two parameters to be known: A basic frequency of the internal oscillator (F_b), and a discriminating coefficient (N). To calculate the range, the following equation can be used:

$$N = F_b/F_d \qquad \text{for } F_b >> F_d \qquad (4)$$

where N = discriminating coefficient

F_b = basic frequency of the internal oscillator

F_d = discriminating frequency

The basic frequency of the oscillator we have chosen is equal to F_b = 20 MHz. For this example, the frequency band from 430 kHz to 480 kHz (455 +/− 25 kHz) was chosen. By using equation (4):

N (low) = 20,000/430 = 46.51

N (high) = 20,000/480 = 41.67

If we set a low limit at N = 47 (binary 11110100) for the lowest frequency (longest duration) and a high limit at N = 41 (binary 10010100) for the highest frequency (shortest duration), the resulting band pass is 425.532 kHz to 487.805 kHz. The Q inputs of the HC688 and the HC682 are set as shown in Figure 5. An ungrounded input means "1" or "HIGH" and a grounded means "0" or "LOW." The above example shows that the accuracy of setting the limits depends on the frequency of the internal oscillator. In the application where the accuracy of setting the bandwidth is important, a higher frequency of the internal oscillator has to be chosen. For example, using a frequency of 100 MHz, N (low) = 233 (in this case, at least a 10-bit comparator has to be used) this makes low frequency rejection equal to 429.2 kHz, much closer to our (430 kHz) desirable corner.

The P>Q output pulse is pulse width modulated (PWM). Only its width carries useful information. There are several methods that can be used to demodulate the PWM signal. An R-C based integrator is an inexpensive and simple solution, but it could be difficult to achieve satisfied frequency band and dynamic range. Figure 5 shows a more sophisticated approach, where each pulse is integrated and the maximum value of it sampled, held and low-pass-filtered. The pulse discharges through a low R_{ds} (ON) resistance of less than 30 ohms.

Performance Results

The performance of the FVCD circuit was evaluated by the experimental set up shown in Figure 7. The FVCD output waveforms were stored in the DATA 6000 (a universal waveform analyzer by Data

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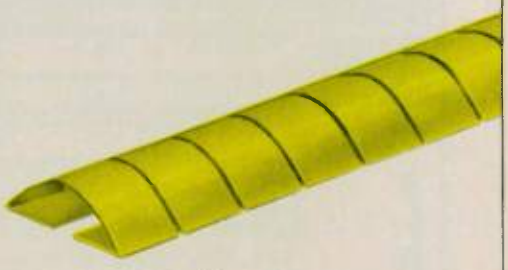

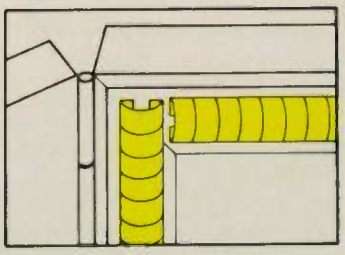

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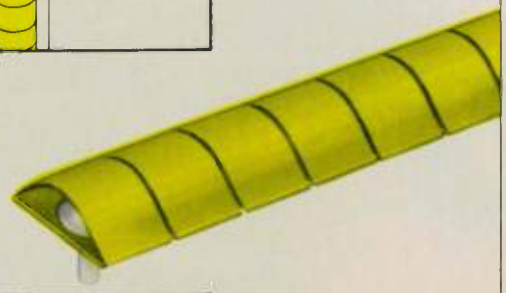

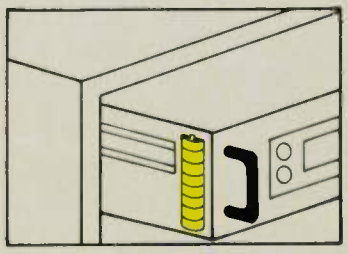

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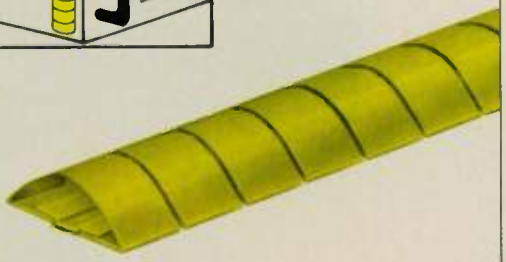

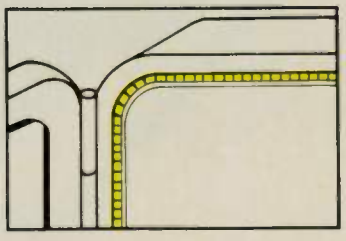

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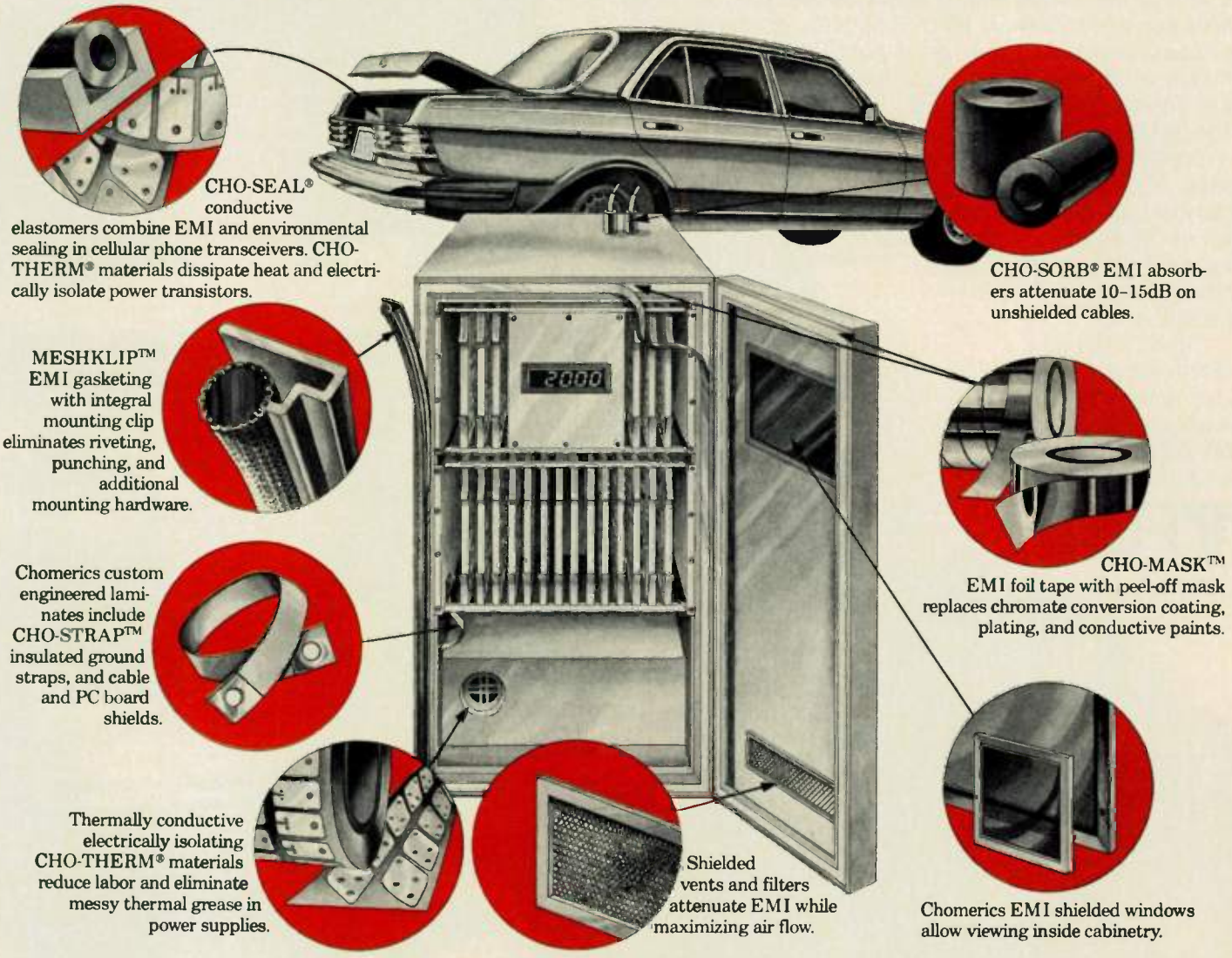

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Precision) and plotted on an HP 9278B X-Y Plotter. Switch one (SW1), Switch two (SW2), and Switch three (SW3) were used to set all experiments described below. The first result was obtained by turning the SW1 to position 2 and SW2 to position 1, where the FVCD processed a 455 kHz carrier frequency FM modulated by a signal from the Wavetek unit. The small step response of the system is shown in Figure 8. The signal output is swinging −140 mV and +140 mV, for an input step of 454.200 kHz to 455.768 kHz. The large step response of the system is shown in Figure 9. The signal output is swinging .3 V and 10.3 V for an input step of 419 kHz to 475 kHz. In both cases, the FVCD response remains well controlled and there is no indication of any irregularity during the transitions.

To determine the dynamic range of the system, an unmodulated carrier (455 kHz) was applied to the FVCD. Three generators were used, an SN74324 based oscillator, Wavetek model 22, and B&K Precision 3020, to obtain the results. The SN74324 based oscillator was designed to generate a 455 kHz carrier frequency. Figure 10 shows a result of those measurements, with results plotted in same scale and at same bandwidth. The SN74324 based oscillator shows the best short-term stability of the three, but its output frequency was somewhat sensitive to the power supply (Figure 10, top recording). Its short-term frequency fluctuation (which contributed to the FVCD output voltage variation) was much higher than the background noise of the FVCD. The absence of a low level noise oscillator made it difficult for us to measure the FVCD background noise. To reduce the noise of the VCO, a very low noise 5 V power supply was built. The noise level was measured and calculated as follows:

1. A level of noise was measured: 1.35 mV (RMS) with a 455 kHz unmodulated carrier.

2. One millivolt (RMS) of 1 kHz was applied on the VCO input and the output result was measured again. It was equal to 57.06 mV (RMS).

3. From the above, calculations were performed and it was found that the sensitivity (background noise) was less than .023659 mV (RMS). This noise level made the resolution equal to .1324 Hz or .0000291% at a 455 kHz carrier frequency. The dynamic range of the system was equal to 112.5 dB (for 100% modulation and 56 kHz frequency swing).

The above calculation was made under the assumption that with a "new" power supply the VCO has become a noiseless oscillator. It is obvious, that the obtained "background" noise is a sum of noises from two sources: the FVCD background noise and the VCO noise.

Figure 11 was prepared to illustrate the high linearity of the FVCD. The frequency response of the system, when driven with sinewave excitation, is shown in Figure 12.

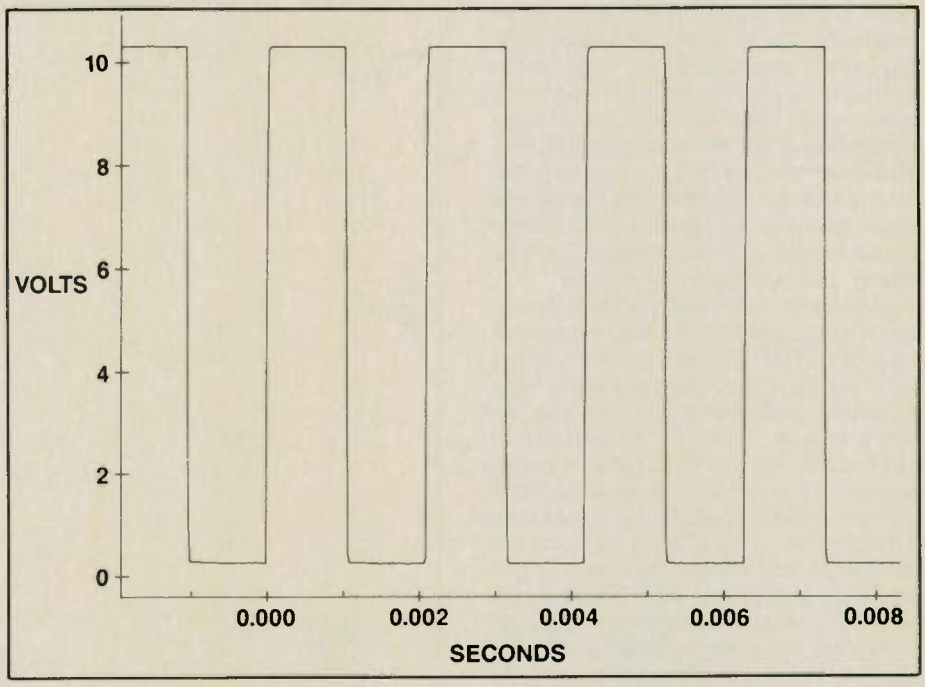

Figure 9. Large-step response of FVCD.

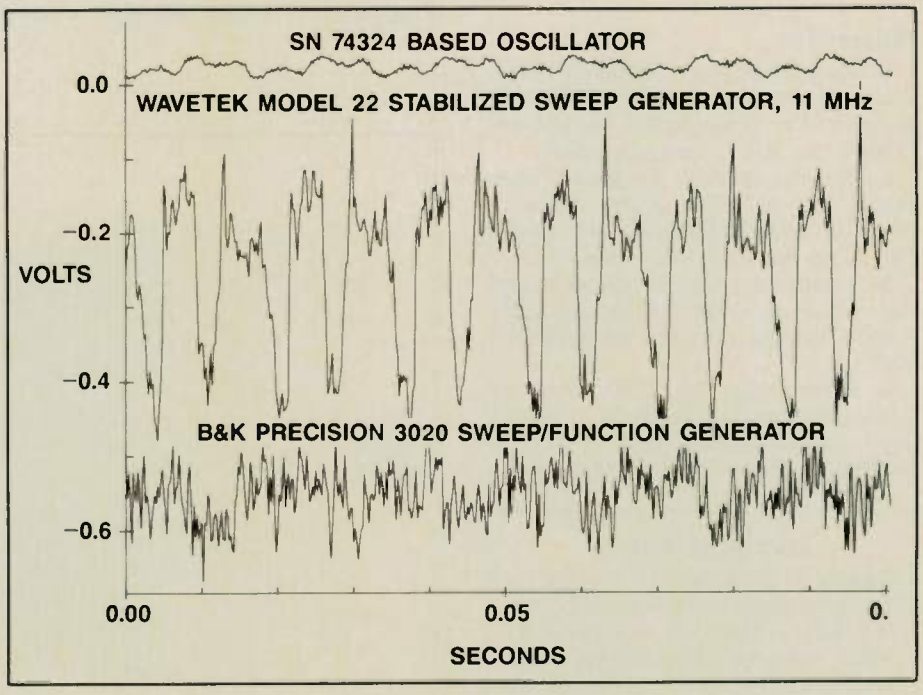

Figure 10. Stability comparison of three sweep generators.

Conclusion

It was found that the Frequency-to-Voltage Converter/Demodulator could detect signals in a linear region over 112 dB dynamic range for roughly 80 kHz band-

width signals around a 455 kHz carrier frequency. The FVCD can be adjusted to any carrier and bandwidth, with proper components chosen for high frequency applications. The FVCD background noise is extremely small, better than 200 nV/√Hz. This level of noise made us believe that in a practical situation the resolution would be limited by the level of noise from the source (for example, from an FM modulator), but not the FVCD's noise.

The design described above has numerous applications in the field of communication: DTMF, process control, voltage isolation, frequency and pulse width measurement techniques, and data-acquisition problems. Some of the beauties of this circuitry are: the FVCD can be implemented in a single IC chip (absence of an inductor makes it possible) and, because it has provisions for a digital control of the bandwidth and middle frequency, it can be easily adapted to a CPU based system. The FVCD circuit shows a very high resolution, super high stability and insensitivity to interference. It can make a major contribution to the communication and measurement fields. rf

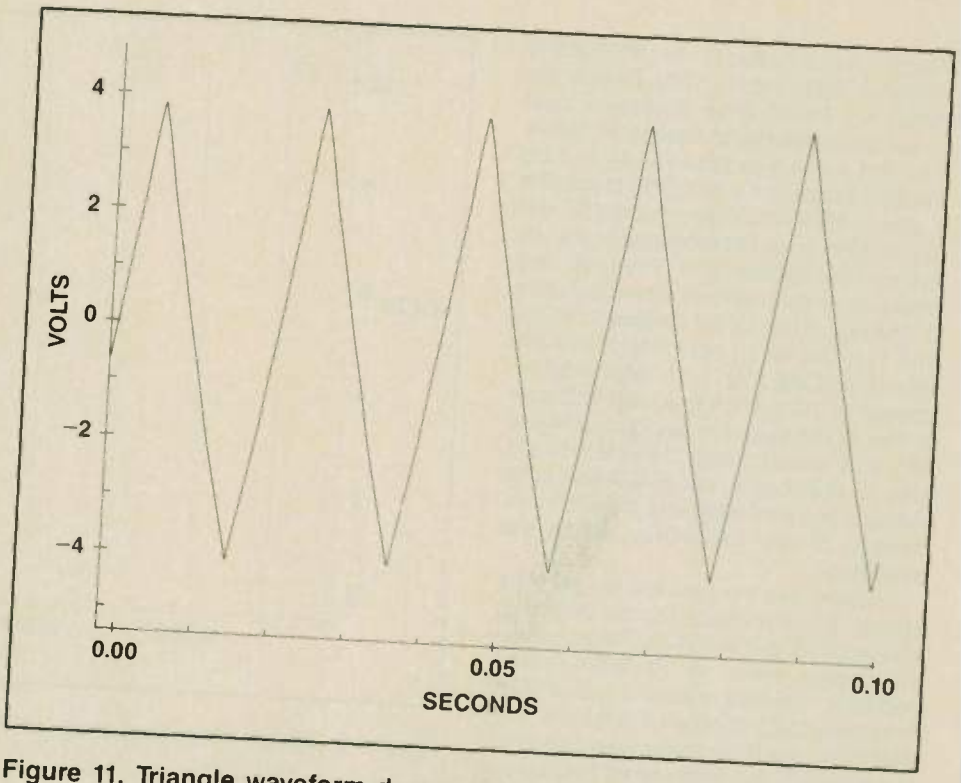

Figure 11. Triangle waveform demonstrates linearity of FVCD.

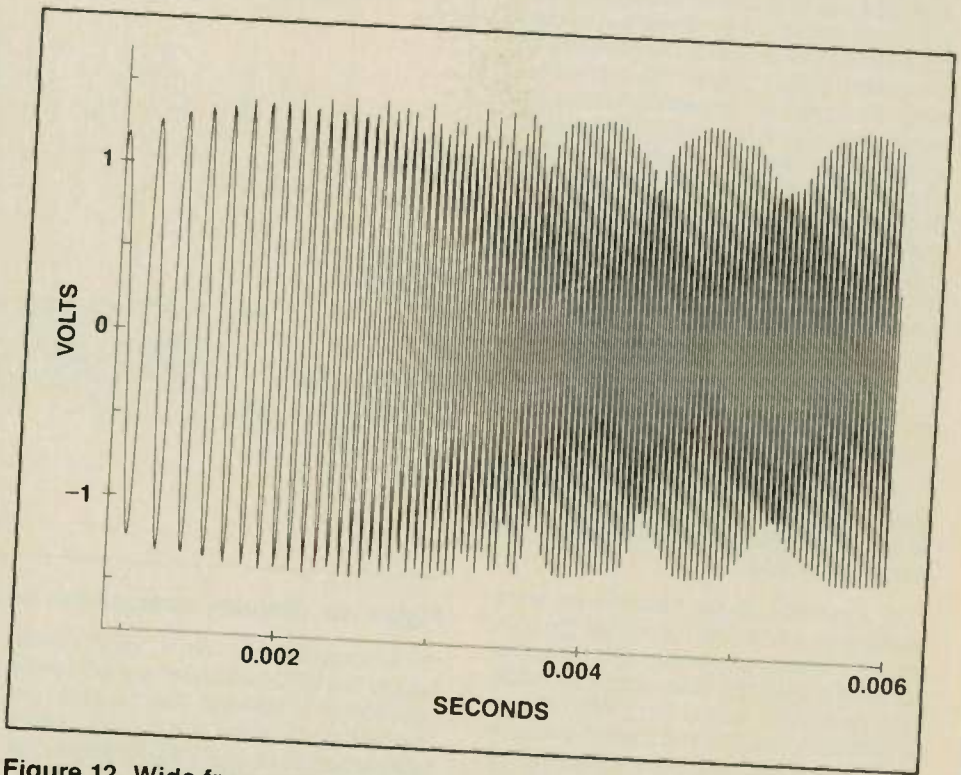

Figure 12. Wide frequency response of FVCD with swept sine wave input. Amplitude variation is due to aliasing in the DATA 6000 oscilloscope, not performance of the FVCD.

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2. Shvartsman, A.V., "Perpetual Pulse-Width Counter," IEEE Trans. on Instrumentation and Measurements, Vol. IM-34, Part II, pp. 620-623, December 1985.
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4. Shvartsman, A.V., "High Sensitivity F-to-V Converter/Demodulator," Proceedings of the IEEE/IMTC/86 Conference, Boulder, Colorado, March 25-27, 1986.

About the Author

Vladimir A. Shvartsman is president of Electronic Design & Research Co., Inc., 770 Medical Towers S., Louisville, KY 40202. He has a BSEE and MEE from the University of Leningrad Polytechnic Engineering and a Ph.D. degree in biophysics from Jdanov Memorial University. He has developed and patented techniques in very low level real-time signal processing, analog data compression, communication, and noninvasive diagnostic technology. He can be reached at the above address or by telephone at (502) 589-9968.

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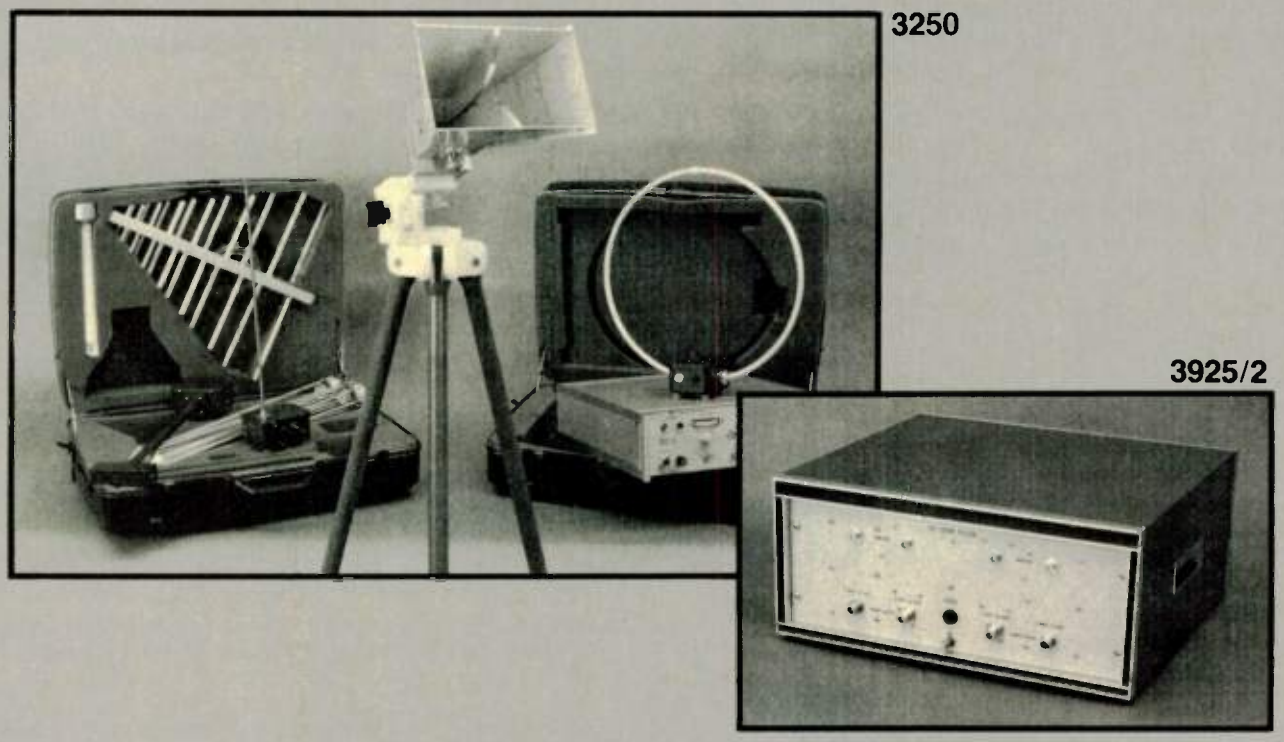

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Understanding TEMPEST Requirements

Part I: "Red" Signals, "Black" Signals and National Security

By Michael L. Brooks,
Teledyne Systems Company

A complete understanding of the implications of TEMPEST requirements is essential in defining the applicable cost and schedule impacts. These cost and schedule impacts will be the result of additional design tasks necessary to control classified information within the confines of a system or piece of equipment. This article provides a sufficient background in TEMPEST definitions, requirements, and design techniques so that a government contractor can be aware of these implications and, thus, create a product that is both properly designed and cost-effective.

The word "TEMPEST" is not an acronym, but is an unclassified short name referring to the study and containment of "compromising emanations." As stated in the TEMPEST documentation, these emanations are data-related or intelligence-bearing signals (in either conducted or radiated form) which, if intercepted and analyzed, would reveal national security information. The study of these TEMPEST emanations within a system or in a sub-system involves understanding *which* signals are to be protected, *from what* other signals they are to be protected, and *how* the signals are to be protected.

Those classified signals or signal-lines which are to be TEMPEST-protected are defined as "Red." The unclassified signals or lines from which these Red signals are to be protected (isolated or shielded) are defined as "Black." Therefore, the term "Red/Black" implies an interface or junction between Red and Black signals, which involves major design considerations (as will be discussed later). The emphasis in TEMPEST designs is to contain the Red information to the Red circuitry, signal-lines, or compartment and prevent it from being either conducted or radiated onto Black circuits or lines.

The terms "Red" and "Black" should not be confused with the respective terms "secure" and "clear." These terms are not synonymous: "Red" refers to classified signals or circuits while "secure" refers to encrypted information, and "Black" refers to unclassifed signals or circuits while "clear" refers to "plain-text" or unencrypted (de-crypted) information. Red and Black indicate the type of classification whereas secure and clear are equipment modes of operation. (Note from these definitions that a "secure Red" signal is also Black, and either Red or Black signals may be processed in the clear mode!)

Security Awareness

The classified TEMPEST documents referred to in this article contain Communication Security (COMSEC) information. As such, this information is strictly controlled by the National Security Agency (NSA) and is disseminated only on a "need-to-know" basis. As is stated in these documents, no person, solely be-

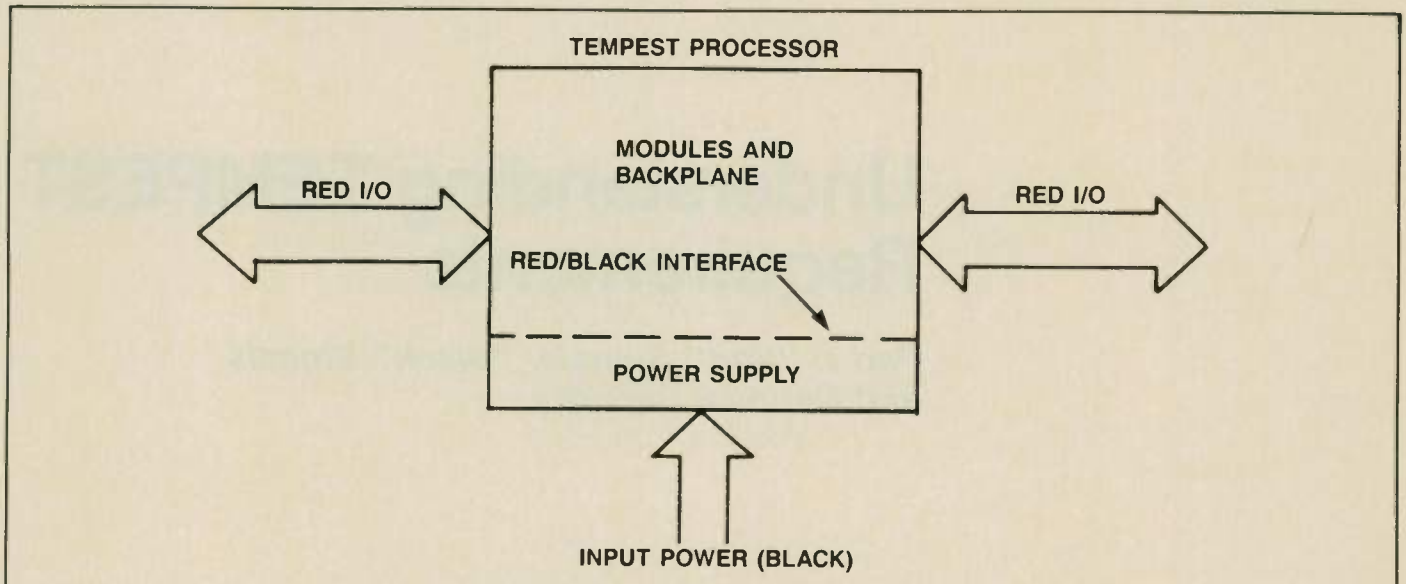


Figure 1. A simple Red/Black interface.

cause of his or her office, position, or security clearance, is entitled to knowledge of or access to classified TEMPEST information. Physical security of COMSEC documentation is just as important as the electrical/mechanical TEMPEST design. Classified COMSEC information cannot be discussed with anyone who has not had a COMSEC briefing. To do so would be a serious violation of national security (requiring the appropriate consequences). TEMPEST engineers and managers should be vigilant in ensuring that the appropriate and sufficient security precautions are administered whenever TEMPEST information is discussed.

These classified TEMPEST documents contain the following statement: "COMSEC Material — Access by Contractor Personnel Restricted to U.S. Citizens Holding Final Government Clearances." This statement indicates that all individuals having a "need-to-know" must also have the proper security clearance issued by the U.S. government; i.e., a *final* Confidential or Secret clearance. A COMSEC briefing is thus an additional requirement, distinct from the security levels of Confidential, Secret and Top Secret.

The security aspect surrounding TEMPEST engineering designs must be emphasized, since this COMSEC subject matter is concerned with the prevention of compromise of national security information in electronic form. The imposition of a TEMPEST requirement upon a system or subsystem demands that much attention be paid to the containment of the pertinent electronic classified information. A disregard for proper TEMPEST design constraints in the early stages of a design will create insufficient design criteria for final development (and a potential compromise of classified information).

The importance of the critical design constraints for TEMPEST compliance requires that the cognizant TEMPEST Engineer occupy a high-level position within the project organization, providing him or her with visibility and a command of the relevant design decisions. To ensure this, the TEMPEST design organization (or group) itself must occupy a preferred position within the company engineering organization. Program management must be aware of the TEMPEST requirements and depend on the TEMPEST Engineer for detailed design directions. A sufficient and complete TEMPEST design can never be achieved with a "design by committee" of unknowledgeable individuals.

TEMPEST Requirements

Most TEMPEST requirements at the unit or subsystem level will require compliance to NACSIM 5100A. (NACSIM is an abbreviation for "National COMSEC Information Memorandum, replacing the previous designation NACSEM.) This document describes the test limit requirements and test procedures for both conducted and radiated emanations. Guidelines for equipment design are given in NACSEM 5201, while NACSEM 5109 provides the fundamentals of TEMPEST testing. The titles of these and a representative sample of other classified TEMPEST documents are as follows:

NACSIM 5100A	Compromising Emanations Laboratory Test Requirements, Electromagnetics
NACSEM 5201	TEMPEST Guidelines for Equipment/System Design
NACSEM 5109	TEMPEST Testing Fundamentals
NACSEM 5204	Shielded Enclosures
NACSEM 5112	NONSTOP Evaluation Techniques
NACSIM 5203	Guidelines for Facility Design and Red/Black Installation

As previously defined, TEMPEST engineering is concerned with the containment of compromising emanations, or signals having a classified information content. This is the major difference between TEMPEST and Electromagnetic Interference (EMI), where EMI deals only with a design to control conducted or radiated signal levels regardless of their information content. Thus, an equipment can satisfy EMI requirements and not TEMPEST requirements, or vice versa. The important aspect of this difference is the intelligence contained in the detected signal and whether or not it can be correlated to Red data, which is the TEMPEST problem. EMI problems relate only to noise levels and not to any correlatable intelligence contained therein. MIL-STD-461/462 and NACSIM 5100A are companion EMI/TEMPEST documents for equipment-level testing, whereas MIL-E-6051 and NACSEM 5112 are companion documents at the system level. In addition to

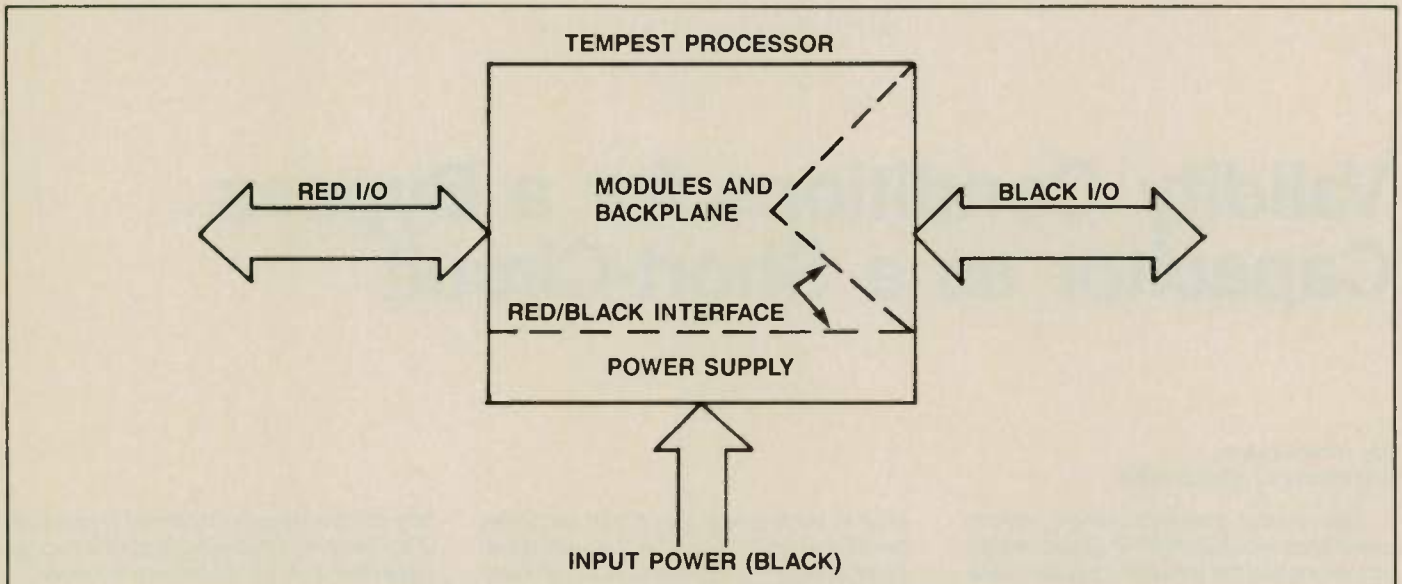


Figure 2. A more complex TEMPEST design.

NACSEM 5201 and NACSIM 5203, the Air Force Systems Command EMC Design Handbook 1-4 can be utilized as a guide to designing for EMI/TEMPEST compliance.

Red/Black Interface

The following statement will often appear in an equipment specification: "The equipment will be designed to the TEMPEST requirements of NACSIM 5100A." By itself, this statement is of no value in providing proper TEMPEST design direction since no information is given on the Red and Black signals interconnecting within the equipment. Once the Red or Black designation of signals is known, then the design can proceed. Unless the equipment is totally Red (implying no Black I/O connections, which is unusual since input power is normally Black) or totally Black (implying no TEMPEST constraints), then there will exist within the unit Red/Black interfaces, which are the "critical path" for the TEMPEST design.

The Red/Black interface is critical to the TEMPEST requirement to prevent conduction or radiation of Red signals onto Black circuits. There are many design considerations associated with Red/Black interfaces, but only a few will be described here. The important aspect of this discussion of Red/Black interfaces is to understand the design consequences (and the resultant cost and schedule impacts) of defining a circuit or signal-line as being Red or Black.

A simple Red/Black interface is indicated in Figure 1. This equipment interfaces with all Red I/O (input/output) signals and connects to Black power. Therefore, the Red/Black interface is located at the junction between the power supply (Black) and the module backplane (Red). Design constraints must be employed in this situation to prevent the Red backplane signals from being conducted onto the power lines (by filtering) or radiated into the power supply (with shielding). Shielding must also be utilized to prevent radiation of the Red signals into the outside environment.

A more complex and costly TEMPEST design is shown in Figure 2. In this illustration, the equipment has a combination of Black, as well as Red, I/O signals and Black input power. The design of this unit will involve more than one Red/Black interface, since some backplane circuits are Red and some are Black. In this situation, the location of the Red/Black interfaces will determine the feasibility of the electrical/mechanical design of the equipment, as well as the compatibility of the TEMPEST design with other design constraints (such as functionality, weight, size, thermal, reliability, maintainability and cost).

One design alternative would be to isolate the Red signals from the Black signals in the backplane and carry this isolation through to the I/O connectors, possibly creating a multitude of Red/Black interfaces which could severely complicate the design. Another design alternative would be to "partition" the backplane into Red and Black sections, creating fewer Red/Black interfaces and implementing better control measures. Different modules would be designated as either Red or Black and placed in the segregated Red and Black sections of the backplane. In most situations, the fewer the number of Red signals, the less complicated will be the design (implying fewer Red/Black interfaces).

The emphasis in these examples is for the TEMPEST engineer to get involved in the very early stages of the design (including the proposal effort) to ensure that the TEMPEST architecture is complete and sufficient to satisfy the requirements. Delaying TEMPEST design considerations can have a major impact on design, development and delivery schedules.

This article provided the fundamental basics to understanding TEMPEST requirements and their implications. Part II will emphasize general TEMPEST design techniques, including mechanical partitioning and shielding, grounding configurations, and cabling with a discussion of test costs. *(Part II is scheduled for the August issue. — Editor.)*

About the Author

Mike Brooks is an EMC/TEMPEST Engineer at Teledyne Systems Company, 19601 Nordhoff St., Northbridge, CA 91324. He has a BEE degree from the University of Delaware and a MSEE from Duke University, plus over ten years of experience in the EW, EMI/EMC, EMP and TEMPEST areas.

Validity Conditions for a Bypass Capacitor as a Short-Circuit

By Noël Boutin
University of Sherbrooke

This article presents simple validity conditions which permit RF circuit designers to choose the value of a bypass capacitor in such a way that it can be considered a short-circuit from the variational point of view. Furthermore, when the validity conditions cannot be met in practice, it is shown how the presence of a bypass capacitor can be taken into account.

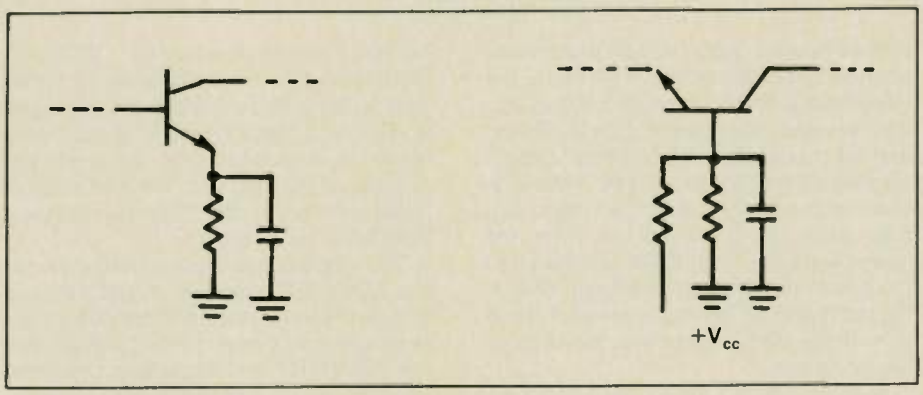


Figure 1. Typical uses of a bypass capacitor.

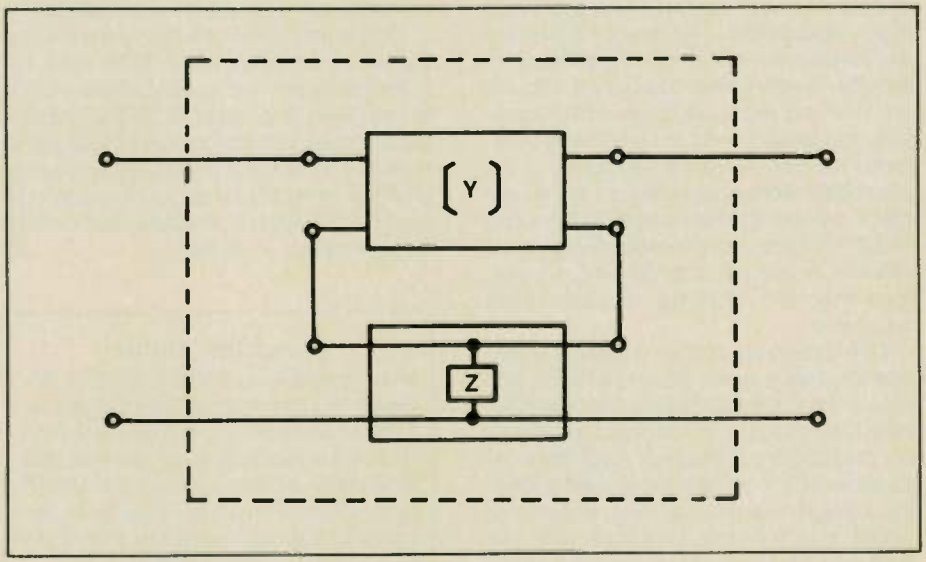


Figure 2. Analytical representation of Figure 1.

Classic radio frequency circuits invariably use resistors to bias active elements into their linear zone of operation. From a variational point of view, the presence of those resistors is detrimental. This is why they are often shunted by capacitors whose impedances in the frequency band of interest are such that they can be considered as short-circuits. Those capacitors are called "bypass capacitors."

Most of all modern textbooks on radio frequency circuit design do not attach enough importance to the way by which the proper value of a bypass capacitor must be chosen in order for it to behave like a short-circuit. Without any analysis, many designers adopt rules of thumb which invariably fail at times. It is the purpose of this note to give designers some simple guiding rules which will permit them to compute the right value of a bypass capacitor. It is also shown how to take into account the presence of a bypass capacitor which, for practical reasons, cannot be considered as a short-circuit.

The Validity Conditions

Figure 1 shows two typical situations where a bypass capacitor is used to shunt biasing resistors. Each of those circuits can be considered as being two series connected four port networks, as shown in Figure 2. The impedance Z represents the parallel RC network whose value must be determined in order to consider it as a short-circuit.

The overall y parameters of the resultant four port network are given by:

$$y_{11_{total}} = \frac{y_{11} + Z\,\Delta y}{1 + Z(y_{11} + y_{12} + y_{21} + y_{22})} \quad (1)$$

$$y_{12_{total}} = \frac{y_{12} - Z\,\Delta y}{1 + Z(y_{11} + y_{12} + y_{21} + y_{22})} \quad (2)$$

$$y_{21_{total}} = \frac{y_{21} - Z\,\Delta y}{1 + Z(y_{11} + y_{12} + y_{21} + y_{22})} \quad (3)$$

$$y_{22_{total}} = \frac{y_{22} + Z\,\Delta y}{1 + Z(y_{11} + y_{12} + y_{21} + y_{22})} \quad (4)$$

where $\Delta y = y_{11}y_{22} - y_{12}y_{21}$ and y_{ij} are the y parameters of the upper four port network shown in Figure 2.

The impedance Z can be considered as a short-circuit if and only if each of the y_{total} parameters is equal to each corresponding y parameter of the upper four port network. From (1) to (4), this implies that the following two inequalities must be satisfied:

$$Z << \frac{1}{y_{11} + y_{12} + y_{21} + y_{22}} \quad (5)$$

$$Z << \frac{y_{ij}}{\Delta y} \text{ for all ij} \quad (6)$$

If, in the frequency band of interest, no practical value of bypass capacitor can be found such that inequalities (5) and (6) are satisfied, the impedance Z cannot be considered as a short-circuit. However, it is quite easy to take its presence into account by using the y_{total} parameters given in (1) to (4) instead of the original y parameters of the upper four port network.

Finally, it is interesting to note that, if the upper four port network is unilateral ($y_{12} \equiv 0$), no value of Z other than zero satisfies inequality (6). In this particular case, the presence of an impedance Z results in an overall non-unilateral four port network. As mentioned in [1], an improper choice of Z may even lead to instability when the upper four port network is an active device

Reference

1. Carson, R.S., *High-Frequency Amplifiers*, (John Wiley & Sons, New York, 1975).

About the Author

Noël Boutin is a member of the Faculty of Applied Sciences in the Department of Electrical Engineering at the University of Sherbrooke, Sherbrooke, Quebec, Canada J1K 2R1.

RF Power Amplifiers in MRI

Performance Specifications and Design Criteria

By Daniel Myer
Fonar Corporation

Today's technology has called for some fascinating new applications of solid-state high frequency power. One of the more interesting uses for RF power is Magnetic Resonance Imaging (MRI). This type of medical scanning device provides high-contrast, cross-sectional images of the body which are useful in detecting disease in human tissue. In order for MRI to work, it is necessary to manipulate large amounts of RF power. Since MRI is basically in its infancy stage, accurate and quantitative amplifier design criteria are generally not available. This article presents design specifications for MRI power amplifier systems, and methods of meeting those requirements.

MRI RF power requires specific performance in the following general areas: high power, broad bandwidth, high gain, excellent linearity and stability, plus low noise output during the MRI signal acquisition period. To accurately represent overall performance specifications, each of these areas requires examination.

While there is no given formula for necessary maximum *power output*, it has been found that 2 to 15 kW should satisfy most present and future needs. This power rating is for a pulsed signal, usually with a duty cycle no greater than 20%. Since any power specification is useless without a distortion requirement, a value of −40 dBc or better for second order harmonic distortion will suffice.

In practice, the *bandwidth* required for most MRI applications (at a given scanner site) is from 5 to 40 kHz (obviously it is not here where the need for broad bandwidth arises). Broad bandwidth becomes essential since it is sometimes necessary to have magnets with completely different values of field strength. Realizing that the operating frequency of a scanner (Larmour frequency) is proportional to field strength, there will be a vast frequency difference from scanner to scanner. The difference between high and low field strength systems could be as much as 70 MHz. Since it would be desirable to have an amplifier satisfy all frequency needs

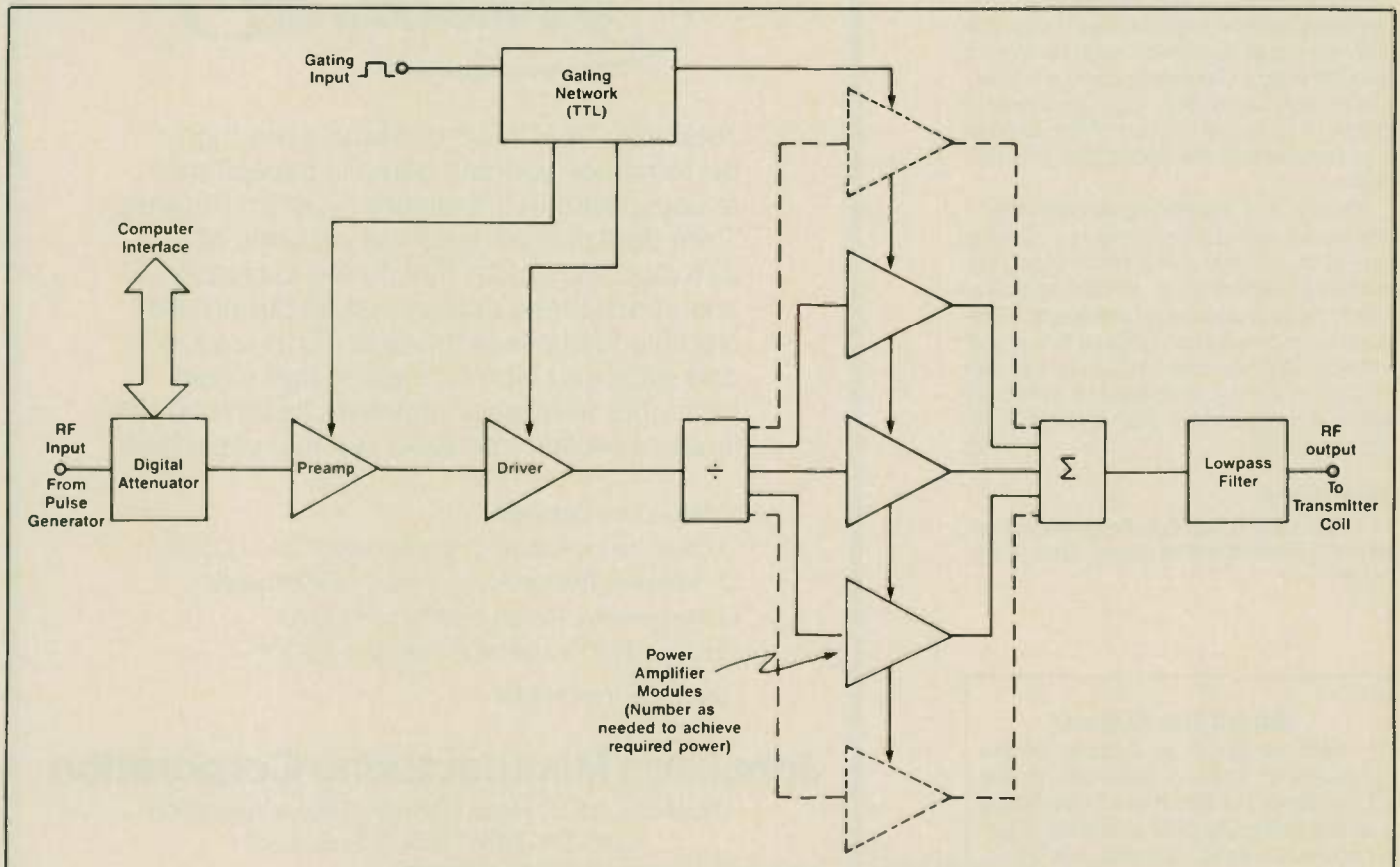


Figure 1. MRI RF Power Amplifier system diagram.

instantaneously, the required bandwidth stretches from 10 to 90 MHz. The gain of the amplifier system should be on the order of 60 dB so it can easily be driven by an RF pulse generator. Gain flatness is not very critical; over the required bandwidth ±2 dB is sufficient.

Linearity is of prime importance in MRI since the RF pulses applied to the power amplifier purposely differ in amplitude and are in exact proportion to one another. In different modes of scanning it is necessary to use different power levels, but at the same time the pulse amplitude proportions must be preserved accurately. A crude expression for linearity such as the "compression point" could be used, but is not a sufficient measure. Linearity can be more accurately expressed in terms of intermodulation figures. In an MRI amplifier, d_3 (or IM_2) should be −35 dB or better.

Optimistically and audaciously, amplifier manufacturers rate their amplifiers as being "unconditionally stable" into any source or load. A more conservative approach on *stability* puts realistic limits on this specification since no amplifier is truly "unconditionally stable." The constraints put on stability are in terms of VSWR and phase angle. Since a VSWR of 3:1 corresponds to about 25 percent of the forward power being reflected back, it would be senseless and wasteful to tolerate any VSWR greater than this. Therefore, if the amplifier is stable into a 3:1 mismatch at all phase angles, it should work well in any MRI system.

Low noise design can be extremely difficult to perform and, unfortunately, in MRI the power amplifier has to put out as little noise as possible during the MRI signal acquisition period. This requirement may appear to present a tenacious challenge in itself since power amps inherently run hot, and since noise is related to temperature, this could pose a serious problem. Fortunately this seemingly formidable problem can be solved quite easily, as will be shown in the following design notes.

Design Solutions

Satisfying the power level criteria has become a very simple task. With the advent of high power transistors (such as Motorola 150 Series TMOS FETS) and the convenience of hybrid power combination (1), virtually any power level can be achieved. The best approach to power amp design is to construct a basic "building block" power module. The power module can be combined with other similar modules to form the power output stage. The same module could also be used as the driver to the power section. The fact that the power is pulsed only relieves the thermal design of the amplifier (physical size). Lower powered CW rated amplifiers could be pulsed to relatively higher power levels (up to 5 dB higher), but only at the expense of linearity.

Meeting the harmonic distortion spec is as easy as inserting a 50 ohm low pass filter (Chebychev or elliptic) at the output. The break frequency should be 10 percent higher than the highest frequency used at a particular scanner to minimize insertion loss.

The design of a power amplifier for one specific scanner could be accomplished using lumped LC networks as narrowband matching networks. But for the more flexible multi-octave broadband designs, it is necessary to take advantage of the distributed elements inherent in transmission lines. Therefore, all impedance matching done in a multi-octave amplifier is performed by transmission line transformers. It is also recommended that MOSFET power devices be used since broadband operation is more readily accomplished than with bipolar devices.

The linearity criteria can be achieved in one of two ways. One way is Class A push-pull if the linearity rating is stringent or, in less demanding design situations Class AB will suffice. Class AB is also more advantageous than Class A in that more power can be derived per device. Push-pull amplification, whether Class A or AB, is desirable since it presents the following advantages over single ended designs:

- Easier to match and broadband due to doubled device impedance.
- Better efficiency due to even order harmonic suppression.
- Elimination of ground referenced RF loops.
- Fewer peripheral matching components per pair of transistors.
- Automatic combination of power from two devices without losses experienced in hybrid combiners.

Stability, for obvious reasons, is considered the "black art" of RF design. While stability of the front end of the power amp (pre-amp, pre-drive) could be evaluated using Linvil and Stern stability factors, the stability of the overall amplifier is a function of physical layout. Given here are some practical techniques which can aid in ensuring stability up to a given VSWR:

- Employing chip capacitors to eliminate possible formation of poles in operating frequency region.
- Low profile circuitry to reduce stray inductance and capacitances as well as possible feedback paths.
- Using toroidal ferrite for transmission line transformers (to confine magnetic fields).
- Use of a separate DC supply for high gain preamplifier stages.
- Use of ferrite beads to choke out RF pickup on DC lines.
- Minimize input to output coupling possibilities in placement of power modules and preamplifiers.

Unfortunately, shielding of power output modules does not enhance stability (it literally has no effect), so careful placement of modules is a must.

Finally, the noise problem turns out to be the easiest to solve of all. Since the power amplfier is not required to function during the MRI signal acquisition period, it can be gated with cutoff bias, reducing the output noise to only the real (resistive) part of the transmitter coil. The gating network should be TTL compatible. Along with solving the noise problem, gating also eases the thermal design of the amplifier. It not only reduces the heatsink size by 60 percent or better but also yields a better MTTF per transistor.

Circuit Description

Figure 1 shows the block diagram of an MRI RF amplifier system. The input should require approximately 0 dBm drive level, which has amplitude control via the digital attenuator and the controlling computer. The driver module is typically identical to one of the combined power amplifier modules.

The number of amplifier modules is a function of required power output, but is limited by the reduction in linearity as more amplifiers are combined. Not shown are protective circuits for such things as overdrive, VSWR, operating temperature, excess drain current, or combiner unbalance. These can use the gating network to apply cutoff bias in the event of a failure.

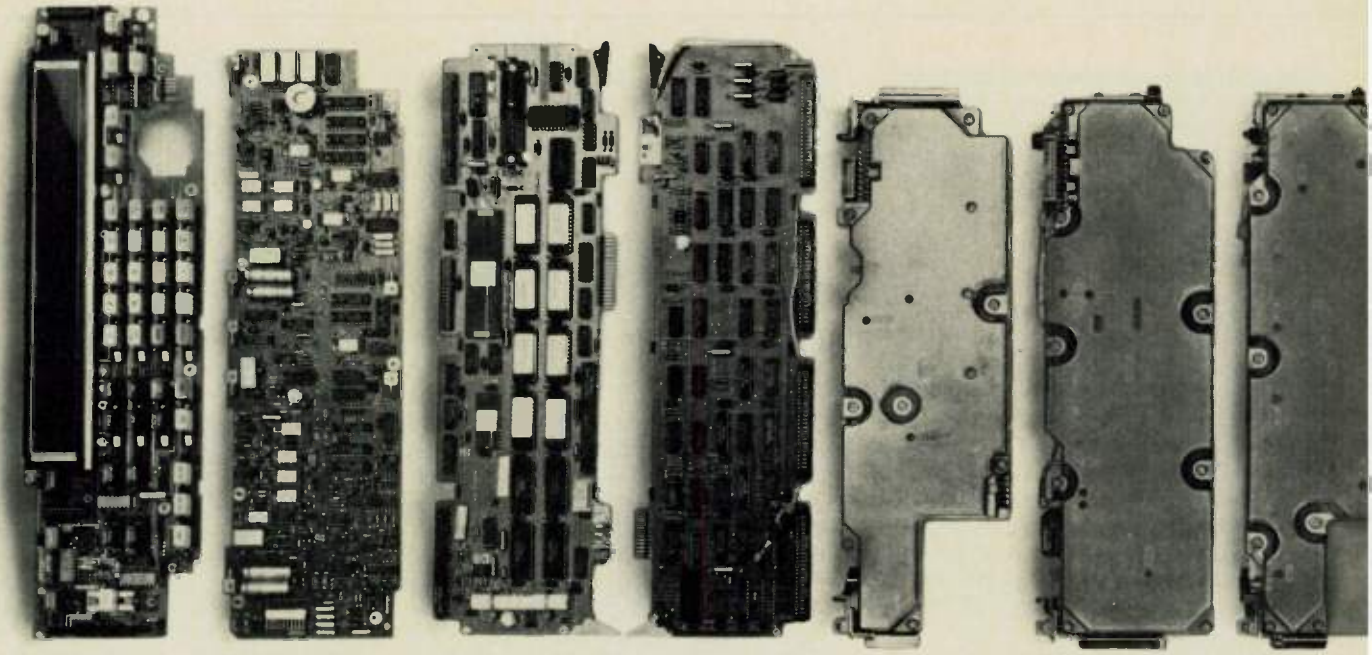
As a final note, all RF system modules are designed for 50 ohm input and output. This greatly simplifies testing and servicing of the MRI amplifier system.

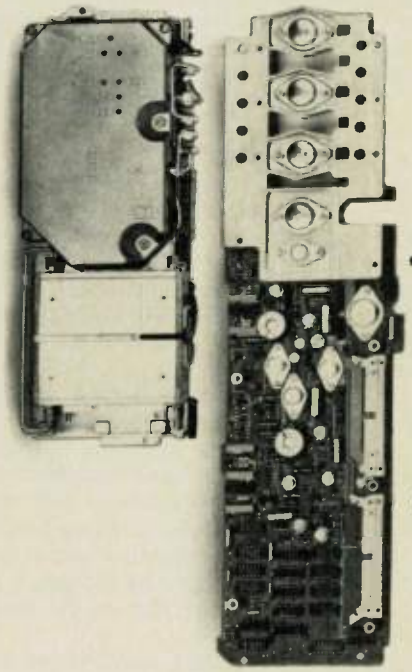
References

1. Helge O. Granberg, "Broadband Transformer and Power Combining Techniques for RF," Application Note AN-749, Motorola Semiconductor Products, Inc., Phoenix, AZ.

About the Author

Dan Myer is an RF Design Engineer with Fonar Corp., 110 Marcus Drive, Melville, NY 11747.





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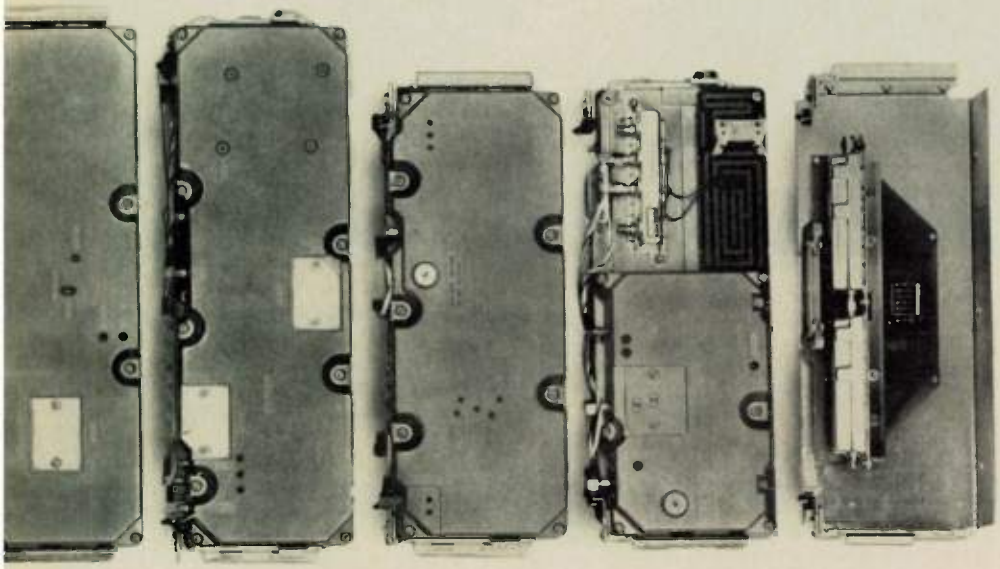

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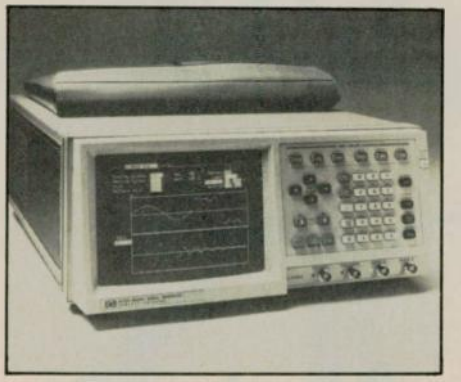
rf products

FET Amplifier Covers 1 to 4 GHz Range

The model A45 GaAs FET amplifier from Watkins-Johnson Company offers 17.5 dB of gain with 19.5 dBm output power over the 1 to 4 GHz frequency range. Typical noise figure is 4.5 dB and VSWR is 1.8:1. Performance is guaranteed from −54 to +85°C at 15 volts. The amplifier may be specified in a standard TO-8 can or in a new W-J "KA" microstrip-compatible package. **Watkins-Johnson Company, Palo Alto, Calif. Please circle INFO/CARD #137.**

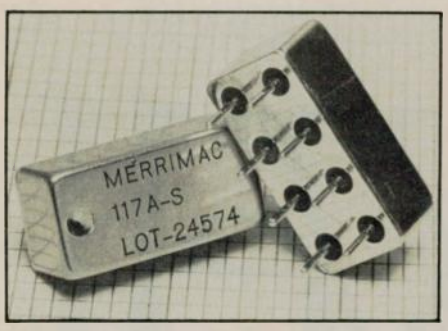
Generator Has Dual Arbitrary Waveforms

Enhancements to Hewlett-Packard Company's HP 8175A digital signal generator bridge the gap between digital and analog applications. Option 002, the dual arbitrary waveform generator, will provide users with the ability to generate two arbitrary analog signals with 10-bit amplitude resolution and a sample update rate of 50 MHz. The two synchronous output signals can have completely different output shapes and output levels. Option 002 costs $3,200. The option in conjunction with the HP 8175A digital signal generator is $13,250. **Hewlett-Packard Company, Palo Alto, Calif. Please circle INFO/CARD #134.**



Surface Mount Crystals Cover 4 to 150 MHz

The Bliley Electric Company has announced a series of crystals which are designed for surface mounting using "gull wing" leads. The new crystals are available in frequency segments that range from 4 to 150 MHz, with operational temperatures of −55°C to +90°X. Maximum series resistance falls between 25 and 90 ohms, depending on frequency and maximum drive levels of 2 or 5 mW. Resistance-weld holders reduce contamination and permit low cost volume production. These surface mount crystals use Bliley's in-house cultured quartz. **Bliley Electric Company, Erie, Pa. INFO/CARD #133.**



Double Balanced Mixers are MIL-Screened

Merrimac Industries has introduced the Model 117AS Double Balanced Mixer, screened to MIL-M-28837. This mixer is suited for PSK modulation applications and has a bandwidth of 0.5 to 500 MHz to allow for very high data rate modulation. Reliability screening includes a stabilization bake, temperature cycling over the storage range, and operating burn-in for 160 hours at room temperature.

The screened Model 117AS comes in a standard Relay PC package and is priced at $35.00 each for quantities of 1 to 9. **Merrimac Industries, West Caldwell, N.J. INFO/CARD #132.**

External Frequency Standard Improves Counter Accuracy

The Counter-Mate personal frequency standard provides stable 1 MHz and 10 MHz signals to improve the accuracy of counters and other instruments. A precision third-overtone 10 MHz crystal mounted in a proportionally controlled

copper oven ages less than $\pm 3 \times 10^{-9}$ per month and drifts less than $\pm 5 \times 10^{-8}$ from 0 to 40 degrees C. A 50-turn frequency trim exhibits a settability of 1×10^{-9}. Both outputs will drive TTL or 50 ohms with 5 ns rise and fall time square waves. The price is $350.00 **Wenzel Associates, Inc., Austin, Tex. INFO/CARD #131.**

Amplifier Features 14.5 dB Gain, 3.3 dB NF

Vector's new MHT-1013 is a cascadable thick film hybrid RF Amplifier in a TO-8 4-pin package. This amplifier features a bandwidth of 5 to 1000 MHz with 14.5 dB gain and output power of +5 dBm with a 3.3 dB noise figure. The MHT-1013 operates from a +15 Vdc source at 10 mA. All Aydin Vector microelectronic RF amplifiers are designed and manufactured to meet the specifications of MIL-STD-883 and MIL-Q-9858A. **Aydin Vector Division, Newton, Pa. INFO/CARD #130.**

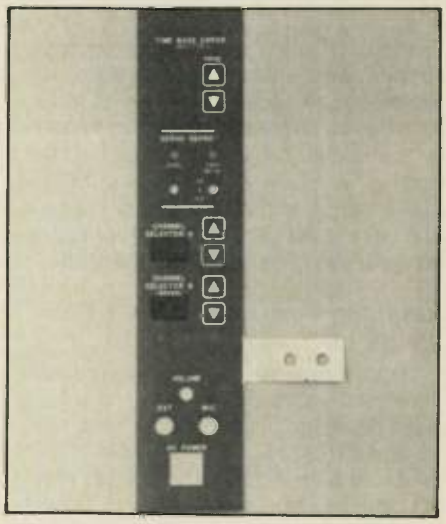
2.4 mm Connector Operates to 50 GHz

Amphenol Products has announced a new precision 50 ohm coaxial connector that provides resonance-free TE_{11} mode signal transmission through 50 GHz. Identified as the Amphenol APC-2.4™ connector, it is designed for use with 2.4 mm 50 ohm impedance rigid coaxial air lines. Return loss is greater than 26 dB,

even at 50 GHz. Straight plug and straight jack configurations provide for direct connection to 2.4 mm air lines. Pricing per mated pair in small quantities is approximately $100. Between-series adapter families will be available later this year. **Amphenol Products, Lisle, Ill. Please circle INFO/CARD #129.**

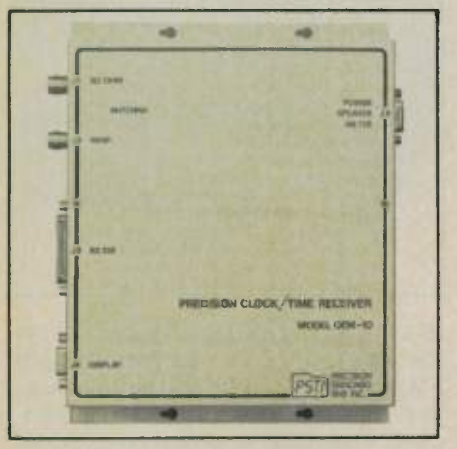
Control Panel Overlay Provides ESD Shielding

A control panel overlay that shields components against electrostatic discharge has been introduced by W.H. White Co. Bradyshield™ ESD control panel overlays of faceplates are constructed of a .003 to a .020 inch layer of polyester or polycarbonate, second-surface printed, an aluminum sheet .00035 inches thick and a polyester substrate that provides insulation between the metal and components below the panel. The three layers are bonded by high performance adhesives and have a metal tab for grounding. Pressure-sensitive adhesives fasten the panel to the frame or cabinetry. **W.H. Brady Co., Nameplate Division, Milwaukee, Wis. INFO/CARD #128.**



Time Receiver Incorporates a Precision Clock

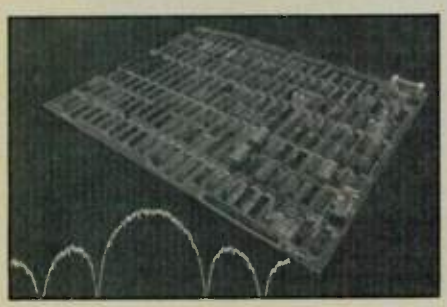
The OEM-10 provides the user with precise time by receiving and decoding the WWV and WWVH radio signals broadcast by the National Bureau of Standards (NBS). The received signals are synchronized to within 10 milliseconds of the NBS atomic clock. The time informa-



tion includes days, hours, minutes, seconds, as well as tenths and hundredths of a second. The receiver section consists of a five channel, crystal controlled receiver and a microprocessor section monitors and controls all the data acquisition and data correction activities. The unit price is $450.00 **Precision Standard Time, Inc., Santa Clara, Calif. INFO/CARD #127.**

Spread Spectrum Generator Provides Test Signals

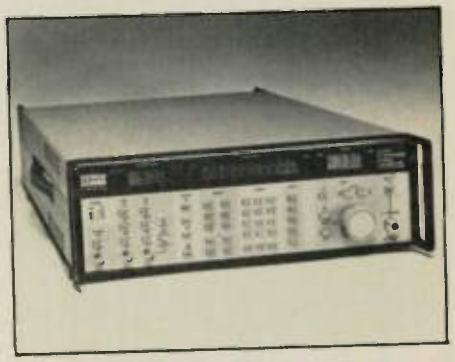
New Wave Instruments introduces a pseudorandom sequence generator packaged on a single 12"× 9.5" printed circuit board. The PNG-100 is a pseudo-noise generator with the desired sequence selected by setting the feedback pattern, the initial contents of a 16-bit shift register, and the length of the sequence. These three parameters can be changed in real time, providing the generation of highly complex sequences. The price is $3,500. **New Wave Instruments, San Jose, Calif. INFO/CARD #126.**



rf products Continued

Synthesized Signal Generator Goes to 2500 MHz

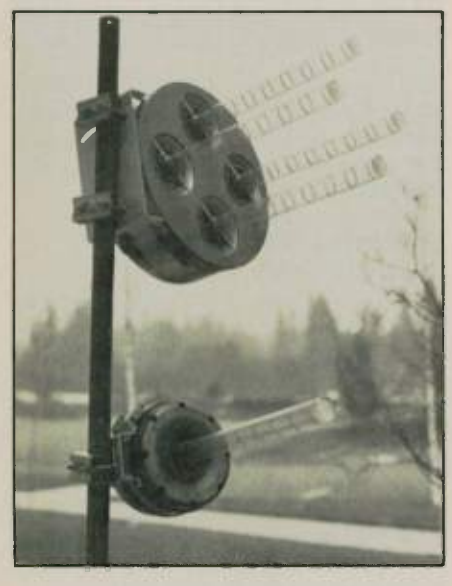
Systron Donner has introduced a new synthesized signal generator providing frequency coverage from 100 kHz to 2500 MHz with a resolution of 1 Hz to 1500 MHz and 2 Hz to 2500 MHz. The model



1502 output has an output level from −130 dBm to +13 dBm in 0.1 dB steps. AM and FM modulation, an internal pulse moderator, and an IEEE-488 interface are standard. The 1502 is priced at $20,000. **Systron Donner Corp., Concord, Calif. INFO/CARD #125.**

Multi-Element ITFS/MDS Antenna

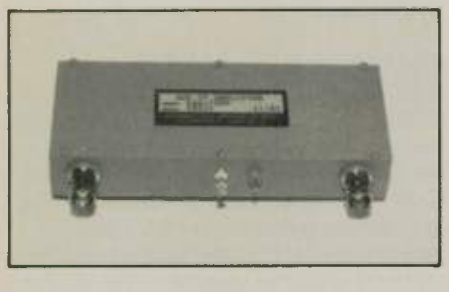
Spatial Communications has announced the introduction of the Microtenna-ME, an ultra-compact multielement antenna for reception of multichannel television at distances greater than ten miles from the transmitting antenna site.



The antenna with integrated downconverter provides better than 48 dBi system gain for MMDS/ITFS channel groups in the 2500-2700 MHz band. Price of the Microtenna-ME is $195 in small quantities. **Spatial Communications, Inc., Portland, Ore. INFO/CARD #124.**

IF Amplifiers Have Built-In AGC

International Microwave introduces the Series IAA linear IF amplifiers with built-in automatic gain control which eliminates the need for AGC drivers. Use of hybrid technology results in consistent performance with respect to match, frequency response, and other electrical parameters.



These units are usable for both AM and FM systems and feature high 1 dB compression point, and built-in voltage regulator. Amplifiers are wideband and can be tuned to any bandwidth required. **International Microwave Corporation, Stamford, Conn. INFO/CARD #122.**

Mixer Spans 0.5 to 500 Mhz

Mini-Circuits' new RMS-1 surface-mount mixer measures 0.25 by 0.25 inches, the smallest mixer now available. The mixer uses a local oscillator of +7 dBm, and has a conversion loss of 8.5 dB (min.) across its bandwidth. LO-to-RF isolation is better than 44 dB at 62 MHz and greater than 24 dB at 531 MHz with LO power at +7 dBm. The mixer can be

supplied in a tape-and-reel format for automated pick-and-place machines. **Mini-Circuits, Brooklyn, N.Y. Please circle INFO/CARD #121.**

New Attenuators Handle 3 Watts

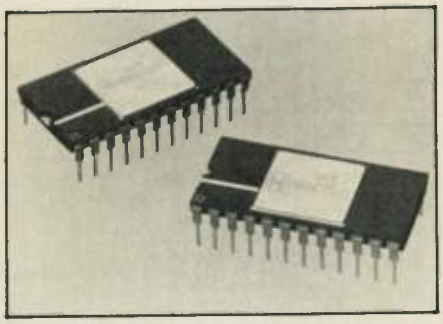
Kay Elemetrics has introduced two new high wattage attenuators that can handle an average of 3 watts power. The model 432 HW has an attenuation range of DC-1000 MHz (50 ohms) with a minimum step of 1 dB, and can handle 3 watts average at 12.25 VRMS continuous operation (25°C). The model 431 HW has an attenuation range of DC-41 MHz (50 ohms) and also handles an average of 3 watts power. Prices for the 431 HW and 432 HW are $304 and $350, respectively (2-9 units). **Kay Elemetrics Corp., Pine Brook, N.J. INFO/CARD #120.**

Portable Communications Service Monitor

Ramsey Electronics has announced the COM-3 Service Monitor designed to analyze and test transceivers in the 100 kHz to 1000 MHz range. The COM-3 features a programmable microprocessor memory for up to ten test setups. The unit covers every band, frequency, and IF with parameters of 100 kHz to 1 GHz in 1 kHz steps. The keyboard offers programmable offset keys that simplify frequency entry for duplex or repeater radios. Introductory list price for the COM-3 is $1995. **Ramsey Electronics, Penfield, N.Y. Please circle INFO/CARD #103.**

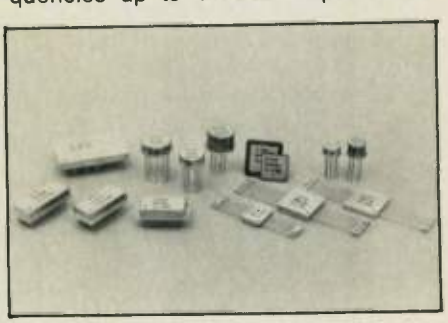
8-Bit DACs Update at 275 MHz

Honeywell has introduced four high-speed digital-to-analog converters (DACs) capable of accepting video data at either 275 or 165 MWPS (Mega Words/sec) rates. The four DACs are the HDAC10180 (A and B) and HDAC10181 (A and B). All are pin-compatible with TRW's TD1018. The HDAC10181 (A and B) include an internal precision band gap reference, which can act as a "master" reference to "slave" HDAC10180s. In a 24 lead CERDIP package, and 100-pc quantities, the HDAC10180A sells for $42.50, the HDAC10180B for $32.50, the HDAC10181A for $43.75, and the HDAC10181B for $33.75. **Honeywell Inc., Signal Processing Technologies, Colorado Springs, Colo. INFO/CARD #102.**



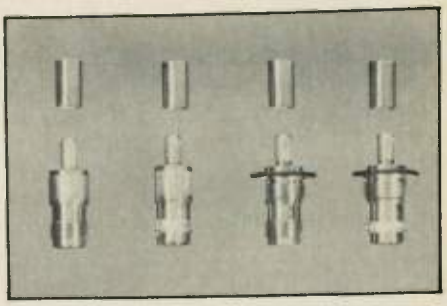
DIP Oscillators Put Out Sinewaves

Q-Tech Corporation has recently introduced its newest product, sinewave oscillators in 14 pin DIP. These stable, low frequency oscillators are available in frequencies up to 1 MHz. Sophisticated filtering techniques provide total harmonic distortion better than 0.1 percent and amplitude stability of ±0.5 percent. All units can be screened to MIL-M-38510 and MIL-STD-883. **Q-Tech Corporation, Los Angeles, Calif. INFO/CARD #101.**



BNC and TNC Dual-Crimp Connectors

Four new BNC and TNC dual-crimp female connectors have been announced by Ava Electronics. Designed for RG 59/62 Teflon-jacketed cable installations, the new connectors can be attached with a standard hex crimp tool. The high-reliability connectors include chassis-mount and standard D-hole mounting.



The connectors are designed for up to 500-volt operation and have an impedance rating of 50 ohms nominal. **Ava Electronics Corp., Drexel Hill, Pa. INFO/CARD #100.**

Solderless SMA Offers Easy Assembly

Suhner C-grip SMA attachment is amazingly simple: when screwing on the connector housing, tiny dentiform grooves equi-circumferentially grip the cable jacket. The front face of the soft copper jacket forms a contact with the connector for long-term stability and low SWR. The Suhner C-grip SMA range contains 11 types for semi-rigid cables of 0.085 and 0.141 inch diameter. **Huber & Suhner AG, RF and Microwave Division, Herisau, Switzerland. INFO/CARD #99.**

New GPS Receiver

Austron's new GPS (Global Positioning System) Receiver has been designed to capture the ultimate accuracy of the GPS Navstar Link 1, C/A code transmissions. Synchronization of time to the Coordinated Universal Time (UTC) scale is possible through the GPS master clock system to accuracies better than 150 nanoseconds. In addition, the 2101 provides traceable time-of-day accuracy to the United States Naval Observatory, National Bureau of Standards or the International Bureau de l'Heure. The price is $24,500. **Austron, Inc., Austin, Tex. INFO/CARD #98.**

Fluoroscope Checks RF Hybrids for Flaws

Manufacturers of RF communication devices can now check for voids in substrates or other defects and correct the resulting radio frequency problems as the devices are being produced. The LIXI® fluoroscope is a portable X-ray system showing real-time images of the hidden flaws, such as voids in substrates. Since LIXI fluoroscope works on-line and shows instant, real-time images, it replaces cabinet type X-ray systems typically installed away from the production line. **LIXI, Inc., Downers Grove, Ill. Please circle INFO/CARD #97.**

Attenuator Features High Voltage, Fast Risetime

Barth Electronics has introduced their Model 102GP 50 ohm attenuator, which has a 45 ps risetime in a 10:1 voltage ratio (20 dB) configuration. The 102GP is rated at 2.5 kV (400 ns squarewave). The new attenuator is a low cost unit developed from Barth's 202GPA series of high performance attenuators. Current application of high voltage, high speed attenuators have been primarily in nuclear underground testing, but high pulse power RF and microwave uses, and EMP applications are also suitable. The 102GP is priced at $280. **Barth Electronics, Inc., Boulder City, Nev. INFO/CARD #119.**

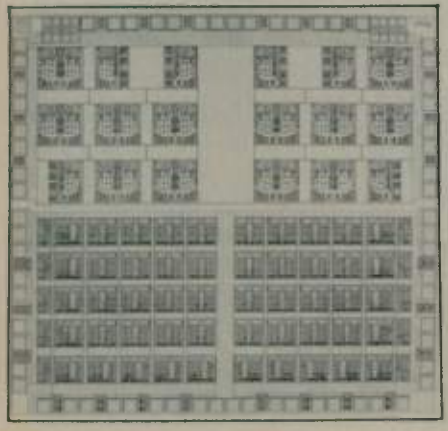
Lowpass Filters Packaged in TO-5 Case

RLC announces a new series of TO-5 Lowpass Filters, Model TLP. These miniature filters have up to seven ultra-high "Q" elements included in this compact configuration. Standard units with

cut-off frequencies of 100 to 1500 MHz are offered in 2 or 3 sections. A 600 MHz 3 section unit can provide an insertion loss of less than .5 dB and a VSWR of less than 1.5 while providing a greater than 40 dB of rejection at 1 GHz. **RLC Electronics, Inc., Mt. Kisco, N.Y. INFO/CARD #118.**

One IC Die is Analog and Digital

Tektronix today announced the availability of the QuickChip 4 IC, a high-speed, high-performance bipolar array for integration of both analog and digital functions on one die. The array has high-speed, medium voltage capabilities with typical npn transistor f_T of 6.5 GHz analog, and up to 500 MHz digital clock frequency. QuickChip 4 ICs are available within three weeks of design approval. Prototype wafers and/or packaged parts are priced at $26,000, plus non-recurring engineering (NRE) charges. **Tektronix Integrated Circuits Operation, Beaverton, Ore. INFO/CARD #117.**



PIN Diodes for Phased Arrays

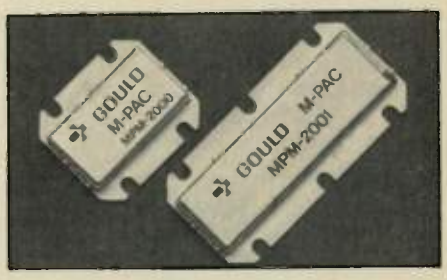
The HPND-4028 and 4038 beam-lead PIN diodes are designed for low capacitance, low resistance and fast switching at microwave frequencies. A switching speed of 2.6 ns for the HPND-4028 and 2.4 ns for the HPND-4038 makes these diodes applicable for high-speed, missile-switch matrix and switch-module applications. These diodes have low resistances of 2.3 ohms and 1.5 ohms at a low bias

rf products *Continued*

of 10 mA. The HPND-4028 is $8 each and the HPND-4038 is $7.60 (1000 pcs). **Hewlett-Packard Company, Palo Alto, Calif. INFO/CARD #115.**

GaAs FET Amplifiers Designed for MIL-Users

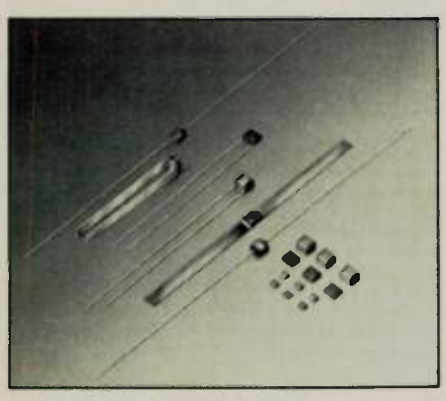
Gould now has available a 6 to 18 GHz GaAs FET amplifier, providing a max-



imum 6.0 noise figure and gain flatness of ±1.5 dB at a minimum small signal gain of 26 dB. Power output at 1 dB compression is +13 dBm minimum, input and output VSWR is 2.0:1 maximum, and the unit is hermetically sealed and is screened to the basic requirements of MIL-STD-883C. **Gould, Inc., Microwave Products Division, San Jose, Calif. INFO/CARD #116.**

Ceramic Capacitor for Hybrid Circuits

Republic Electronics Corp. introduces STABLE-K, a multilayer ceramic capacitor for use in hybrid circuits, with temperature



characteristic X7R, and two sizes: .055 square and .110 square. It is suited for DC blocking, by-pass, and filtering purposes. **Republic Electronics Corp., Paterson, N.J. INFO/CARD #114.**

Diode Surface Mount Package

Metelics introduces its first surface mount package with useful frequency range extending from DC to 26 GHz. Although specifically designed for microwave use, the package has wide ac-

ceptance for use at UHF and lower frequencies. The package is available in 8 mm feed tape per ANSI/EIA-481-1982. Package dimensions are 50 mils × 80 mils (standard 0805 size similar to chip resistor and capacitor). **Metelics Corporation, Sunnyvale, Calif. INFO/CARD #112.**

Modulation Meter is Portable, Digital

RF Industries announces its Model 100 and 110 AM/FM digital modulation meter. The Models 100 and 110 feature small size, battery operated digital readout, and auto tuning. The Model 100 (AC operated) and Model 110 (AC and internal NiCad battery operated) feature: 1.5 MHz-1 GHz auto tuning, −30 dB to +10 dB input level range, and ±3 percent accuracy. Both

models will be available mid-June with tentative prices of $795-830. **RF Industries, Hialeah, Fla. Please circle INFO/CARD #113.**

rf products *Continued*

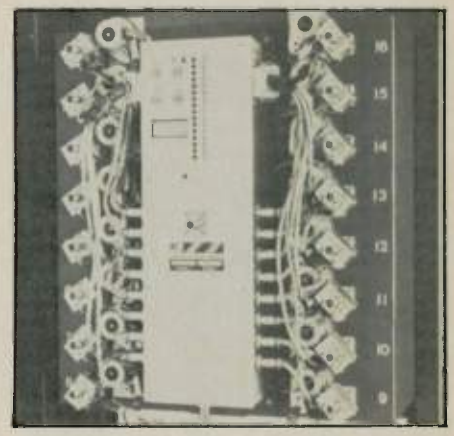
Low Cost RF Generator Boasts High Precision

A new RF signal generator has been introduced by Wavetek. Designated the Model 2500, this phase-locked, synthesized signal generator covers a frequency range of .4 to 1100 MHz. A single phase-lock loop employing both fractional division and direct digital synthesis allows fine control of frequency without the usual

complexity and with fewer spurious signals. Mircoprocessor-based self-test and internal calibration routines extend laboratory calibration cycles and reduce actual calibration time. Other standard features include 50-W reverse power protection, 1 MHz peak FM deviation, DC AM modulation, and GPIB interface. Special introductory pricing of $5495 is being offered until Sept. 1, 1986. **Wavetek Indiana, Inc., Beech Grove, Ind. Please circle INFO/CARD #138.**

Cellular Combiner is Self-Tuning

Antenna Specialists has announced the development of new transmitter combiner technology that may ease the growing problem of cellular frequency congestion by dynamic channel assignment (a "frequency borrowing" scheme). The new combiner employs a microprocessor cir-

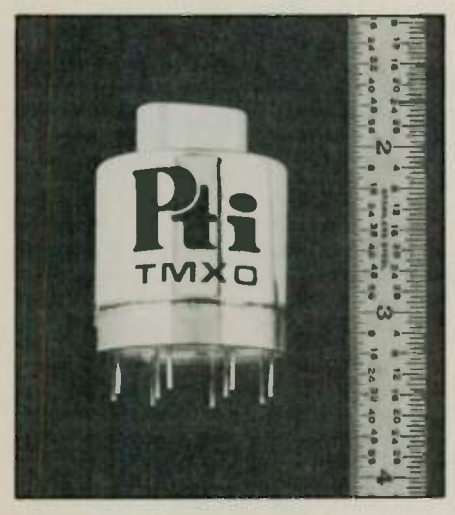


cuit to permit both self-tuning and self-monitoring via two-way directional detectors at each cavity input. With this system, standby transmitters can be allocated for dynamic channel assignment or the entire system may be reconfigured to meet

changing traffic patterns. **The Antenna Specialists Co., Cleveland, Ohio. INFO/CARD #139.**

Tactical Miniature Crystal Oscillator

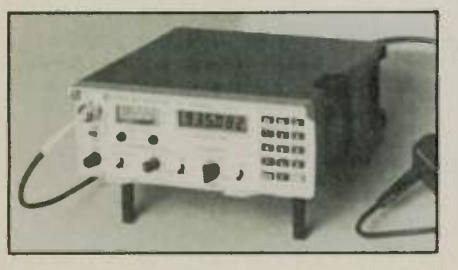
Piezo Technology is now offering a very advanced miniature ovenized crystal oscillator, the TMXO (Tactical Miniature Crystal Oscillator), developed under DOD sponsorship for use as a precision frequency reference on major DOD programs. An SC-cut crystal resonator is packaged in a special ceramic flatpack, and the oscillator and temperature control circuitry have been reduced to a single sealed hybrid circuit module in intimate thermal contact with the crystal unit. This assembly is housed in an



evacuated enclosure. Frequency stability is $\pm 5 \times 10^{-9}$ over an operating temperature range of −55 to +75°C. Standard frequencies are 10.0 and 10.23 MHz (custom frequencies are available). Price: $4,000, 1-9 pieces. **Piezo Technology, Inc., Orlando, Fla., INFO/CARD #135.**

Portable Receiver has Professional Performance

The Miniport Receiver EB 100 by Rohde & Schwarz-Polarad is a portable, battery-operated mini receiver with performance comparable to stationary receivers. The unit has high setting accuracy, simultaneous monitoring of several frequencies, a dB-linear S-meter



of 80 dB, and demodulators and bandwidths for all radio services in the frequency range of 20-1000 MHz. **Rohde & Schwarz-Polarad, Inc., Lake Success, N.Y. Please circle INFO/CARD #136.**

Fast-Switching Multichannel Oscillator

Greenray Industries introduces their series M-509, offering four separate crystal controlled oscillators in one package. Any one of the four frequencies can be digitally selected to the single output pin. Continuous operation of all four oscillators permits frequency to frequency switching time of only 20 microseconds. AGC maintains the RF output at +7 dBm ±0.25 dB, both channel to channel and over a temperature range of 0° to +70°C. The four output frequencies may be ordered to cover up to a 10 percent bandwidth, over a frequency range of 1 MHz to 600 MHz. **Greenray Industries, Inc., Mechanicsburg, Pa. INFO/CARD #123.**

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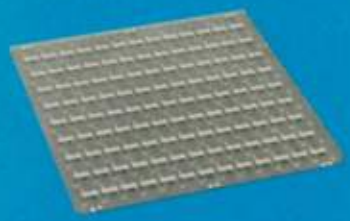

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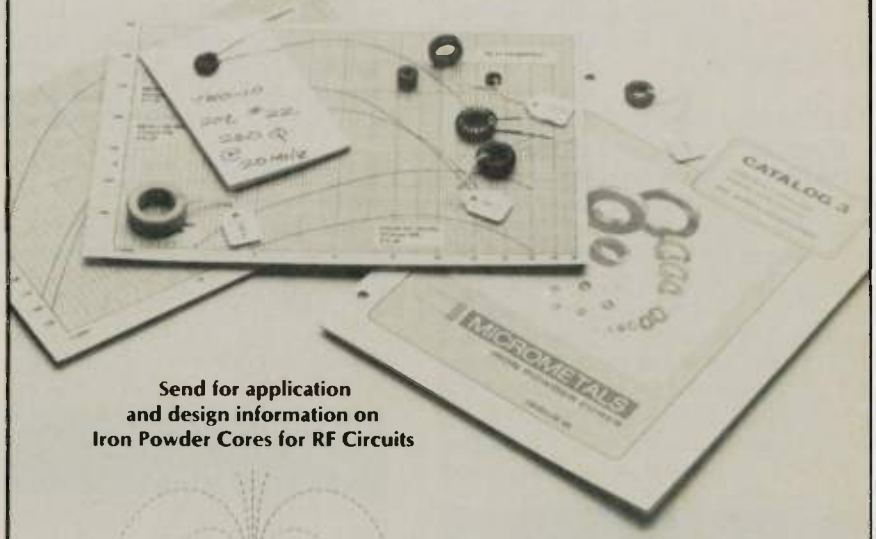

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Model	Freq MHz	Gain dB	Flatness (dB) 1-500 MHz	Flatness (dB) 5-800 MHz	Noise Figure	Input VSWR	Output Capability	Hum Modulation	Size	Weight
A62/20	1-500	20	±.15	±.1	7 dB max. 5 dB typical	1.5:1 max. 1.1:1 typical	.7V min output for 1 dB gain Compression (saturation 1 V)	.5% max.	EIA Panel 1 3/4" x 19" 3 1/8" chassis depth	2 1/2 lb. nominal
A52/30		30	±.20	±.15						
A52/40		40	±.30	±.20						
A52/50		50	±.45	±.25						
A72/60		60	±.60	±.30						
A62/20/6	1-600	20	±.15	±.1						
A52/30/6		30	±.22	±.15						
A52/40/6		40	±.30	±.20						
A52/50/6		50	±.45	±.25						
A72/60/6		60	±.60	±.30						
A520/30	1-900	30	±.50							

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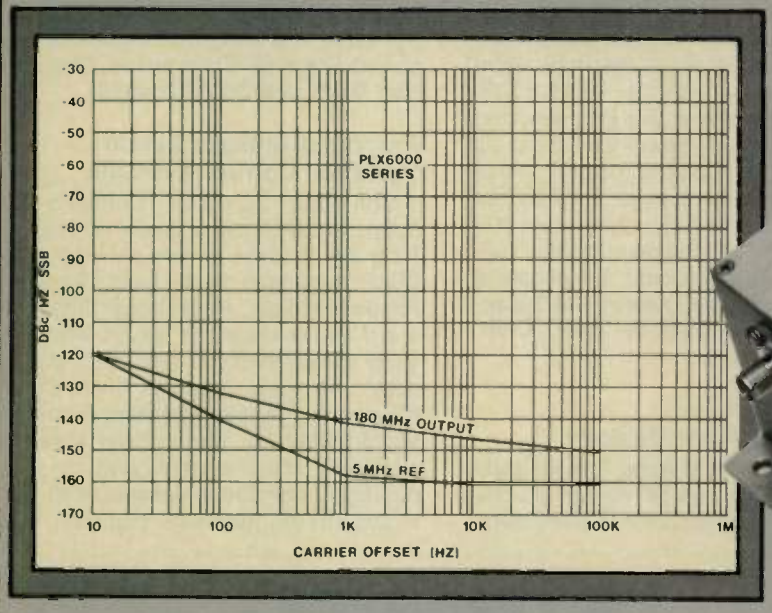
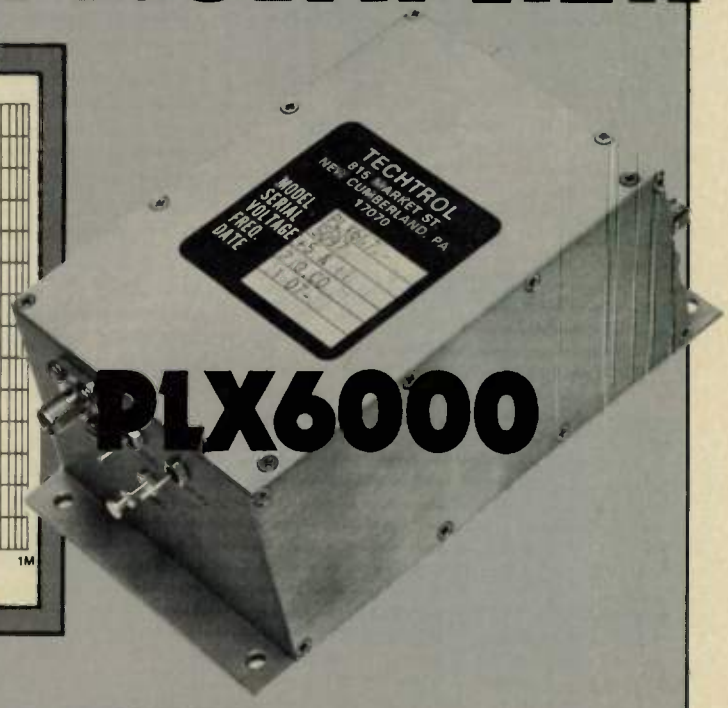
INFO/CARD 75

NEW PRODUCT

LOW NOISE SYNTHESIZER-MULTIPLIER





The PLX6000 series provides low noise multiplication by application of digital and analog synthesis techniques. This method provides an output signal with the lowest possible noise.

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INFO/CARD 40

rf software

Package Automates Network Analyzer

The Model 9000 Automatic Network Analyzer upgrades the HP 8410 Network Analyzer from a manual to a fully automatic system using an IBM PC controller and proprietary accuracy enhancement software. This software makes 8 or 12 term vector error-corrected measurements. The upgrade includes complete interface system, plotter, printer, rack, computer stand and NODAL, IR&D's RF/microwave circuit analysis program, and meets the same performance criteria as the HP 8409B. Options include phase lock, sweep generator, or synthesizer. Operational frequencies range from 200 MHz to 18 GHz based on customer supplied equipment. Upgrade cost begins at $30,000 for a turn-key system. **IR&D Electronics, Inc., Mountain View, Calif. INFO/CARD #176.**

Program Aids in Butterworth Filter Design

RF Notes No. 3, Volume 1, is the third in a series of low cost RF design aid programs. This program aids in the design of low pass, high pass, band pass, and band-reject Butterworth response filters to the 7th order. Inputs are in graphical (response curve) form, and the outputs are all in schematic diagram form with circuit values included. Predicted response curves are included. The price is $85.00, Color/Monochrome selectable, for IBM PC, PC XT, PC AT, PC jr. (enhanced). DOS 2.1, 128K, and IBM graphics card are required. **Etron RF Enterprises, Diamond Bar, Calif., INFO/CARD #175.**

Programs Analyze Linear Systems, Control Systems

California Scientific Software announces LSAP (Linear Systems Analysis Program). Using a simple data input file, LSAP generates Bode plots, Transient Response plots, Root-Locus diagrams, and Nyquist diagrams. LSAP works on linear systems with up to 45 zeros and 45 poles. Also introduced is Micro-CSMP (Continuous System Modeling Program). Micro-CSMP is particularly good at modeling control systems and can handle highly non-linear systems, with built in support for hysteresis, backlash, clip-

ping and saturation. LSAP is $450 and Micro-CSMP is $900. Micro-CSMP requires microsoft Fortran 77 V3.30. Both support the 8087/80287 math coprocessor. **California Scientific Software, El Toro, Calif., INFO/CARD #174.**

PC/DOS Computers Get Active Filter Design Software

RLM Research announces the release ot an "Active Filter Design" software package for the IBM family of personal computers. This program designs Butterworth, elliptic, Chebishev and Bessel low pass, high pass and band stop active filters. It also allows the direct entry of pole and zero locations or transfer functions. Active implementations of type of MFB, VCVS, biquad and state variable are available using standard value components. Outputs from the program include a filter description, pole and zero locations, transfer function and circuit component values. Facilities have also been included for cascading filters and storing filter data for future analysis or modification. The program is priced at $450 for a single copy license. Site licenses are available. **RLM Research, Boulder, Colo. Please circle INFO/CARD #173.**

Antenna Utilities Bundled Into One Package

Straightforward introduces Antenna Buttons. This bundle of programs for the fundamental functions of antenna design includes computations for shortened vertical antennas and shortened dipole antennas, horizontal rhombic antennas and colinear and cylindircal antenna arrays. Also included are parabolic antenna computations, RF path loss and shortwave transmission path computations. The programs come in standard and 8087 versions and are priced at $39.95 per bundle. **Straightforward, Gardena, Calif., INFO/CARD #172.**

Step Attenuator Data Sheet

This four-page data sheet gives the complete specifications for Weinschel Engineering's newest Latching Programmable Step Attenuators — the 3220 Series, containing operating and switching specifications, construction descriptions, dimension drawings and photographs plus diagrams showing typical measured incremental attenuation. The 3220 Series attenuators are designed for use in ATE and OEM systems operating in the DC to 2 GHz range. 3220 Series attenuators provide virtually flat frequency response, with attenuation ranges available from 0 to 127 dB in 1 dB steps, 0 to 120 dB in 10 dB steps; 1 to 31 dB in 1 dB steps. **Weinschel Engineering, Gaithersburg, Md. INFO/CARD #86.**

EMI Filtered Connectors

Spectrum Control announces a new EMI filtered D-Subminiature connector catalog. It includes filter performance, specifications, mounting considerations, ordering information, accessories and specifications. The catalog highlights Spectrum's latest ceramic technology and unique feedthrough design to meet all testing to MIL-STD 202 and MIL-STD 24308, plus providing compatibility with EIA Standards RS-232 and RS-449. Available are 9-, 15-, 25-, 37- and 50-position connectors which mount in existing chassis hole patterns. **Spectrum Control, Inc., Erie, Pa. INFO/CARD #85.**

Antenna Measurements Textbook

Scientific-Atlanta has published the third edition of Microwave Antenna Measurements, a textbook authored by Hollis, Lyon, Clayton, et. al. The textbook is an authoritative source book covering both theory and practical application of all phases of antenna measurements, including automatic measurement techniques. The textbook can be obtained from Scientific-Atlanta. The price is $60, including shipping and handling. **Scientific-Atlanta, Inc., Atlanta, Ga. INFO/CARD #84.**

Silver-Epoxy Coating Bulletin

Chomerics, Inc. has published a technical bulletin describing CHO-SHIELD® 598 A/B, a highly conductive silver-epoxy EMI coating. This two-component coating provides exceptional salt spray corrosion resistance when applied to aluminum flanges which incorporate conductive EMI gaskets. When mixed, CHO-SHIELD 598 coating is applied with an air gun at room temperature. The compound dries to the touch within one hour, attaining full chemical resistance in one week. Surface resistivity is 0.06 ohms/sq. based on 1-hour RT cure followed by 1-hour cure at 250°F. **Chomerics, Inc., Woburn, Mass. INFO/CARD #83.**

Conductive Metallites Brochure

Conductive nickel flakes, nickel spheres and silver-coated particles are described in a new brochure from Novamet. The brochure discusses the use of nickel flakes for EMI/RFI shielding, nickel spheres for polymer thick film ink systems and conductive gaskets, and silver and gold coated nickel products for a variety of conductive applications. Scanning electron micrographs of the products accompany the discussions. **Novamet, Wyckoff, N.J., INFO/CARD #160.**

Power Measurement Catalog

A new 60-page RF Instruments catalog of Thruline® directional wattmeters, coax load resistors and attenuators, calorimeters and RF components is now available from Bird Electronic Corporation. This catalog of RF measurement instrumentation and components from 2 milliwatts to 250 kilowatts, 0.235 to 2300 MHz, features triple indexing — by function, power level and model number. **Bird Electronic Corporation, Cleveland (Solon), Ohio. INFO/CARD #171.**

Crystal and Oscillator Catalog

A new catalog features AT-cut quartz crystals from 5 MHz to 150 MHz and crystal oscillators from virtually DC to 1 GHz for military and commercial applications. Oscillators are available and temperature compensated (TCXO), ovenized (OCXO), and voltage controlled (VCXO) designs. These products have an emphasis on high reliability military applications for oscillators and on microwave applications for crystals. **EG&G CINOX, Cincinnati, Ohio. INFO/CARD #170.**

Power Tube Product Guide

A new product guide describing RCA Power Tubes and associated circuit components has been issued, providing technical data for power tubes with output capabilities from a few watts to megawatts, and frequency coverage extending from DC to over 1400 MHz. The guide has separate sections for Broadcast, Communications, and Special Purposes types in addition to a comprehensive section on tube characteristics. **RCA Tube Operations, Lancaster, Pa. INFO/CARD #169.**

RF Filter Catalog

Reactel, Inc. has just published a new RF and microwave filter catalog. Bandpass, lowpass, highpass and band reject filters are covered in different series and sizes of tubular, LC, cavity, combline, interdigital, miniature and micro mini configurations. The catalog provides electrical, mechanical and environmental specifications and information about connectors, special packages and mounting. **Reactel, Inc., Rockville, Md. Please circle INFO/CARD #168.**

Towers and Passive Repeaters

Microflect has released a brochure describing their capabilities in the design and fabrication of microwave passive repeaters and communications towers. The brochure contains many color photographs illustrating in-plant operations as well as on-site construction. **Microflect, Salem, Ore. INFO/CARD #167.**

Thick-Film Users Newsletters

Material Matters Volume VI Issue 2 has been released for interested users of thick film materials, describing papers given by Electro-Science Laboratories scientists. One paper addresses the issues of metal powder concentration and particle size in solders chosen for surface mounting applications. A second paper describes the extension of capacitance dielectric usage through selection of electrode composition and bonding ingredients. **Electro-Science Laboratories Inc., King of Prussia, Pa., INFO/CARD #166.**

Pocket Guide to GaAs ICs

GigaBit Logic has released a pocket guide to their PicoLogic™ and NanoRam™ GaAs IC products. Included in the pocket guide is a description of available foundry services using their 1 micron D-MESFET process for applications up to 4 GHz. **GigaBit Logic, Newbury Park, Calif. INFO/CARD #90.**

Components Capabilities Catalog

A new Microwave Components and Capabilities Catalog has

been published by EMC Technology, Inc. New products include a line of step attenuators, either in DIP configurations or for surface mounting, and a high power coaxial attenuator series. Also included is a MIL Spec cross reference table which lists the EMC model number and its counterpart military part number. **EMC Technology, Inc., Cherry Hill, N.J. INFO/CARD #89.**

Attenuator and Termination Catalog

Elcom Systems, Inc., catalog No. 861 lists a complete line of coaxial RF attenuators and terminations as well as minimum loss pads, multicouplers, double balanced mixers, and detectors. They are available in BNC, N, TNC, and SMA connectors, and operate over the frequency range of DC to 4.2 GHz. **Elcom Systems, Inc., Boca Raton, Fla. INFO/CARD #165.**

Coaxial and RF Relays

A new catalog contains information about coaxial relays designed for minimum size and weight, AC or DC operation, with Time Delay or auxiliary contacts. Unshielded RF switching relays are also included. These coaxial relays feature low VSWR, excellent cross talk characteristics and a wide selection of connectors. **Magnecraft Electric Company, Northbrook, Ill. Please circle INFO/CARD #164.**

GaAs IC Design Rule Manual

Honeywell has published a gallium arsenide (GaAs) design rule manual to help potential foundry users design GaAs ICs. The HGD-1000 foundry design rule manual gives designers enough information to use Honeywell's current GaAs production technology, which is a one-micron, depletion mode MESFET process with double-level metal interconnect. The rule manual sells for $500, and includes any updates released during the two years following the purchase. **Honeywell Inc., Gallium Arsenide IC Product Center, Richardson, Texas. INFO/CARD #163.**

Comb Generator Data Sheet

A new data sheet from TRW Microwave describes the company's line of Step Recovery Diode Coaxial Comb Generators, including applications information, electrical specifications, outline drawings and curves showing typical performance. TRW's A9G series of comb generators features drive frequencies from 100 to 1000 MHz with a narrow output pulse width which is typically 120 psec. Input is matched to 50 ohms. **TRW Microwave, Sunnyvale, Calif. INFO/CARD #162.**

Waveform Generator Catalog

Avtech Electrosystems introduces a short form catalog of nanosecond waveform generators and accessories (Cat. No. 6S). The catalog describes over 100 models of pulse generators, transformers, power splitters, delay generators, sample and hold amplifiers and scope probes covering the PRF range of 0 to 250 MHz, rise times from 40 psec to 10 nsec, pulse widths from 130 psec to 100 usec and amplitudes from 5 to 350 volts. **Avtech Electrosystems Ltd., Ottawa, Ontario, Canada. Please circle INFO/CARD #161.**

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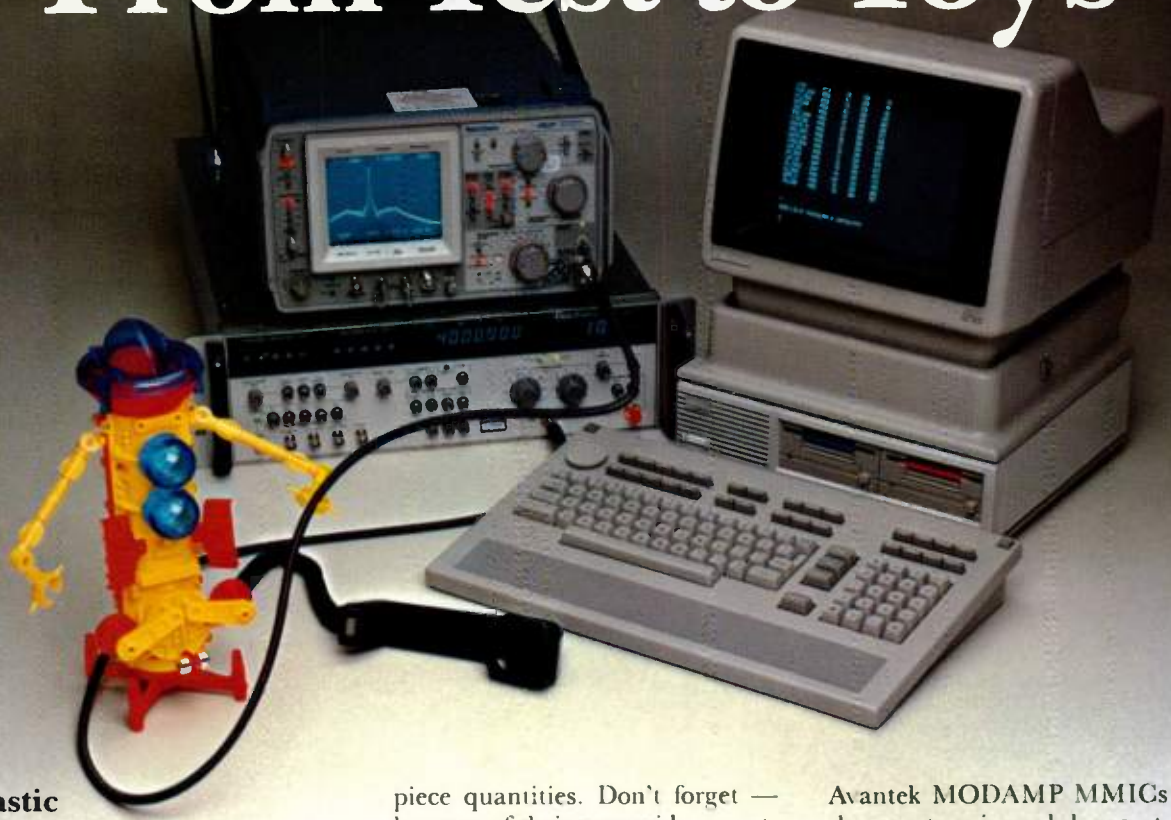
From Test to Toys



Plastic MMIC gain blocks. Avantek 4-Pac amplifiers. $1.80 each*.

Avantek's series of MODAMP™ silicon monolithic microwave integrated circuit amplifiers are ready to drop into your 50-ohm circuit, with no design problems — virtually no concern for what comes before or after. These MMICs are unconditionally stable and provide cascadable gain blocks at any frequency up to 2 GHz.

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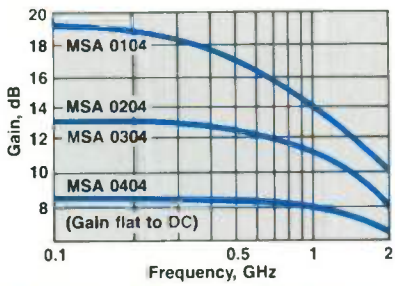
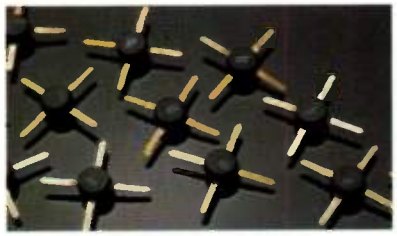
Avantek 4-Pac MODAMP MMICs are available today from your nearest distributor. Prices start at $2.75 and go to $1.80 in 10,000 piece quantities. Don't forget — because of their very wide operating range, the same amplifier can work from DC through video all the way up to 2 GHz. And you can stack them like building blocks to add whatever gain you need. Avantek innovation — designed to make your design job easier.

Gain vs. Frequency





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