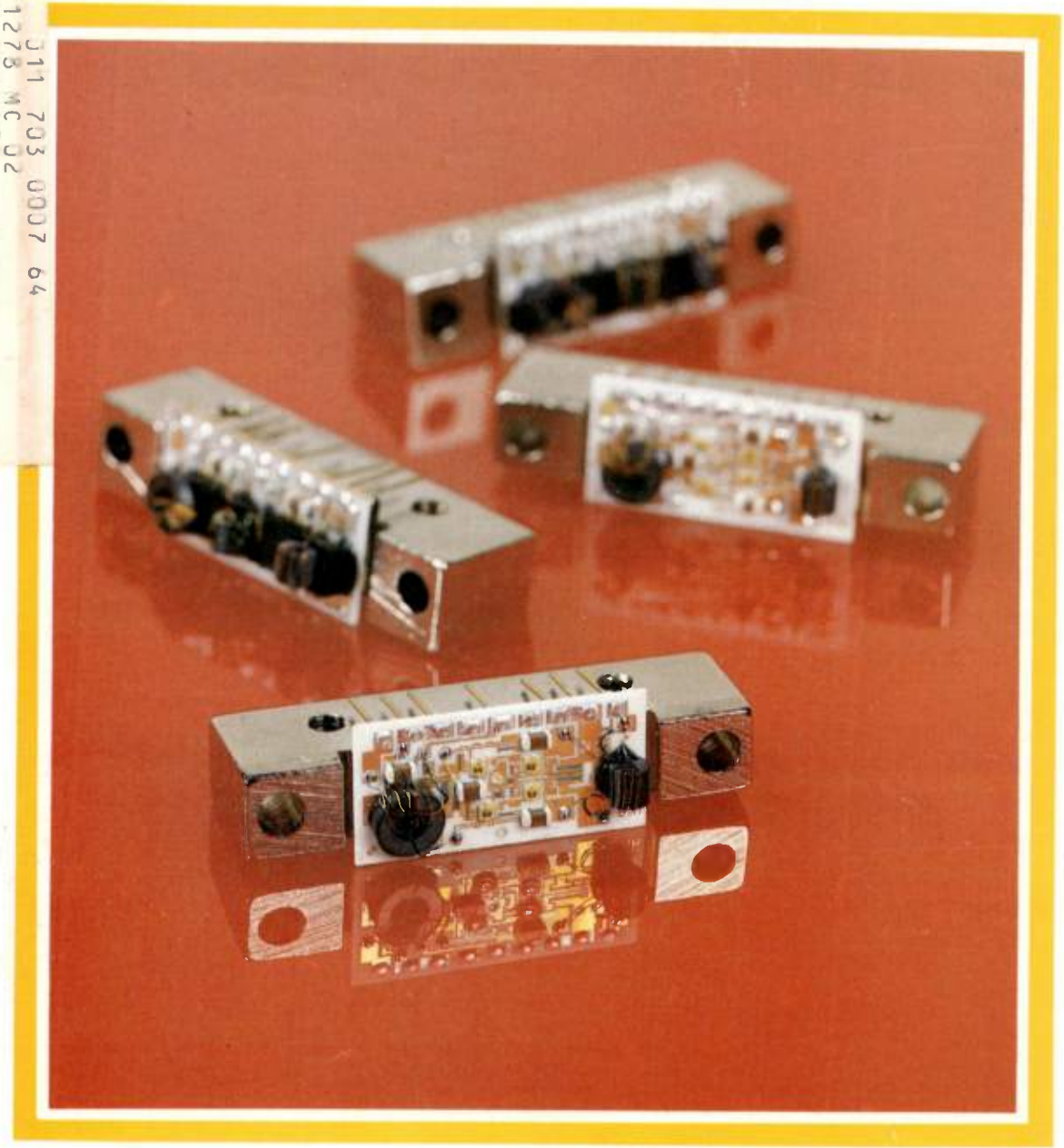
January/February 1979

A Cardiff Publication

rf design



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Frequency Counter Survey

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Model No.	Freq. (MHz)	Conv. loss (dB max.)	Signal 1dBm compr. level (dB min.)	Connections	Size (w x l x ht.) (in.)	Price (Qty.)
TFM-1H	2 — 500	8.5	+14	4 pins	0.21 x 0.5 x 0.25	$23.95 (5-24)
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TAK-1H	2 — 500	8.5	+14	8 pins	0.4 x 0.8 x 0.25	$19.95 (5-24)
TAK-1WH	5 — 750	9.0	+14	8 pins	0.4 x 0.8 x 0.25	$23.95 (5-24)
TAK-3H	0.05 — 300	8.5	+13	8 pins	0.4 x 0.8 x 0.25	$21.95 (5-24)
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ZAD-1WSH	5 — 750	9.0	+14	BNC,TNC	1.15 x 2.25 x 1.40	$44.95 (4-24)
ZAD-3SH	0.05 — 300	8.5	+13	BNC,TNC	1.15 x 2.25 x 1.40	$42.95 (4-24)
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ZLW-3SH	0.05 — 300	8.5	+13	SMA	0.88 x 1.50 x 1.15	$52.95 (4-24)
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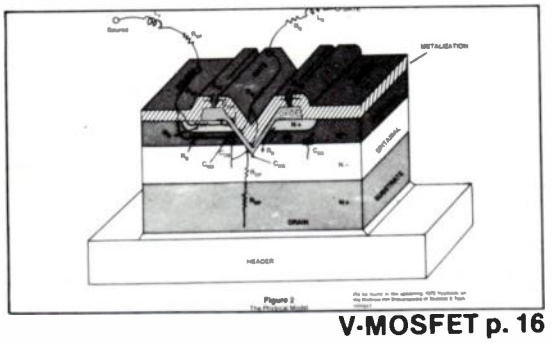
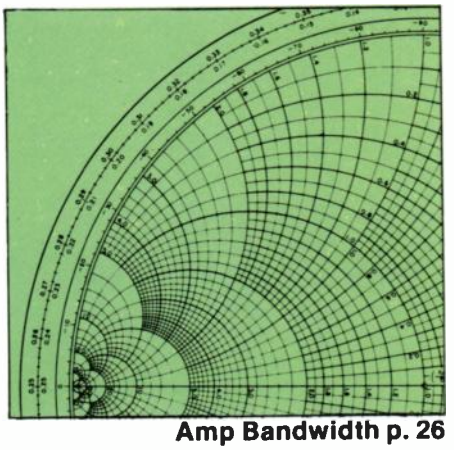
G36/Orig

r.f. design

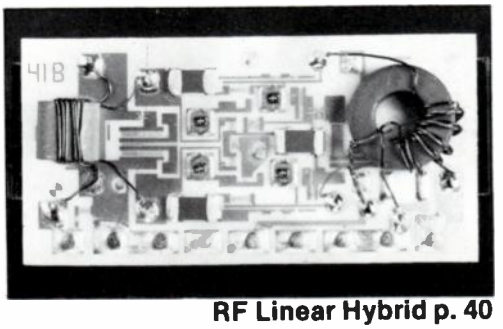
January/February 1979



V-MOSFET p. 16



Amp Bandwidth p. 26



RF Linear Hybrid p. 40

Number of significant figures including ±1 digit	8
Time base crystal oscillator used RTXO, TCXO, OCXO, POXO	RTXO TCXO
Long term time base stability ppm/month	RTXO .6/M
Time base frequency change over 0°C to 50°C temperature range. ppm	±5

Frequency Counter p. 49

Help us serve you by returning the r.f. feedback card on page 67.

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SRA-1

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RF	0.5-500
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0.5-500 MHz	6.5	8.5

Isolation (dB)		Typ.	Max.
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	LO-IF	45	35
5-250 MHz	LO-RF	45	30
	LO-IF	40	25
250-500 MHz	LO-RF	35	25
	LO-IF	30	20

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"It Won't Fly, Wilbur!"

Back in 1901, a couple years before they actually made it happen, Orville Wright told Wilbur, "Never in the next 100 years will man be able to fly". The cause for Orville's bad attitude on the particular day was the aviation literature of the day. He and his brother had been discovering over and over again that what other people had written down as being engineering fact really was not. One of their big problems was deciding what was valid from the literature and what was not, because most of it turned out to be bad research.

A few weeks ago we visited the Bureau of Standards and NOAA in Boulder, Colorado, where they are doing some things today which are analagous to what the Wright brothers were doing 75 some odd years ago. For example, they are conducting experiments pumping megawatts of energy into the ionosphere thereby "heating" it up and getting radio-frequency reflection at frequencies and at times of day when it is not possible under normal circumstances. In another interesting project, they have developed a technique for measuring ocean currents by scattering "h.f. radar" off the fundamental standing waves in the ocean and measuring the doplar shifts as the waves move. The h.f. frequency used matches the six-meter wavelength of fundamental ocean waves. Therefore, even in a storm the velocity of fundamental wave motion can be measured because all others cancel.

The engineers and scientists in Boulder have exactly the same need that Orville and Wilbur had for reliable technical information...good solid technical information is the backbone of new discovery and better design. They need to know, for example, when transistors will really fail...they need to know what are the implications of new products like V-MOSFET semiconductors (page 16 of this issue)...they need to know the latest in test gear so that they can better instrument (page 49 this issue).

Good engineers will overcome almost any obstacle (including the literature) like Orville and Wilbur and ultimately come up with a working design. But good technical literature sure helps a lot. *r.f. design* intends to be a main source of that kind of information. Help us to do so. Let us know your suggestions and what you think so far by sending in the feedback card on page 67. □

Pat Wiesner

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Rockland Series 5600 Programmable Frequency Synthesizers employ the *direct* synthesis technique – no slow and noisy phase-locked loops – yet cost less than many PLL designs in this range! Resolution is *constant*: 1 Hz across the entire 0.1 to 160 MHz range. That's a *single* range, too; no range switching, no multipliers. Spectral purity is outstanding: –70 dB phase noise: –35dB harmonics; –70 dB spurious. Stability is exceptionally high: 1×10^{-9}/day, with a very low T.C. (1×10^{-8} from 0°C to 50°C). Or inject your own external reference. Output levelling is exceptionally tight: ±0.5 dB throughout the frequency range.

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- Designing With PIN Diodes

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- New Designs in ILS Systems
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- Managing R&D Dept.
- and much more!

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I wanted to compliment you and your staff on the premiere issue of *r.f. design*. I was really impressed from an information, editorial and layout standpoint.

I in particular paid special attention to the editorial in the first issue and can honestly say I really enjoyed it and learned a lot.

Thank you for your editorial interest in Racal-Dana and keep up the good work.

Dennis P. Hollow
Vice President, Public Relations
Basso/Boatman

I've just received a copy of the first edition of *r.f. design.* Congratulations — at last here is a magazine which satisfies RF circuit designers working in the HF through UHF bands.

There is an omission and corrections which need to be indicated in your next edition. In Figure 6 on page 49:

1. The units for MTBF are YEARS.
2. Be0 thickness is 40 mil — not 60 mil.
3. Vcc is 12.5V — not 12.54

Keep up the good work!

Alan Wagstaffe
Product Planner
High Frequency Products
Motorola Inc.
Discrete Semiconductor Division

I'd like to extend my hearty congratulations for an outstanding trade journal. I'm probably as excited as you folks are about making a publication available to the long-forgotten RF engineer and technician. Not only have *The Proceedings* gone seriously awry in the subject matter and the manner in which it is presented, but old standby journals such as *EDN* and *Electronics* have capitulated entirely to the computer audience. I don't feel that we're close to abolishing RF communications. Your journal will serve a need that has been starving for several years!

M.F. "Doug" DeMaw, W1FB
Manager, ARRL Technical Dept.
The American Radio
Relay League, Inc.

Tremendous!! After 16 years of RF design engineering, I was delighted to receive the first issue of *r.f. design* and certainly look forward to reading every issue. It is a pleasure to know that the microprocessor hasn't eliminated the forgotten RF man.

Keep up the good work.

Noel Atkinson
Electra "Bearcat"
Division Masco Corp. of Ind.
300 East County Line Road South
Cumberland, Indiana 46229
317-894-1440

I noticed an error in the FM calibrator section on page 28 (*r.f. design* November/December). Apparently it was misread from my draft:

. . . computes peak deviation FM as $[(f_H-f_L)/2]$ (33 kHz) nominal peak. . .

John L. Minck
Stanford Park Division

Congratulations on launching *r.f. design.* There has been a need for such a publication. No other publication addresses itself to the RF equipment design engineer. Your new publication should be an overwhelming success.

Leo G. Sands
Communications Consultant

Just saw the first issue of *r.f. design.* It looks good to me and I'll pass it around our various RF groups just to make sure they are all cognizant. Speaking from an editorial point of view, I'm certain you will be our primary publication for RF material.

Lothar Stern, Manager
Technical Information Center
Motorola Inc.
Semiconductor Products Inc.

I want to congratulate you and your associates on a fine first issue. The quality and readability is excellent, the articles well written and timely.

Having been a design engineer in the past, I can tell you that the book looks and feels right.

Best of luck in the future.

Paul S. Rumford
Product Marketing Engineer
Hewlett-Packard
Loveland Instrument Division

I have seen your November/December issue of *r.f. design* and scanned the editorial. I am impressed. The RF world in which I have spent most of my professional career, needs a dedicated magazine and you might just have the right menu.

Good luck for the future.

David Ford
Product Manager
Hewlett-Packard
Loveland Instrument Division

I would like to apologize to Bert L. Henscheid of Theta-Com CATV a division of Texscan Corporation for not giving him a byline in the November/December issue of *r.f. design.* He wrote the article entitled Co-Ax Provides D.C. Power for Receiver.

Bart Gates
M. Editor
r.f. design □

Attenuator manufacturers used to hide when they saw us coming.

Before we became attenuator manufacturers ourselves, we used to buy them from other vendors.

We were tough customers because the sweep generators and test equipment we made demanded it.

Attenuator specs had to be right on. The quality had to be right up there. The delivery had to be right on time.

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INFO/CARD 5

World Administrative Radio Conference

The FCC has adapted a Report and Order announcing its proposals to amend the international radio regulations to be considered at the general World Administrative Radio Conference in Sept. 1979.

The FCC's Report and Order in this proceeding comes at the end of four years of inquiries in preparation for the general World Administrative Radio Conference (GWARC). The Department of State will now use this Report and Order to prepare United States proposals which will be delivered to the International Telecommunication Union (ITU) in January 1979 for circulation among the nations of the world.

Proposing the expansion of the AM broadcasting band. The expansion would create a band at 1615-1800 kHz which is shared between broadcasting and various other services, and a band at 1800-1860 which is exclusively allocated to broadcasting. This change could result in approximately 14 new channels (for approximately 700 new AM stations). Because most of the available broadcasting channels have been allotted to licensees, this would provide new channels for potential diversities in broadcasting and minority ownership. However, it will require that changes in the design of AM radio receivers be made. These new receivers should not be more costly than existing ones, although a significant number must obviously be in use for the new allocations to be economically viable.

Proposing that the UHF band be internationally allocated equally among most communications services. Because communications technology is rapidly changing and the demand for local communications is increasing, it is highly desirable to minimize international restraints in this band. Therefore, the FCC is proposing to add the fixed and mobile communications services in nearly the entire band between 470 and 890 MHz which is presently allocated exclusively to broadcasting.

Proposing to double the available radio/orbital resource available for advanced satellite communication systems at 12 GHz. Because many of our country's technologically advanced, domestic communication systems will be introduced in the 12/14 GHz bands during the next decade, this issue in considered by many to be one of the most significant for the U.S. at the 1979 GWARC. In light of a number of factors, the Commission is proposing to make the entire range of the geostationary orbit available in the Western Hemisphere equally to fixed and broadcasting services; and at the same time, separating into individual 500 MHz segments the frequency bands within which the services must operate.

Proposing an amendment which would allow future consideration of a land mobile-satellite service in the 806-890 MHz band. This amendment allows the implementation of a land-mobile satellite service in some 20 MHz segment in the 806-890 MHz band. Such a service could provide inexpensive two-way voice and data communications to a wide variety of local, state, and federal government users in mountainous or rural areas where such systems are not presently feasible.

Proposing a number of changes to transmitter technical standards which would improve the efficiency of spectrum use. These changes include additional limits on unwanted signals of radio transmitters, on the requirement that a transmitter stay within a certain frequency range, the eventual conversion to single sideband equipment in the short-wave broadcasting service, and improved control over the pointing of satellite antennas.

Electronic Conventions

April 24, 26, 1979:	Electro/79 Show and Convention, New York Coliseum and Americana Hotel
September 18-20, 1979:	Wescon/79 Show and Convention, Brooks Hall and St. Francis Hotel
November 6-8, 1979:	Midcon/79 Show and Convention, O'Hare Exposition Center and Hyatt Regency O'Hare
May 13-15, 1980:	Electro/80 Show and convention, Hynes Auditorium and Boston Sheraton

Future of Discretes

John R. Welty, Motorola vice president and general manager of the Semiconductor Group spoke out on the future of discrete semiconductor components recently at a Data Quest meeting. Essentially he tied the future of discretes to the booming microprocessor industry. Even though micrprocessors are replacing conventional standard logic integrated circuit families, their impact on discrete components is definitely positive, he said. Microprocessors can not function by themselves. Depending on the application, a number of different types of discretes are required for rectification, voltage regulation, for power handling and for carrying out the actions determined and ordered by the microprocessor. We anticipate rather dramatic growth for power transistors, rectifiers, thyristors and optoelectrics.

Welty

Cellular Mobile Rules Extended

Cellular systems are mobile radio systems that attain large capacities through the coordinate reuse of a group of radio channels. In such systems, each channel can be used many times in separate areas or "cells" within a single city and its surrounding area. Mobile units communicate with any of an array of cell control locations distributed about the system. These in turn are connected by wire line facilities to switching and control centers, and thus are interconnected to the telephone network.

The FCC said it was extending the period for cellular development in the hope that it would lead to the submission of information that would enable it to adopt a framework of rules making possible a nationwide compatible mobile communications network to meet all needs of the American public. The Commission added that it still encouraged the submission of new developmental proposals from the telecommunications industry, and stated that the experience gained from even a short period of developmental operation of a new system might be of more value in designing a framework of rules for future systems than an entire year of pleadings and comments.

CB'ers Cautioned Scramblers Illegal

Recent reports in the media indicate scramblers (automatic encoding and decoding devices) may be marketed for use in the Citizens Band Radio Service. A scrambler is a device which encodes the message upon transmission and decodes it upon receipt. Citizen

Band operators should be aware that use of a scrambler would be in violation of Part 95 of the Federal Communications Commission's Rules.

Violation of these rules can subject the operator to possible fine and loss of license.

CB Licensees Hit All Time High

For the first time the number of Citizens Band licensees has gone over 14 million. Over 2.5 million new licenses have been issued in the last 12 months, which represents a 22 percent growth rate in the CB community. Texas has over a million licensees, California and Ohio have over 800 thousand and Florida, Illinois, Michigan, New York, and Pennsylvania all have over 500 thousand licensees. One out of every ten residents in Wyoming, Alaska, North Dakota and South Dakota have Citizen Band licenses. If the present growth rate continues the number of CB licensees will double every three and a half years.

Trade Imbalance U.S./Japan

Charles E. Sporck president of the National Semiconductor Corporation gave the Japanese some suggestions at conference between the Semiconductor Industry Association and the Electronic Industry Association of Japan. Specifically, the semiconductor industry association would like to see evidence of:

- An active exchange of IC technology between the U.S. and Japan; for example, free access under appropriate licenses to "all" VLSI research;
- A single rather than a two tier pricing system in semiconductors under which the Japanese equalize their domestic and export prices;
- A significant increase in real IC imports to Japan as measured by share of market, which would indicate vigorous and sincere affirmative action by the Japanese semiconductor industry and the government to change the culturally ingrained "buy Japan" attitude. □

Meet the V-MOSFET Model

A modeling of the V-MOSFET Transistor for high frequency design.

Ed Oxner
Siliconix, Incorporated
Santa Clara, Calif.

Vertical MOS transistors for high frequency applications have, within the past year, mushroomed in popularity partly because of the inherent temperature-related advantages unique to the technology. Such advantages include no thermal run-away, no current hogging and, to a lesser extent, a greatly reduced secondary breakdown phenomenon. As a result of this increased popularity it is important that a model is available that allows the designer the freedom to use CAD (Computer Aided Design) techniques for design optimization. Although V-MOS models have been reported by several investigators, none has achieved a fully satisfactory representation that offers viable results over wide ranges of frequencies.[1-2]

The principle deficiency of these earlier models appears to lie in the heretofore neglect of the parasitic bipolar transistor inherent in a vertical channel MOS structure (although not discussed in this paper, the published models of the double-diffused DMOS transistor also suffers from this same neglect.)[3] This parasitic NPN bipolar transistor arises from the interaction of the P channel (base), the N + source (emitter) and the N − drain drift epitaxy (collector).

At D-C and frequencies below 5MHz, it appears that the elements of this parasitic NPN bipolar transistor have little effect on amplifier performance. However, as the frequency rises the continued neglect of including this parasitic transistor into the model becomes increasingly severe.

Device Design

Much has been written offering the casual reader a basic understanding of VMOS design.[4-5] Beginning as a four-layer bipolar transistor all similarity ends when a 'V' groove is anistropically etched vertically into the structure providing access to the P channel for an overlay metal gate. Such design offers an opportunity for high-frequency performance not easily possible with planar silicon MOS technology.

To effectively reduce the parasitic NPN bipolar transistor effect the P channel (base) is shorted to the N + source (emitter) as shown in Figure 1. Generally with the base tied to the emitter an NPN bipolar transistor remains in a non-conducting state.

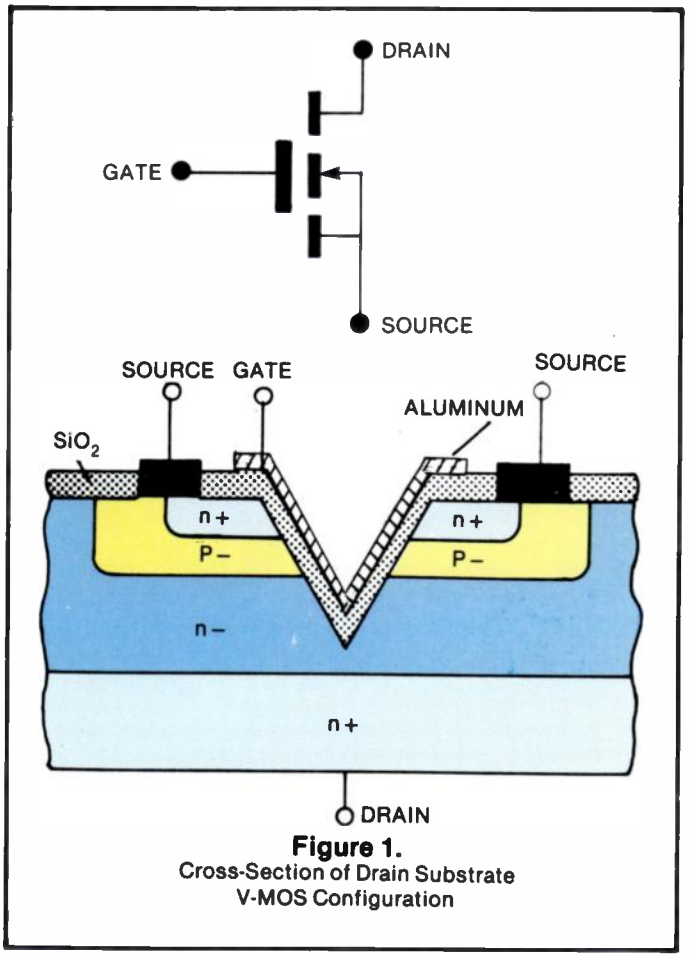


Figure 1.
Cross-Section of Drain Substrate
V-MOS Configuration

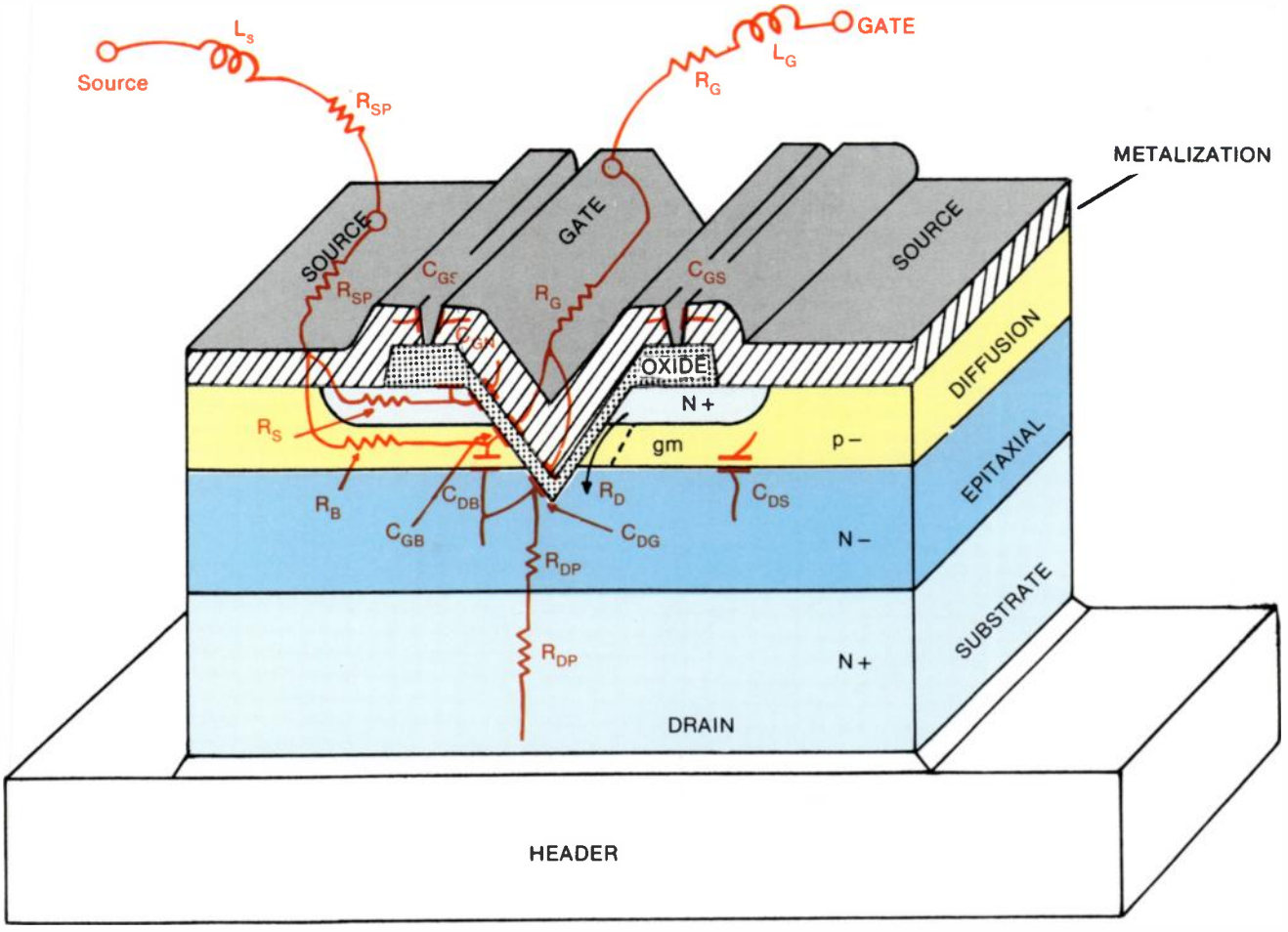


Figure 2
The Physical Model

(To be found in the upcoming 1979 Yearbook on the McGraw-Hill Encyclopedia of Science & Technology.)

Device Simulation

The Physical Model

Once a physical model has been constructed achieving a workable schematic model is easy. Figure 2 shows the basic four-layer structure: An N+ substrate — the wafer itself — with an N− epitaxy into which has been diffused, first a P doped layer and then into this P layer N+ diffusion. Needless to say that this figure is not to scale! Left alone this would be the beginning of a typical bipolar transistor. A 'V' groove, suitable oxide and an overlay metal for gate and source completes the physical model. The model is then mounted on a header — in the case for the Siliconix VMP4 a flanged 380SOE high-frequency package — and, finally, lead bonds attach the source and gate to their respective package terminals. Adding the parasitic capacitors and resistors is obvious. The result is a physical model of the VMOS high-frequency transistor, VMP4.

The Schematic Model

Using the physical model one can trace the entire electrical path and place all the parasitic elements that comprise the schematic model of the VMOS transistor. Figure 3 identifies each element of the schematic model. The element, R_{OS} ($1/G_{OS}$), represents the output resistance (conductance) which cannot be physically realized. L_G, L_S and L_{DP} are not intrinsic (that is, not part of the actual semiconductor element) but represent the package parasitic inductances of the Siliconix VMP4. R_G and R_{SP} represent resistive losses in both the gate and source metalizations as well as the lead losses. C_{GS} differs from C_{GN} in that the former is the field capacitance whereas the latter is that parasitic capacitance existing between the gate metal and the N+ source diffusion.

The parasitic NPN bipolar transistor evident in Figure 1 must be considered as contributing parasitic elements (R_B, C_{GB} and C_{DB}) as well as being a potential parasitic generator; that is, contributing a finite Beta as an active element. The latter is, indeed, possible and some explanation is necessary. Although the VMOS source is metallically tied to the base to reduce the effects of this parasitic NPN bipolar transistor, it so happens that the resistivity of the P diffusion, that forms both the VMOS channel and the parasitic transistor's base, has a finite resistance (measured as ohms-per-square). Although at the point of metallic contact the base-to-emitter resistance is effectively zero, nonetheless as the distance is removed from the short the bulk resistance

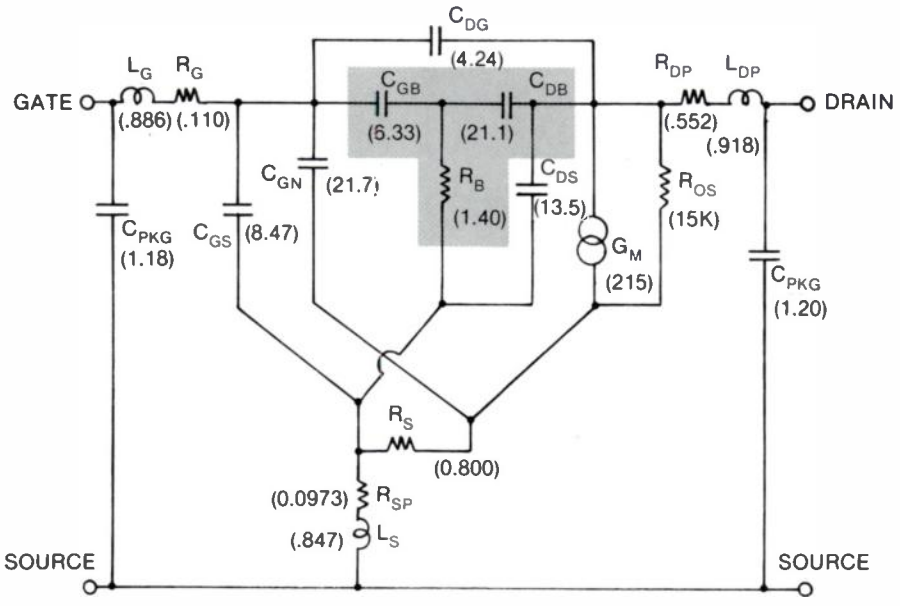


Figure 3. The Schematic Model VMOS (VMP4). The values in parentheses are for This Siliconix VMP4 where resistance is in ohms: capacitance in pF; inductances in nH; and transconductance in mMhos. (To be found in the upcoming 1979 Yearbook on the McGraw-Hill Encyclopedia of Sc ence & Technology.)

increases, so Figure 1 can be 'corrected' as shown in Figure 4. Should a voltage exist across this base resistance, R_B, it is conceivable that the parasitic NPN bipolar transistor can turn ON. One obvious means of placing a voltage across this resistance is by coupling the output voltage on the drain through the drain-base capacitor, C_{DB}. However, it was determined that this parasitic NPN bipolar transistor, acting as an independent parasitic generator is effectively muted having been found not to be a major contributor to the performance of the VMP4 at HF through VHF (400MHz). Nevertheless, the contribution of the NPN bipolar transistor's parasitic elements, R_B, C_{GB} and C_{BD}, as an RC feedback network are of paramount importance as illustrated in Figure 5 where the intrinsic gain, S_{21} (dB), of the VMOS model is computed both with and without the contribution of these parasitic elements.

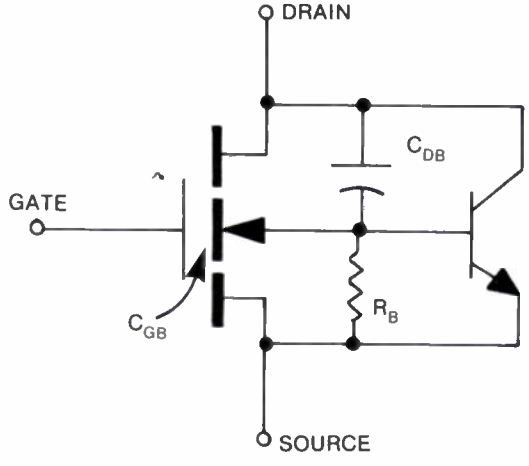


Figure 4
VMOS with a Parasitic NPN Bipolar

Experimental Results

Measured scattering parameters were used as the basis for establishing an exact model. Nodal analysis using the Circuit Optimization Program, Compact[6] working with 15 variables allowed the interconnection of 3 and 4 port networks as illustrated in Figure 6. In the Compact program variables are identified

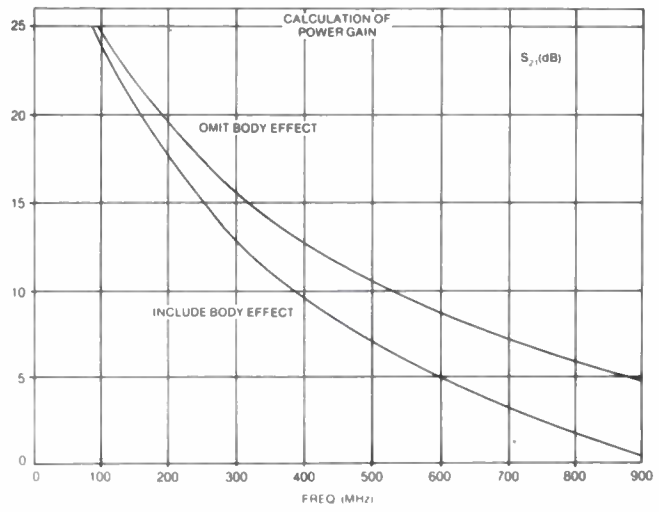


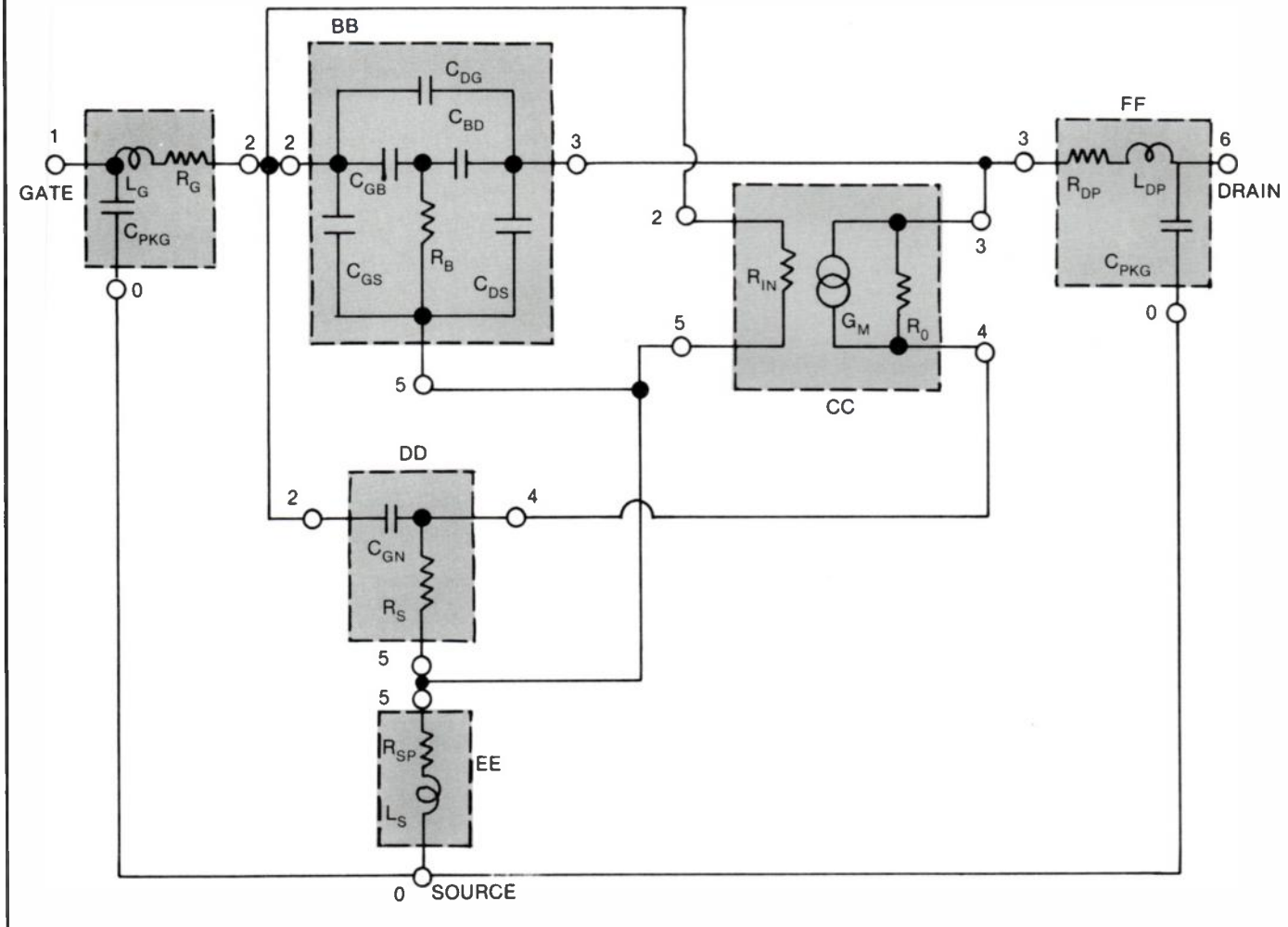
Figure 5
Effect of Including/Excluding The Body Resistance in the Calculation of S_{21} (dB).

as negative quantities. The final program used to determine the values of each element of the VMP4 transistor is listed in Figure 7. Please be aware that one does not simply insert measured S-parameters and let the program crank numbers endlessly. No indeed. First you have to have a good idea of 'where you're coming from,' and use good judgment as to the initial values. Compact's values is an optimization of the initial data to arrive at parameter-fitting model.

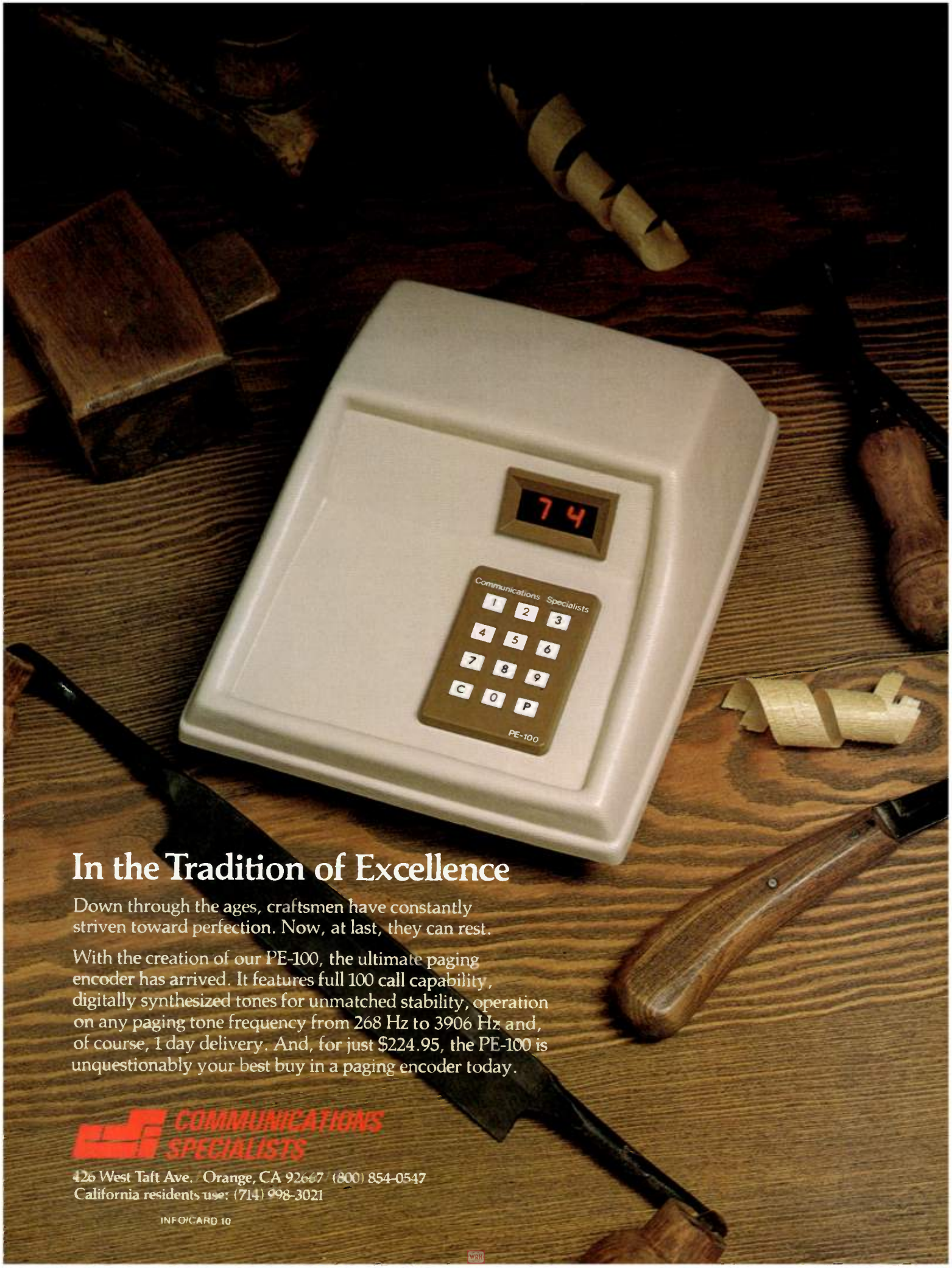
R_{IN} (in Figure 6) is used simply as a sense element required to realize a 4-port generator. To reduce it's effect, a value of 1E10 ohms was assigned. S-parameters measured at 200MHz were entered into the program and the computed Y-parameters were then compared with measured values and found to be in close agreement as shown in Figure 8.

Conclusions

This model offers a designer an excellent start in computer aided design of amplifiers and what-not. To ease the burden of transfering these data into your Compact program, the Siliconix VMP4 S-parameter data file is available in the Compact library under



NODAL ANALYSIS FLOW CHART
For COMPACT SYNTHESIS
Figure 6



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CAP   CC   SE    - 6.33
RES   DD   PA    - 1.40
CAP   EE   SE    - 21.10
CAP   FF   PA    - 13.50
CAX   BB   FF
CAP   CC   SE    - 4.24
PAR   BB   CC
GEN   CC   VC        .100E + 11      0.150E + 05   215
CAP   DD   SE    - 21.7
RES   EE   PA    - 0.800
CAX   DD   EE
SRL   EE   SE    - 0.973E - 01    - 0.847
SRL   FF   SE    - 0.552          - 0.918
CAP   GG   PA      1.20
CAX   FF   GG
CON   AA   T3      1.00             2.00   0.0
CON   BB   T3      2.00             3.00   5.00
CON   CC   T4      2.00             5.00   4.00   3.00
CON   DD   T3      2.00             4.00   5.00
CON   EE   T2      5.00             0.00
CON   FF   T3      3.00             6.00   0.0
DEF   AA   T2      1.00             6.00
TWO   BB   S1     50.0
SET   AA   BB
PRI   AA   S1     50.0
END
200
END
.77   - 146.3   2.14   57.5   .035   - 6.0   .759   - 146.6
END
.001
1     1     1     .627
END

EOF:
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Figure 7. Compact program including the parasitic elements of NPN bipolar in a Nodal analysis.

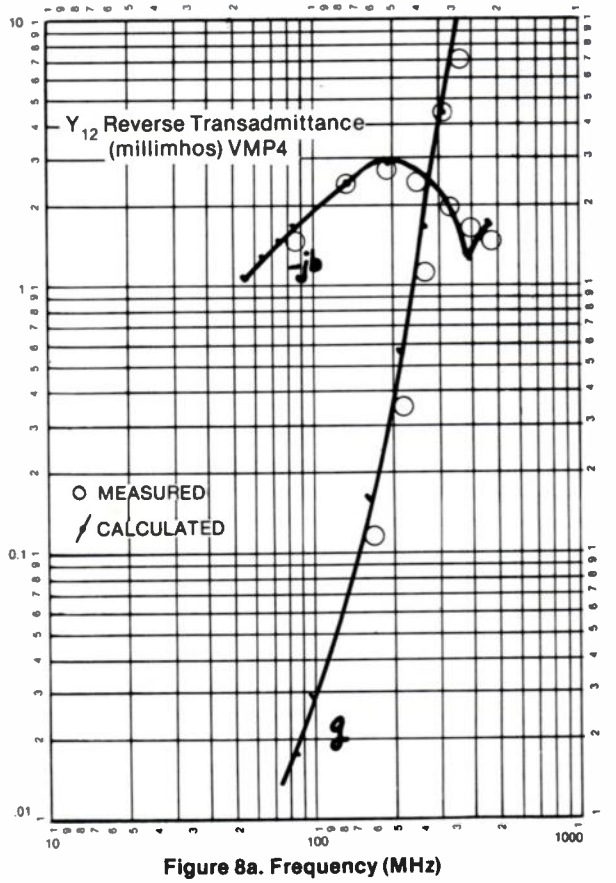

Figure 8a. Frequency (MHz)

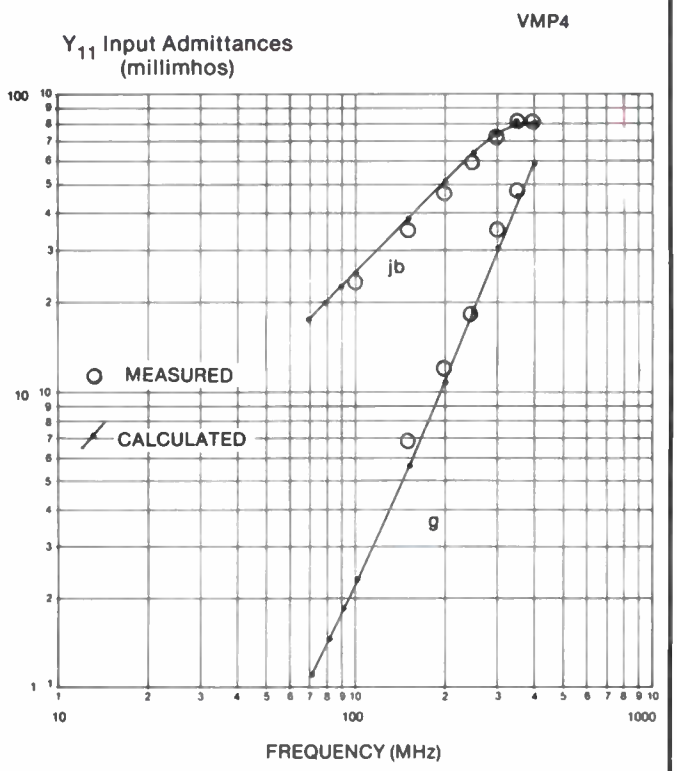

FIGURE 8(b)

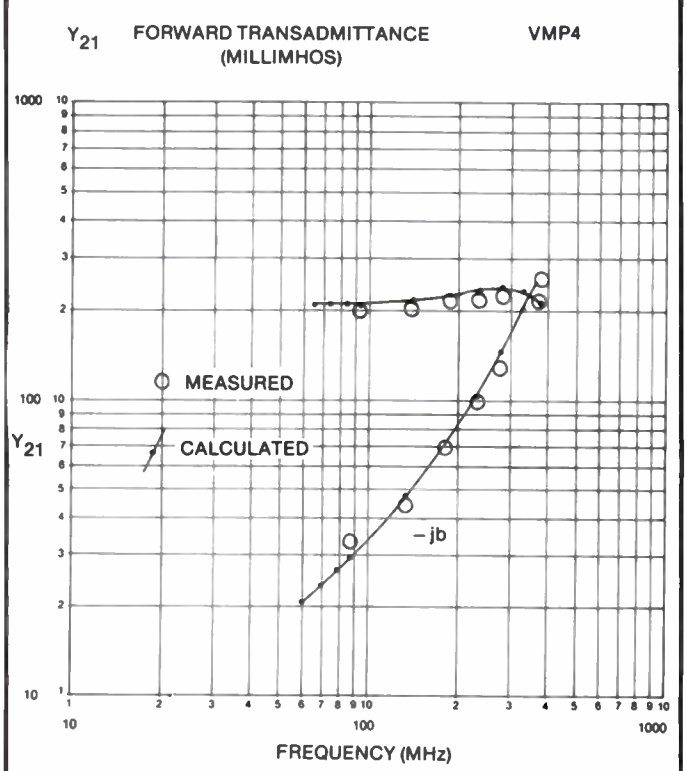

FIGURE 8(c)

the manufacturer's code 'SIX' and device code 'AA.'

Compact is presently available from 6 networks: NCSS; Control Data/Cybernet; GE/Honeywell; United Computing Systems; Tymshare; and, Computility/Call Data.

Finally, I would like to acknowledge the sacrificing work of my close associate, Larry Leighton for his efforts in assisting the development of this model.

Bibliography

1. James G. Oakes, etal., "A Power Silicon Microwave MOS Transistor," *IEEE Trans. Microwave Theory & Techniques,* vol. MTT-24, pp. 305-311, June 1976.
2. T.M.S. Heng, etal., "Vertical Channel Metal-Oxide-Silicon Field Effect Transistor," Final Report, Westinghouse R&D Center, ONR Contract N00014-74-C-0012, November, 1976.
3. Hans J. Sigg, etal., "D-MOS Transistor for Microwave Applications," IEEE *Trans. Electron Devices,* vol. ED-19, pp. 45-53, January 1972.
4. Marvin Vander Kool & Larry Ragle, "MOS Moves Into Higher Power Applications," *Electronics,* vol. 49, pp. 98-103, June 24, 1976.
5. Arthur Evans, etal., "High Power Ratings Extend VMOS FETs Domination," *Electronics,* vol. 51, pp. 105-112, June 22, 1978.
6. Les Besser, Compact *Reference Manual,* National CSS, Inc., Version, 4.50, January 1977. □

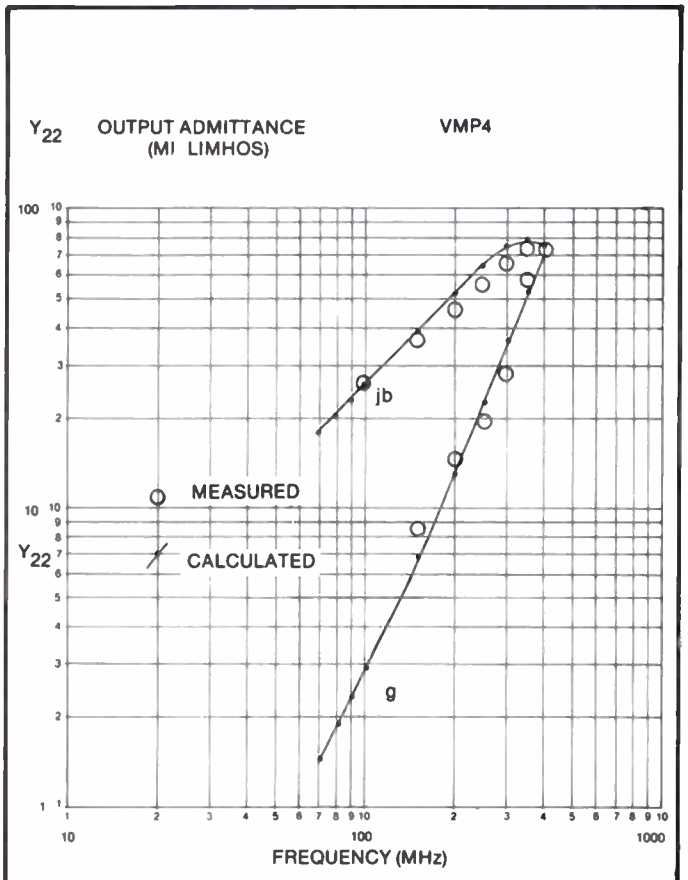

FIGURE 8(d)

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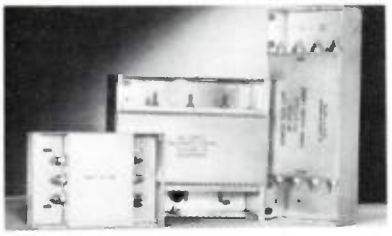

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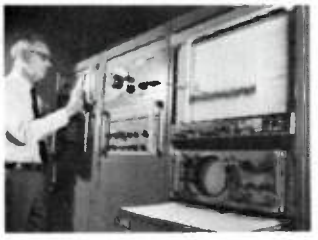

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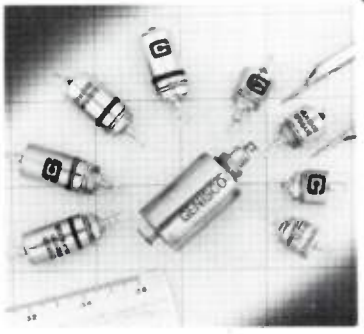

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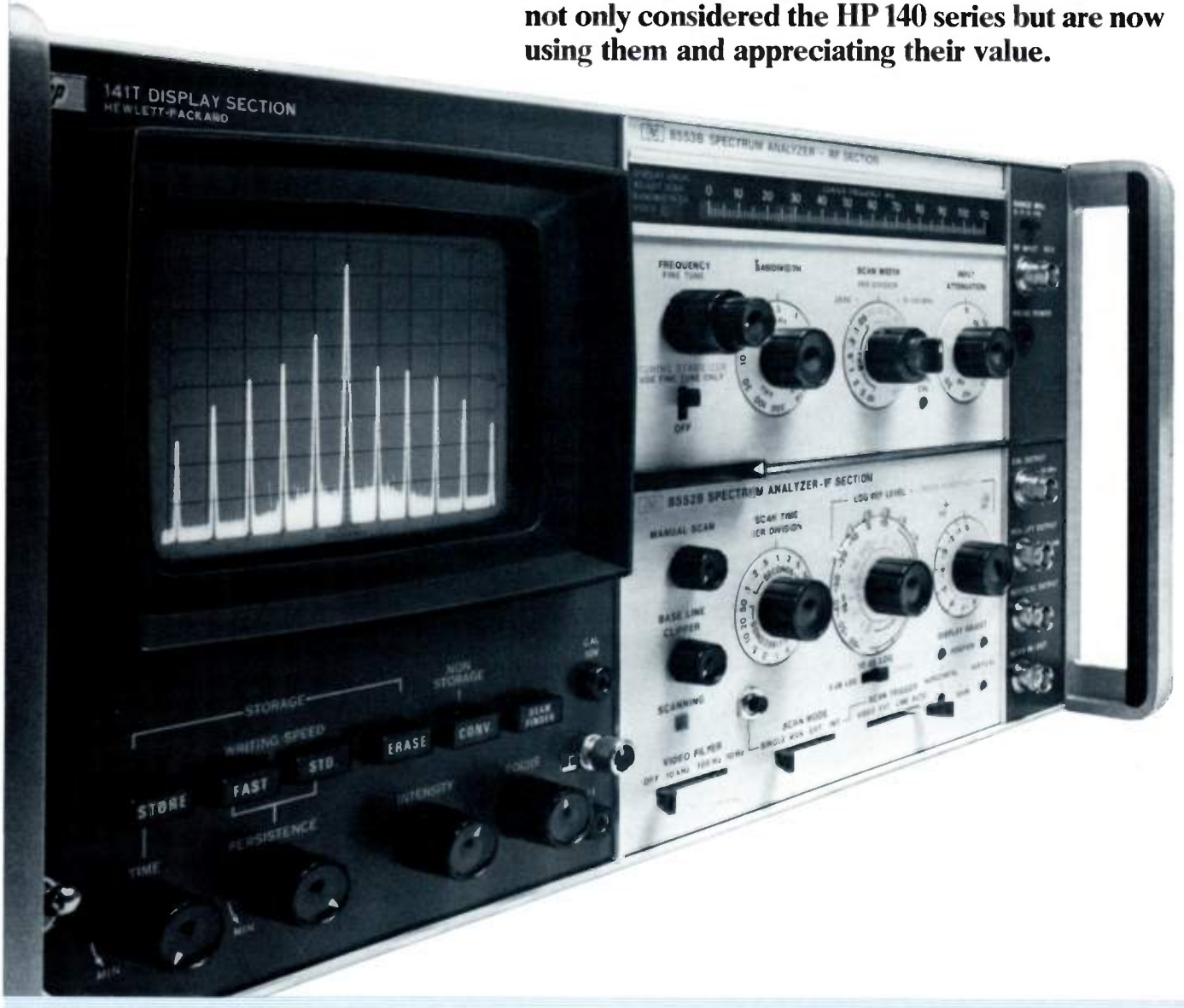

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8443A	Companion Tracking Generator/Counter	$5000
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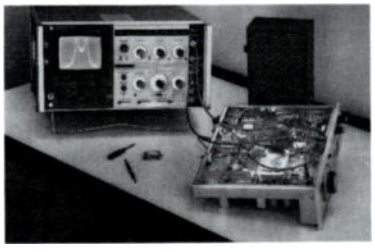
8444A	Companion Tracking Generator	$3675
8555A	10 MHz-40 GHz RF Section	$8100
8445B	10 MHz-18 GHz Automatic Preselector	$3180

20 Hz to 300 kHz



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The 8553B takes you from 1 kHz to 110 MHz with −140 dBm sensitivity and resolution as high as 10 Hz. Signals can be measured with ±1¼ dB accuracy. Choose the companion HP 8443A Tracking Generator/Counter for wide dynamic range swept frequency measurements and precise frequency counting.

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For 10 MHz to 40GHz, choose the 8555A. Its internal mixer covers to 18 GHz, accessory mixer for 18-40 GHz, Maximum resolution is 100 Hz. Measure with ±1¾ dB accuracy to 6 GHz, ±2¾ dB to 18 GHz. For wide scans free from unwanted response between 10 MHz and 18 GHz, add the HP 8445B Automatic Preselector.

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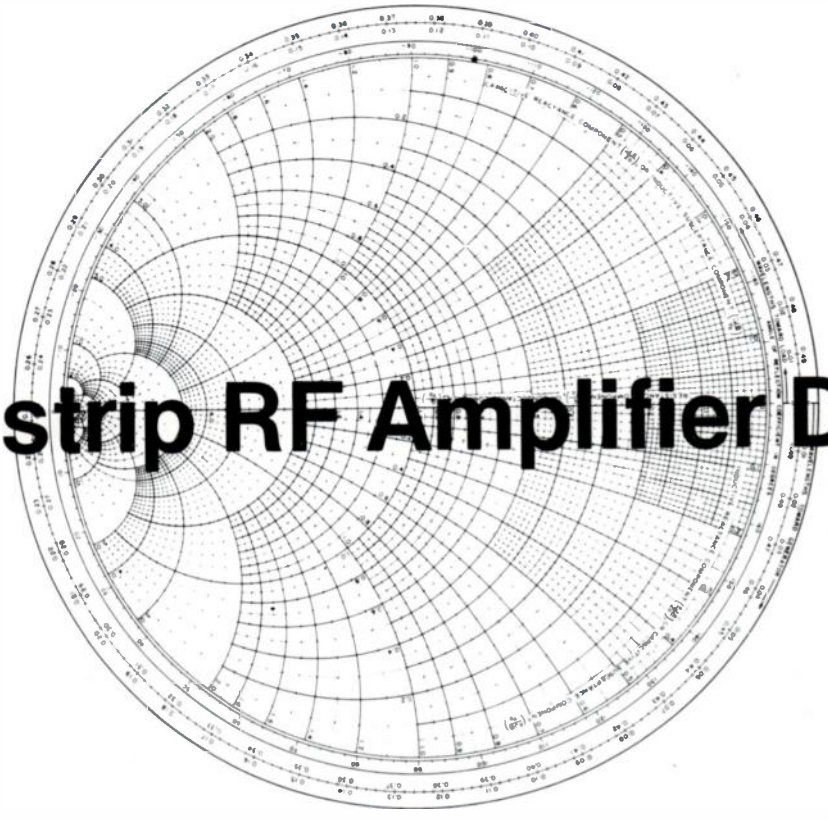

Microstrip RF Amplifier Design

By Thomas P. Litty
Consulting Engineer
3092 Bostonian Drive
Los Alamitos, CA

Of the many graphical aids designed to assist in the computation of microstrip transmission line circuits, the Smith Chart is the most generally useful. In the form in which it is printed, this chart displays orthogonal curvilinear coordinates of normalized impedance components on the voltage reflection coefficient plane. The Smith Chart is derived from the following expression:

$$\rho = \frac{(Z/Z_o) - 1}{(Z/Z_o) + 1} \qquad \textit{Equation 1}$$

Where:

ρ = *The complex voltage reflection coefficient at a transmission line point.*

Z/Z_o = *The normalized value of the impedance at that point.*

Now that you have read this rather sophisticated description of the chart, I will explain how I use it in the design and development of microstrip RF power amplifiers.

What To Do First

There are of course, several steps that must be taken before one can utilize the convenience of a Smith Chart. The most practical Smith Chart is one that has been normalized to 50 ohms characteristic impedance and 20 millimhos characteristic admittance and has coordinates in contrasting colors. This particular arrangement greatly simplies the use of the Smith Chart.

A chart of this nature, however, may not be immediately available to you, so first a discription of how a regular Smith Chart can be used will be given. Then, as a final practical example, a discription of how the design can be greatly simplified utilizing the Immitance Chart will be given. The sequence of design steps actually pertain to the use of both charts.

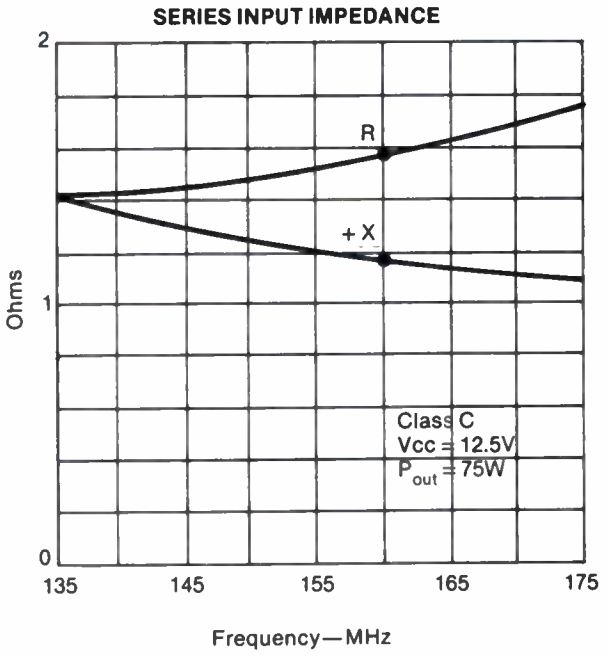

Figure 1a.

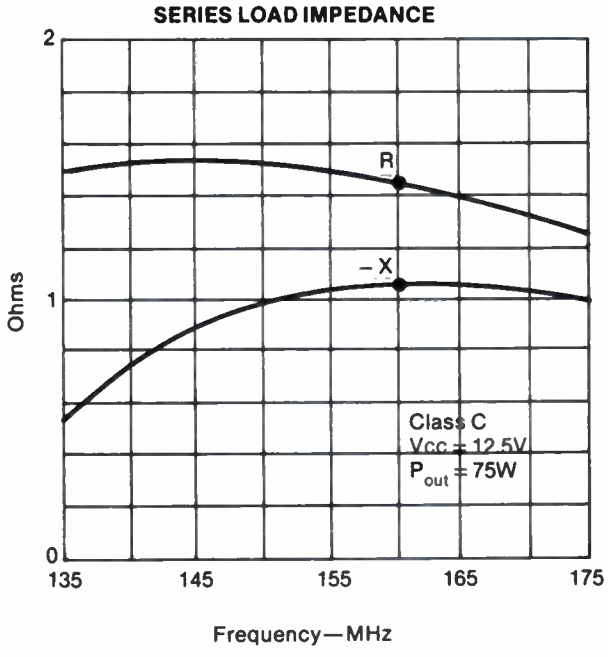

Figure 1b.

TRW JØ 4075

Design Steps

The following is the sequence of steps necessary to effect a practical design utilizing the Smith Chart.

Obtain and arrange all of the design data & Specifications.
Specifications & Design Data A. Transistor input and output impedances B. System Operating Impedance C. Bandwidth and dB Roll-off limits
Source A. Transistor Manufacturer B. Design specifications, usually 50 ohms C. Design specifications

Table I

A. Transistor Input and Output Impedances

This data is typically given by manufacturers of RF power transistors as a series equivalent input impedance at the base and a series equivalent load impedance at the collector of the power transistor. When taking this information from the specification sheet, however, it is extremely important to verify that the data has been given in this format. If the data is in a different format it will be necessary to convert it to a series equivalent circuit. As an example I have chosen the TRW JØ4075 and reproduced the necessary data sheet information regarding these impedances. (Figure 1).

B. System Operating Impedances

For most applications, amplifiers are assumed to be black boxes with a system input and output impedance. This impedance is typically 50 ohms in communications power amplifiers, and as such we will use a chart normalized to this impedance. However, it is not difficult to normalize to any impedance and often useful to convert to several different impedance levels during a given design. Important to note is that what ever impedance the chart is normalized to will be the impedance of the transmission matching networks. Since changing this line impedance through the various stages of matching can make a circuit much easier to fabricate, this technique will be covered.

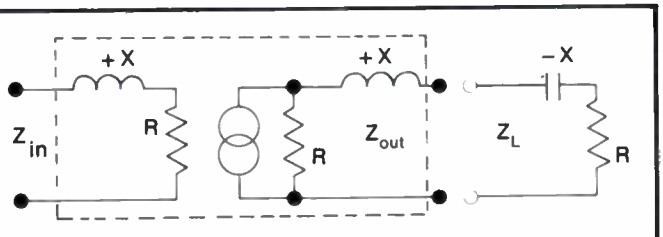

Figure 2. Transistor Schematic.

C. Bandwidth

One of the most important considerations in any amplifier design is that of bandwidth. Bandwidth is, of course, directly related to the circuit Q by the following formula.

$$Q = \frac{f_o}{f_1 - f_2}$$ Equation 2

f_1 = Upper bandwidth frequency limit
f_2 = Lower bandwidth frequency limit

These are the limits at which the power transfer drops by 3 dB.

f_o = The resonance or geometric mean frequency between f_1 and f_2 and is equal to:

$$f_o = \sqrt{f_1 f_2}$$ Equation 3

In most practical RF power amplifier designs, the −3 dB power gain frequencies are not valid points to use as bandwidth limits. Not only is the power gain of the amplifier unacceptably reduced, but collector efficiency and input VSWR are generally to poor for normal applications. Therefore, a good practice is to relate the amplifier −1 dB or less bandwidth to the 3 dB bandwidth and then from these limits calculate the corresponding maximum allowable Q for the matching circuit. This bandwidth relationship between the 3 dB and other bandwidths has been derived for several useful values and these are listed in the following table.

Gain and power reduction at band edge	dB Bandwidth	Ratio to 3 dB Bandwidth
10%	0.5 dB	.34
20%	1.0 dB	.55
30%	1.5 dB	.69

Table 2

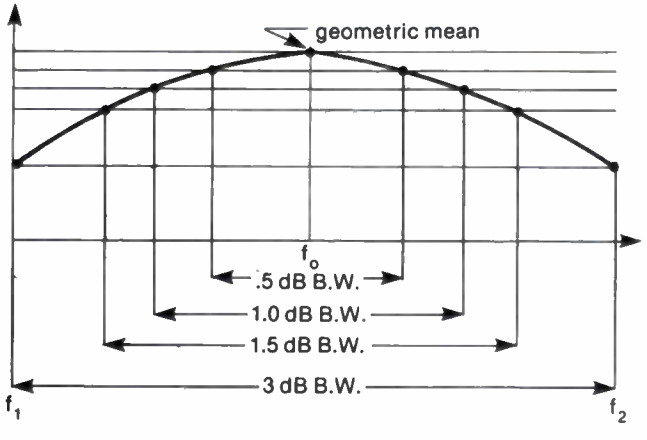

Figure 3.

These numbers are only approximations of the bandwidth because of the variables in a transistor's gain and impedance over a given range of frequencies. To determine the maximum impedance transforming ratio of each section of the matching network we then take the Q calculated from the bandwidth requirements and use it in the following expression.

$$Q^2 + 1 = (Z_2 : Z_1)_{max}$$ Equation 4

here $(Z_2 : Z_1)$ is the impedance transforming ratio.

The parameter that ultimately limits the bandwidth of an amplifier is the transistor's input and output impedance Q. This Q will have to be equal to or less than the calculated matching network Q in order to meet the bandwidth design goals.

For the series Z_{in}

$$Q_{Zin} = \frac{X_L}{R}$$ *Equation 5*

For the series Z_{load}

$$Q_{Zload} = \frac{X_C}{R}$$ *Equation 6*

Using the Smith Chart

When we have determined the Qz_{in} and Qz_{out} of the transistor, the system impedance level, the Q necessary to obtain proper bandwidth and the confirmation that the transistor Q will not be a problem, then we have compiled enough data to intelligently use the Smith Chart.

Let's stop for a minute and see just how we would use the Smith Chart for an arbitrary impedance transformation, then we will apply this technique to the data assembled and an amplifier design will appear.

The Basic Chart

Step 1: Normalize the impedance to the desired system impedance. To do this multiply all of the Z values and R values by the system impedance level. i.e. in a 50 ohm system the 1 ohm in the center of the chart would be multiplied by 50 and become 50 ohms.

Step 2: Normalize the admittance chart to the desired system admittance level. To do this multiply all S and G values by corresponding system admittance levels. In a 50 ohm system this multiplier would be 20 millimhos and the 1 Mho in the center of the chart would become 20 millimhos.

Step 3: When using the Chart series elements appear as impedances or resistances and parallel elements will be read as susceptances or conductances. With a basic Smith Chart it will be necessary to use an accurate measuring instrument to convert from series impedances to parallel susceptances.

Sample Procedure

As the first example Figure 4 we will match a 5Ω + j5Ω source to a 50 ohm system. We will not worry about Q at this time and will match the source to the load with three elements. We will also normalize the chart to 50 ohms and 20 millimhos.

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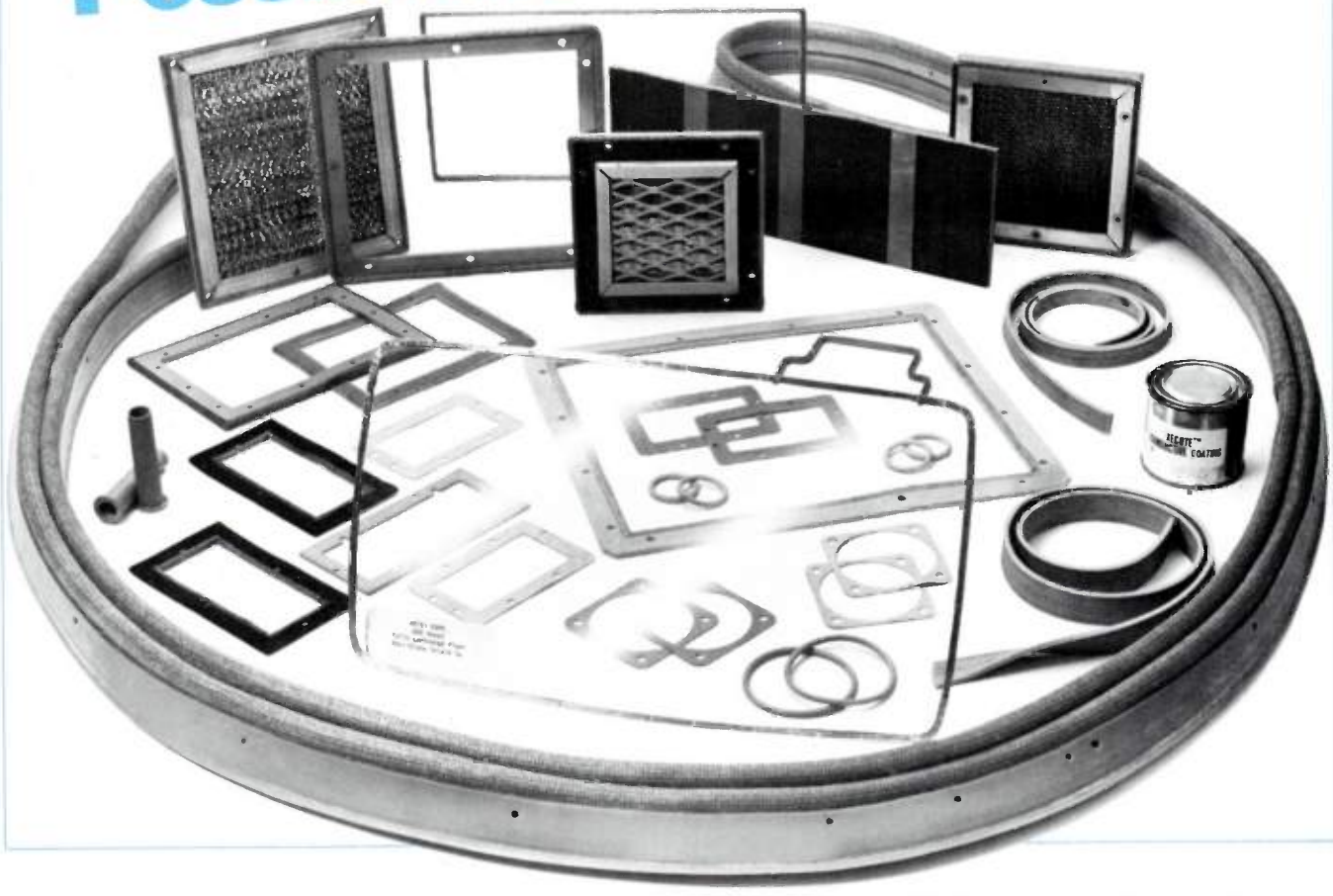

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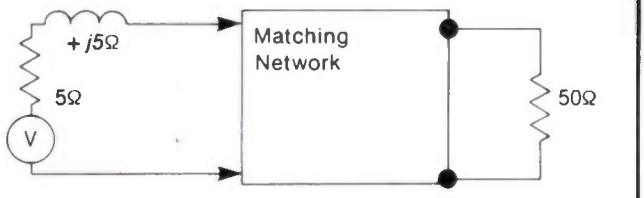


Figure 4a. Schematic Representation

Procedure: (Refer to Figure 6)

Step 1: Locate the series 5Ω + j5Ω intersection on the 50 ohm chart by first locating the 5Ω point on the pure resistance (center diagonal) line and then moving in the inductive reactance direction until the + 5Ω line is intersected.

Step 2: Draw a diagonal line from this point through the center of the chart to a pointequidistant but on the opposite side of the center (50 ohm) point, (distance A). This new point will be the location where – j100 millimhos susceptance intersects the 100 millimho conductance curve.

Step 3: To determine the first element of the matching network we move along the 100 millimho conductance curve until we again intersect the pure conductance line. We have in effect added an element in parallel to make this move to pure conductance on the chart and that element's value is the susceptance (– j100 millimhos) at the start less the susceptance value (0 millimhos) at the finish. It is a capacitator by virtue of the direction in which we moved (towards less inductive susceptance). This element is therefore a capacitator of value j100 millimhos and the circuit now looks like Figure 4b.

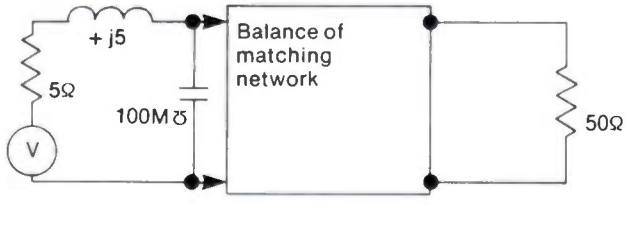
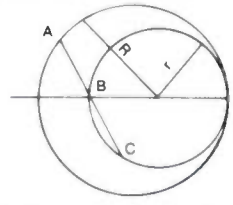


Figure 4b.

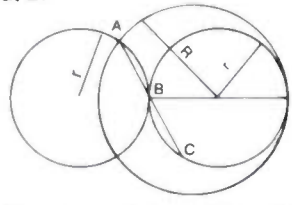
Step 4: We now have to add a series impedance so it will be necessary to move back to the opposite (impedance) side of the Chart. This is accomplished by drawing a line that passes through the center of the chart and measuring an equal distance from the center and the new point to the center and the original point (distance B). This new point is labeled (4).

Step 5: From point (4), 10 ohms, we now move along the constant, 10 ohm, resistance curve until we find a point equidistant from the center of the Chart passing through the center of the Chart that intersects the 50 ohm constant resistance curve, (distance C), point (5). In this procedure we have now determined now many wavelengths we must move to arrive at an impedance requiring only one additional element to complete the matching to 50 ohms. The wave lengths on to a ohm transmission can be read from the chart directly in an extention of the constant impedance line to the outside ring, point (6). In this design it is .06λ. The construction technique is shown in Figure 5.

Construction of line AC, such that AB = BC.



1. Construct a second circle having radius r. tangent to the small circle at B.



The line drawn through the intersection of the constructed circle and the larger circle, and point B will meet the require ment AB = BC.

Figure 5.

Step 6: The final step is now to rotate our 50 ohm intersection, point (7) along the constant 50 ohm curve until we reach a pure 50 ohms, the desired load impedance. The amount of susceptance necessary to move to this point is read from the chart as 40 millimhos and is capacatative. This is a parallel component.

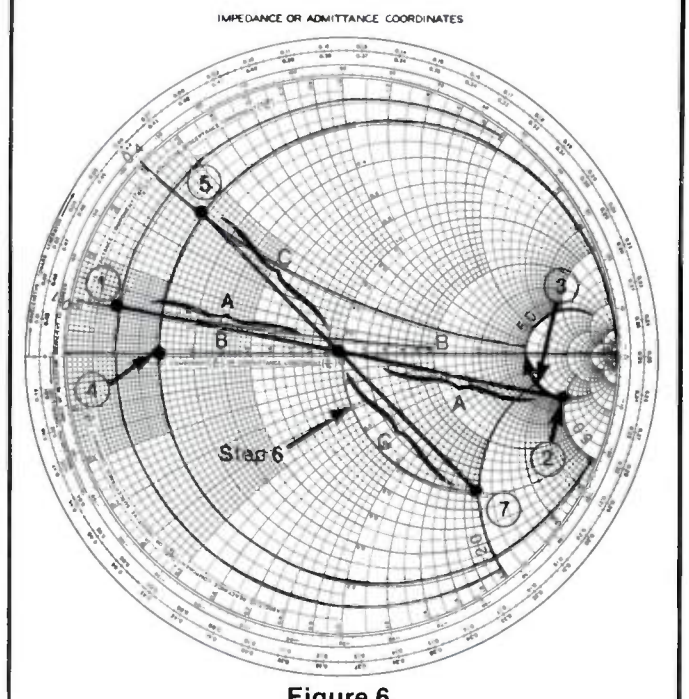
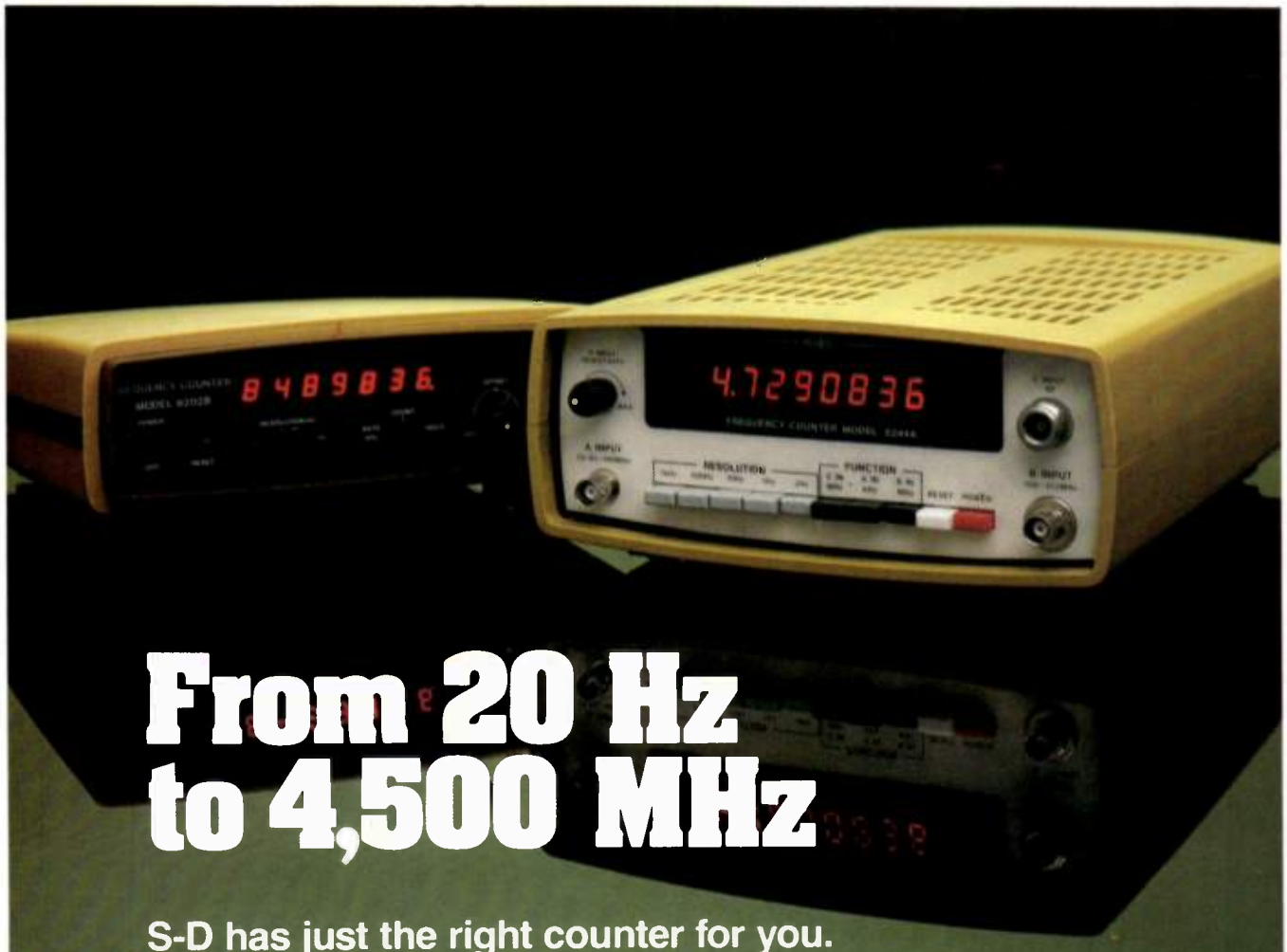


Figure 6.



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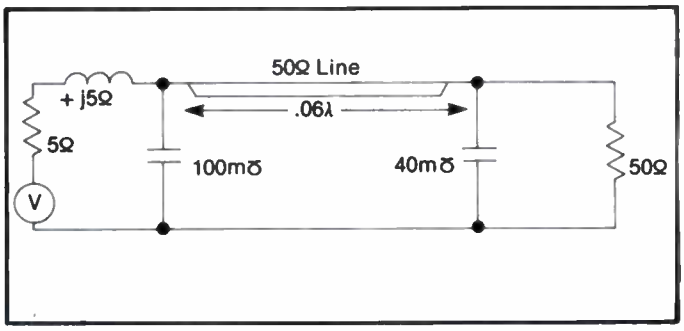

Our matching network is now complete and is shown in Figure 4c.

After going through this laborious exercise of converting from admittance to impedance using a ruler several times one will gain a deeper understanding of the Chart's function. Once Smith Chart understanding has been gained, this latter method should be disregarded, since it is slow and cumbersom. An impedance/admittance overlay chart should then be used for all serious design work.

How The Same Network is Determined On an Overlay Chart

Figure 7 is an overlay Smith Chart on which the same network has been developed. As we can see it is not necessary to go from end to end with a ruler, but to simply refer to the overlay impedance or susceptance curves.

A Practical Design Example

Now after all of the practice, we will design an amplifier. This amplifier will meet the following specifications:

Power input:	15 watts
Power output:	80 watts
DC operating voltage:	13.6 VDC
.5 dB bandwidth:	145 to 174 MHz
System impedance:	50 ohms

Step 1: Determine the Q requirement for the input and output matching networks based on the .5 dB bandwidth from Table 2 and Equations 2 and 4.

$$.5\ bandwidth = (.34)(3\ dB\ bandwidth)$$

$$3\ dB\ bandwidth = 174\text{-}145\ MHz = 29\ MHz \qquad \textit{(Equation 2)}$$

3 dB Bandwidth necessary for .5 dB specified

$$\frac{3\ dB\ bandwidth}{.34} = \frac{29\ MHz}{.34} = 85\ MHz$$

$$f_o \quad \sqrt{f_1 f_2} \qquad \textit{(Equation 3)}$$

$$f_o = \sqrt{(145)(174)} = 159\ MHz$$

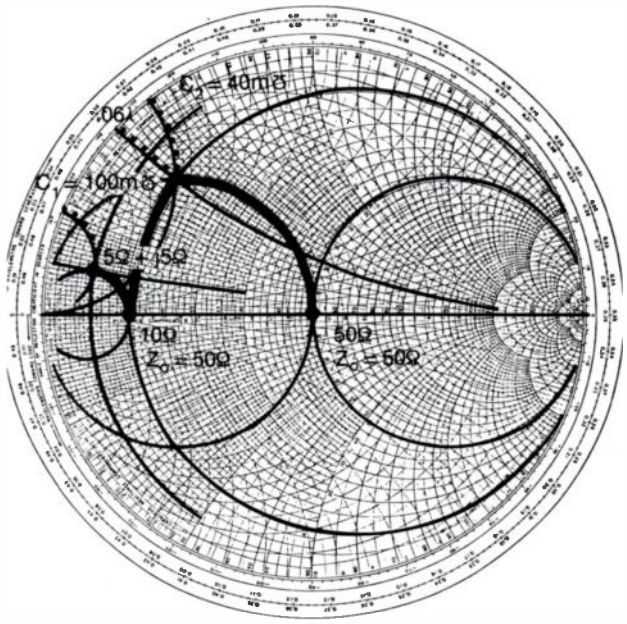

Figure 7.

$$Required\ Q_{max} = \frac{159MHz}{3dB\ Bandwidth} = \frac{159MHz}{85MHz}$$

Step 2: Determine the maximum impedance transformation ratio for each matching section from equation 4.

$$Q^2 + 1 = (Z_2 : Z_1)_{max}$$

$$4.5 = (Z_2 : Z_1)_{max} \qquad \textit{(Equation 4)}$$

the maximum impedance transformation ratio 4.5 is then in any section of our matching network.

Step 3: Transistor Q We will select a TRW JØ4075 since it meets the specifications of power, frequency, gain and operating voltage. Examinin the input and output impedances, (see Figure 1) for the maximum Q requirement we find:

$$Q_{Zin} = \frac{X_L}{R} < 1 \qquad \textit{(Equation 5)}$$

and

$$Q_{Zout} = \frac{X_L}{R} < 1 \qquad \textit{(Equation 6) from 145 to 174 MHz}$$

hence

$$Q_{max} = 1.87 > Q_{Zin}\ and\ Q_{Zout}$$

Our Q requirements can therefore be met by this transistor and the design can proceed.

Step 4: Block diagram the impedance transformation network before calculating values. Important: *For simplicity and design flexability each impedance transformation should bring the circuit back to a real resistance.*

Before determining values of the network elements we must first locate the transistor's complex input and output impedances on the Smith Chart and transform them to pure resistances. See Figure A, point 1 is the input impedance and point 2 is the output impedance.

Step 5: Since the base lead of this transistor is .200 inches in width and the input impedance is very low we will make the first transmission line matching' network a 33 ohm transmission line thereby causing less physical problems in circuit layout. A 33 ohm line of fiberglass G-10 PC board (.0625 in thick) is .230 inches wide so this will quite conveniently fit under the base lead of the transistor. To convert a normalized 50 ohm chart to 33 ohms, multiply all impedances by 33/50, (.66) and multiply all of the admittances by 50/33, (1.5).

Now, to the Chart, Refer to Figure 8.

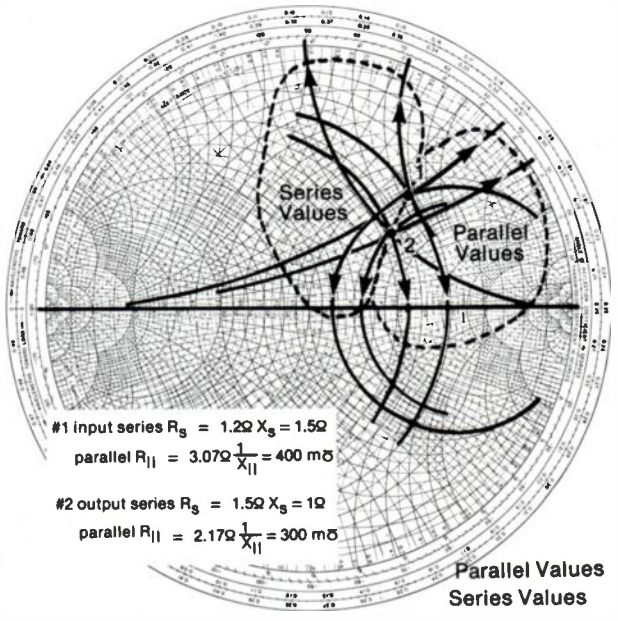

Figure A.

Function & Procedure

1. The base inductance at 160 MHz (1.2 + j1.5) is resonated out by a capacitator of value 400 millimhos. At the design center of 160 MHz this would require 404 pf capacitor. The conductance and susceptance value can be obtained from point 1 in Figure A. The value of the capacitor comes from C = 1/(2πfXc).

2. By placing a 404 pf capacitator on the base of the transistor we now have a gain block with a pure input resistance of 3.07 ohms. Since our Q creteria specifies a maximum of X4.5 for impedance matching we will block diagram out the following circuit scheme.

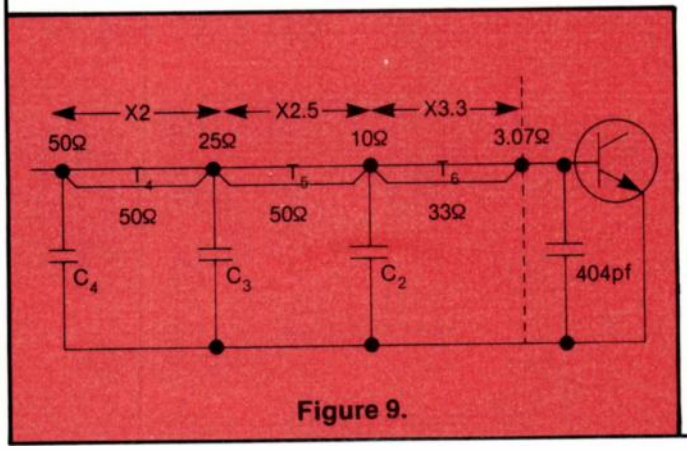

Figure 9.

3. With the Smith Chart normalized to 33 ohms, move along the constant 3.07Ω ohm resistance curve until it intersects the constant admittance curve passing through the 10 ohm (100 millimhos) curve. Rotate this point along the constant admittance curve until it reaches the pure resistance point of 10 ohms. The ending value of susceptance .(0), is subtracted from the beginning value of 159 millimhos and this value, since it was rotated in the direction of decreasing inductive susceptance, is a capacitator, C_2 of value 159 millimhos. To intersect the 10 ohm (100 millimho) curve we moved .022 wavelengths. This value is found by following the line of constant inductive reactance intersecting this latter point to the outside circle marked "wavelengths towards generator". The .022 wavelength line becomes T6.

4. Proceed with each matching section in the same manner being careful to normalize the chart to 50 ohms for the remaining two matching sections. The values of these sections are:

T5 = .039 λ	C3 = 48 millimhos
T4 = .074 λ	C4 = 20 millimhos

5. The collector circuitry is matched in the same manner as the base circuitry. Remember-

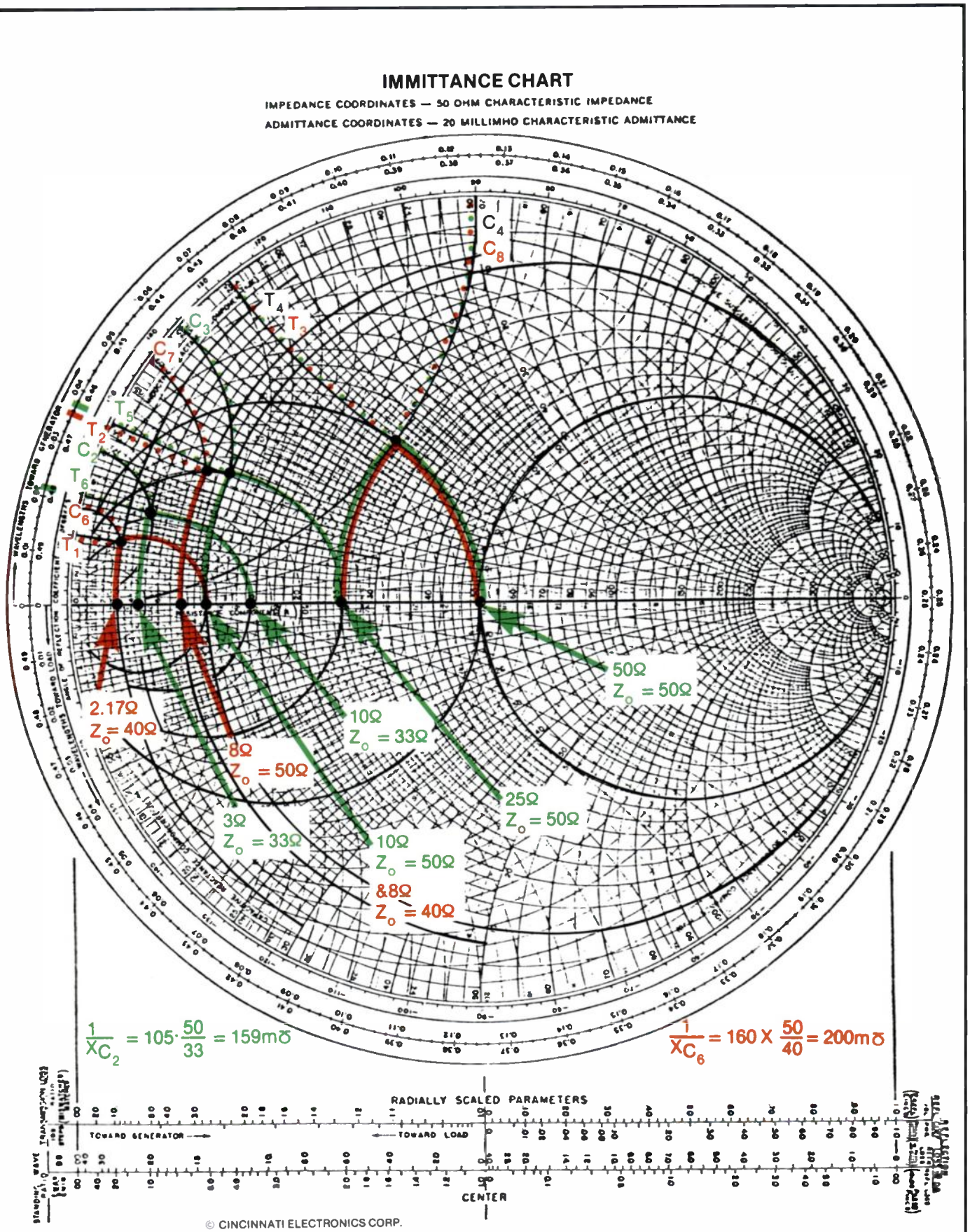
IMMITTANCE CHART
IMPEDANCE COORDINATES — 50 OHM CHARACTERISTIC IMPEDANCE
ADMITTANCE COORDINATES — 20 MILLIMHO CHARACTERISTIC ADMITTANCE
C4
C8
T4
T3
C3
C7
T5
T2
C2
T6
C6
T1
50Ω
Zo = 50Ω
2.17Ω
Zo = 40Ω
10Ω
Zo = 33Ω
8Ω
Zo = 50Ω
25Ω
Zo = 50Ω
3Ω
Zo = 33Ω
10Ω
Zo = 50Ω
&8Ω
Zo = 40Ω
1/XC2 = 105·50/33 = 159mσ
1/XC6 = 160 X 50/40 = 200mσ
RADIALLY SCALED PARAMETERS
TOWARD GENERATOR
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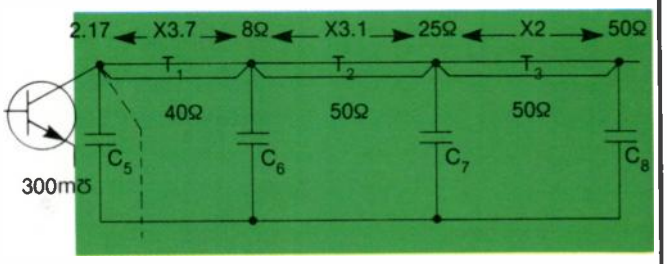
Figure 8.

ing that we want to operate into a capacitative load (1.5Ω — j1Ω) we will know the complex conjugate of this, (1.5Ω + j1Ω), is the collector output impedance. Locating this point on the Smith Chart and then resonating out the collector inductance a capacitator of 300 millimhos leaves us with a pure output resistance of 2.17Ω ohms.

6. With the output impedance converted to a pure resistance of 2.17 ohms we can now block diagram the collector matching circuit, again however, remembering our Q requirements.

7. For physical convenience I choose 40 ohms as the first matching transmission line impedance and normalized the balance of the circuit matching to 50 ohms such that it is identical to the input matching circuitry from the 25 ohm impedance point on to the output.



$T_1 = .014\lambda$ $C_6 = 200m℧$

$T_2 = .036\lambda$ $C_7 = 58m℧ = C_3$

$T_3 = .074\lambda$ $C_8 = 20m℧ = C_4$

Figure 10.

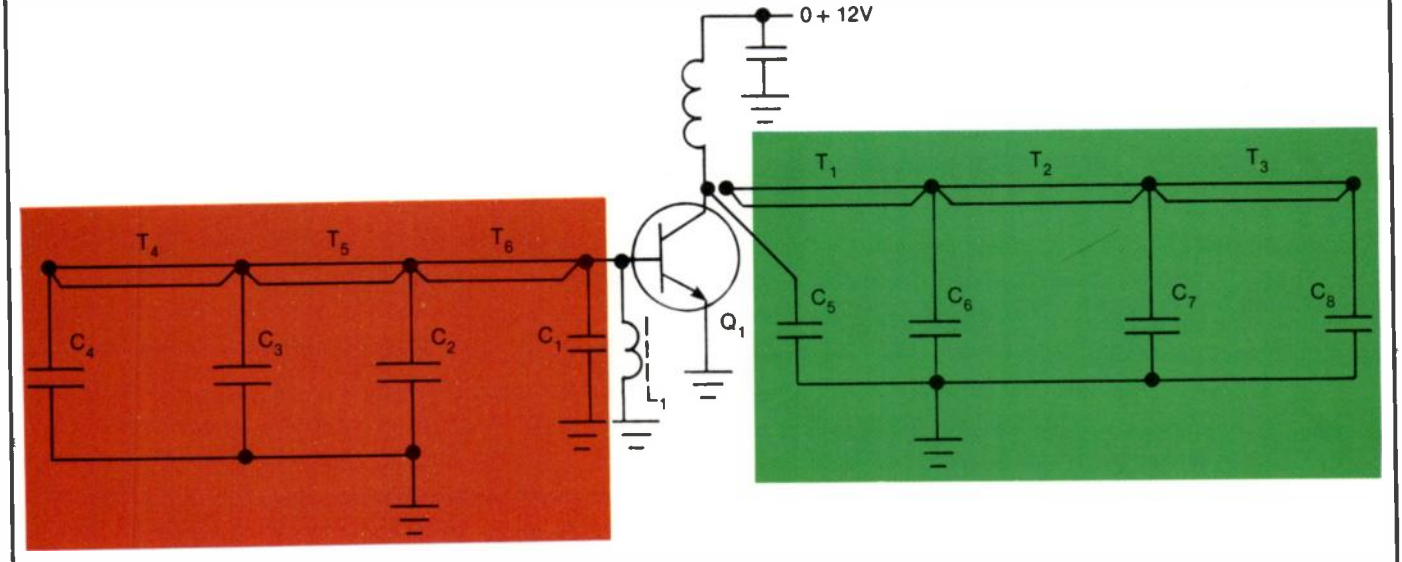


Figure 11.

Next month I will give a number of practical examples including pictures of actual fabricated hardware. This article was not meant to be an in depth dissertation on the use of the Smith Chart. The intent of this article, quite simply stated, has been to show how to apply the Smith Chart to the design of practical RF power amplifiers.

Next month I will also include the information necessary to calculate exact dimensions of microstrip transmission line transformers on any practical material. With this additional information it should then be possible for the designer to develope an amplifier on paper and see excellent results the first time power is applied. □

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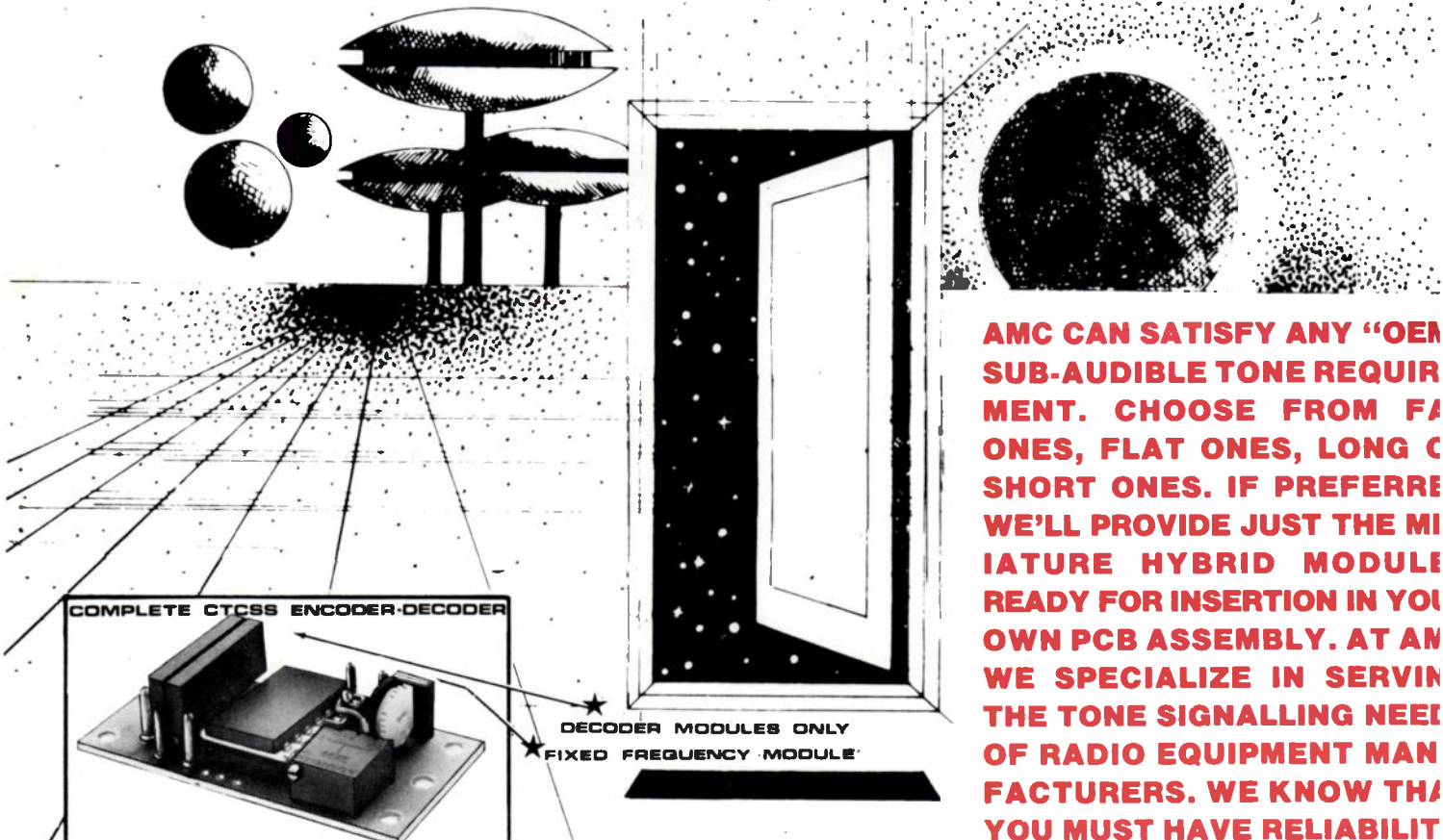

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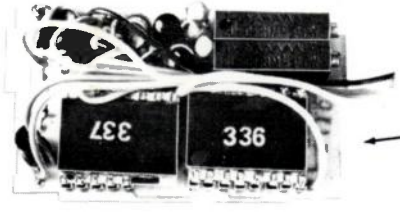

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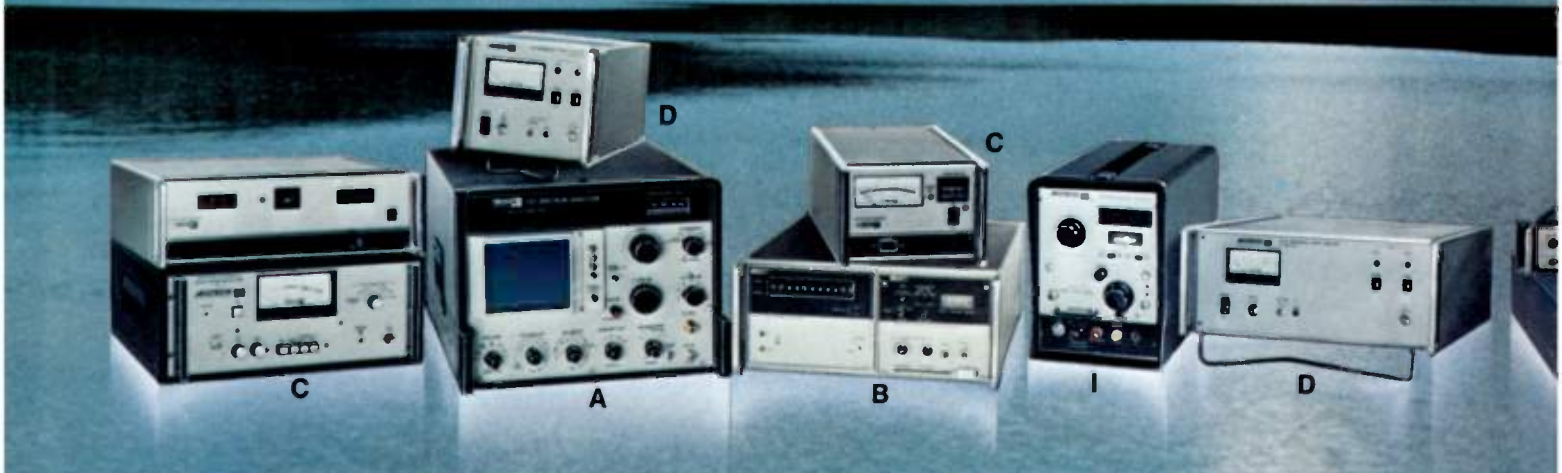

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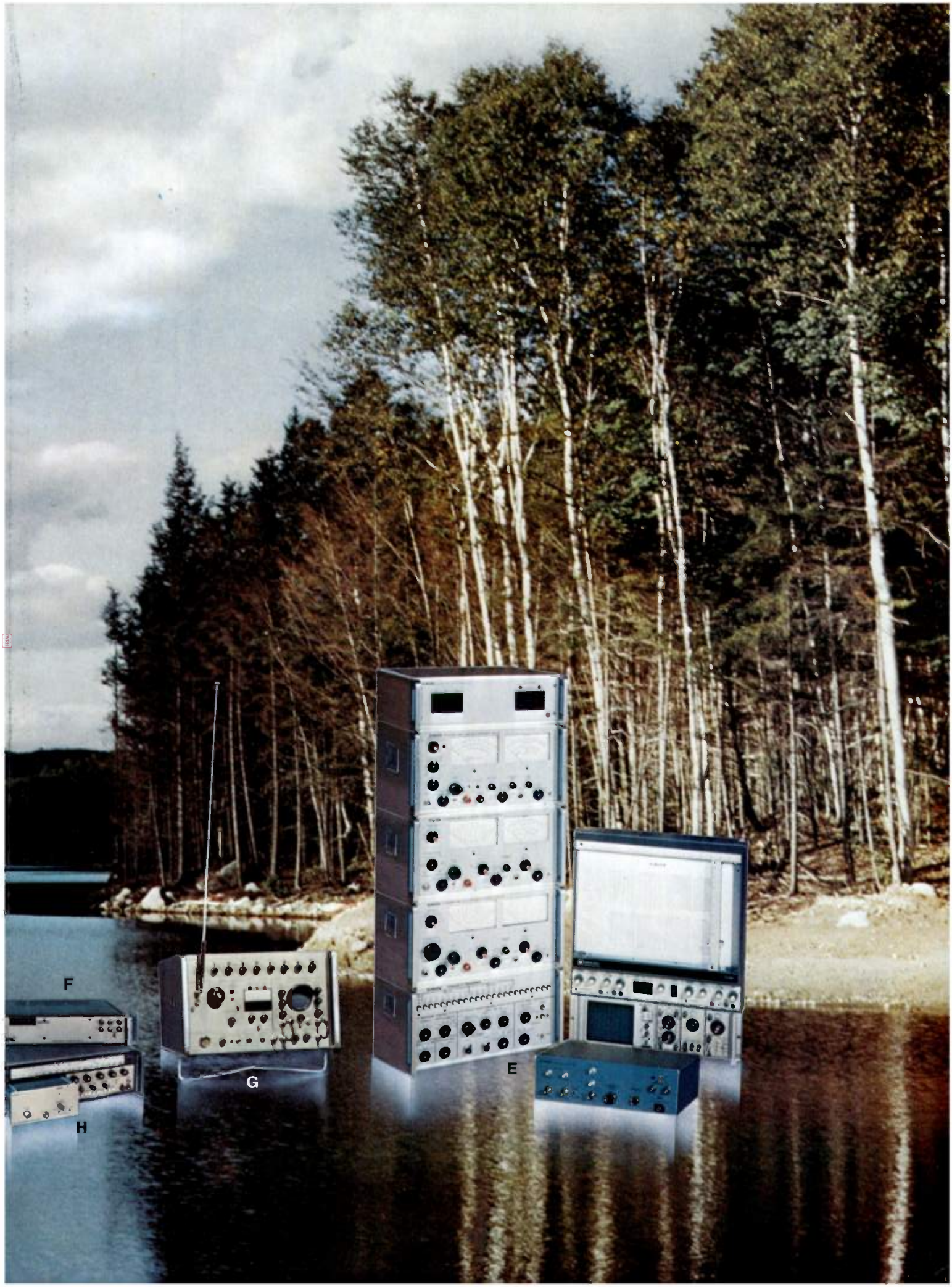
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By Don Feeney
Applications Engineer
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A new class of low cost, high performance hybrid amplifiers has emerged to assist the design engineer working in the frequency range of 1 to 500 MHz. Utilizing the low distortion and wide dynamic range performance technology developed for the CATV industry, these amplifiers feature power output capabilities previously unavailable in hybrid circuits. Two major semiconductor manufacturers, Motorola (MHW series) and TRW (CA series), now offer these devices as standard products for the RF design engineer.

What Are They?

RF linear hybrid amplifiers represent a new family of medium power, broadband gain blocks for multi purpose RF applications. Internally matched at both the input and the output for either 50 ohm or 75 ohm systems, these devices cover gains ranging from 17 to 35 dB, and can accommodate output power levels in excess of 400 mW. Linear class A bias conditions accommodate third order intercept values in excess of +45 dBmV. Depending on quantity and model selected, most prices fall in the range of $30. to $60. If you've been using transistors like the 2N3866, 2N5109, or stud mounted devices, read on. You may save a lot more than just design time.

Construction

RF linear hybrid amplifiers utilize the thin film manufacturing and construction techniques developed for the demanding CATV industry. All ceramic substrates are alumina ($A1_2O_3$) with gold conducting paths. Resistors are either cermet or nichrome, and are laser trimmed to better than one percent tolerance. For maximum MTBF, gold metallized transistor die are used incorporating resistive ballasting in the emitter fingers to provide even thermal distribution across the surface of the die and to eliminate "hot spotting." These transistor die are subjected to rigorous testing through an extensive wafer qualification program before being mounted on the circuit. The hybrid manufacturer must insure that the transistors used will meet the exacting requirements for gain, distortion, and noise figure.

Basic Circuit

To meet the stringent performance requirements of low distortion and low noise figure, the basic parallel cascade circuit shown in Figure 1 has emerged as the standard gain block used in CATV repeater amplifiers. Using resistive feedback techniques to assure product uniformity, this basic circuit accomplishes gain functions ranging from 17 to 25 dB. For higher gain models, two sections of this circiut are cascaded as shown in Figure 2. To accommodate the increased package density in the same form factor, the transmission line transformers are mounted on a bridge assembly suspended above the substrate.

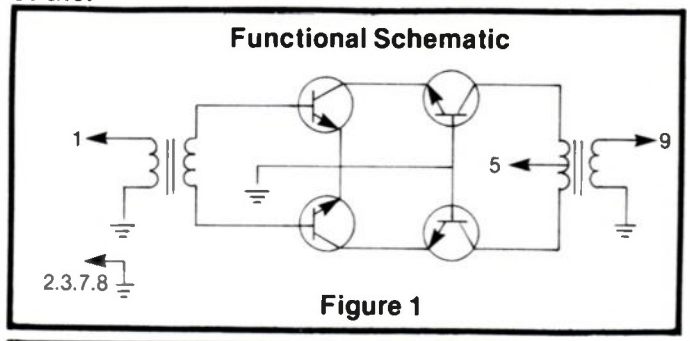


Figure 1

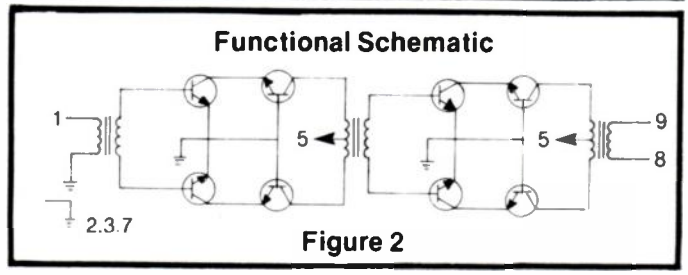


Figure 2

Electrical Performance Features

Gain — RF linear hybrid amplifiers are fixed gain devices (17 to 35 dB) which are fully cascadable for additional gain. If adjustable gain (AGC) is required for a particular application, it must be added externally (as with a conventional pin diode attenuator).

Frequency Range — These hybrid amplifiers utilize broadband transmission line transformers and 5 GHz f_T transistor die to achieve wide bandwidths and linear phase response. Although some models may be optimized over a particular frequency range to fit a certain market, these hybrid amplifiers will often deliver satisfactory performance beyond the frequency ranges specified by the manufacturer.

Impedance — All hybrids are internally matched at both the input and the output for either 50 or 75 ohms. This not only reduces the external components normally required to match to these impedances in discrete designs, but it also simplifies the requirements for interfacing printed circuit board connections. For short path lengths, strip line width has little effect on RF performance.

Output Power — RF linear hybrids are often operated at power levels well below their maximum output capability (for example, in receiver applications). In such cases, operation at a reduced power supply voltage is recommended to reduce power consumption (assuming the full dynamic range is not required).

The maximum power capability for linear class A operation of these circuits may be restricted by several factors:

a) The operating supply voltage, which limits the maximum AC peak to peak swing.
b) The quiescent bias conditions, which limit the maximum current swing across the transformed load impedance.
c) Core saturation in the output transformer, a condition aggravated by high permeability ferrites operating at high ambient temperatures.

Changes in Performance with Supply Voltage — Simply as a point of reference, most RF linear hybrid amplifiers are characterized at a supply voltage of 24V. However, a design engineer may operate above (to increase available output power) or below (to reduce DC power consumption) the rated supply voltage and observe little or no change in gain or frequency response. However, certain specifications are directly affected by the supply voltage:

a) Current consumption. These hybrid amplifiers are biased (quiescent operating point) in a linear mode for class A operation. The higher the supply voltage, the more current they draw. The lower the supply voltage, the lower the current consumption. There is a 1:1 linear relationship between supply voltage and current consumption. Therefore, power consumption varies as the square of the supply voltage.
b) Output power capability. As the supply voltage increases, so does the maximum available output power (higher peak to peak AC swing is possible across a given load).
c) Linearity. Third order intercept, a measure of linearity, is directly related to supply voltage. In many applications, however, these RF hybrid amplifiers offer more linearity than required. In these cases operation at a lower supply voltage is recommended to reduce power consumption.
d) Noise Figure. Just like a low noise transistor, the lower the bias current (or supply voltage, for these hybrid amplifiers), the lower the noise figure.

Packaging Technique

The form factor standardized by the CATV industry allows the hybrid amplifier to be bolted directly to the chassis frame for maximum power dissipation. The pins are located on 0.100" centers for easy connection to a printed circuit board. Mating sockets are manufactured by Amphenol (P/N 502-20071-572) and Barnes (P/N 027-018-02).

One note of caution. DO NOT attempt to lap or file the heatsink of the hybrid amplifier. Not only does this void the warranty (considered "mishandling" by the manufacturer), but you can induce substrate cracking during the machining operation.

Heatsink Your Hybrid

Like all RF power devices, hybrid amplifiers require heatsinking for proper operation. How much heatsinking is necessary? As much as is required to maintain the case operating temperature at the maximum value under worst case ambient temperature and maximum supply voltage. The presence or absence of the RF signal is insignificant due to the class A bias conditions. Reducing the supply voltage will decrease the power consumption, but it will also decrease the linearity. Attach the hybrid amplifier directly to the chassis, to a module card sidewall, to a small baseplate, or to a mounting bracket that is connected to one of the above. But before you complete your design, verify that the maximum case (flange) temperature for the hybrid amplifier is within the manufacturer's specified limits under your worst case operating conditions. This will insure that the maximum junction temperatures of the individual transistor die will not be exceeded (usually 140°C).

Reliability Screening, Military Applications

Since reliability is a major factor in the profitability of CATV systems, the component manufacturers who are supplying hybrid circuits in volume to this competitive industry have developed extensive data bases to insure the reliability of their product. Additional reliability screens uncommon to commerical products are often added at the manufacturer's expense to insure against field failures. Reliability is a major consideration, but these hybrid devices were not designed to qualify to MIL-STD-883, level B.

For example, the caps are sealed with epoxy (non hermetric). The physical mass of the ferrite transmission line transformers prohibits excessive levels of mechanical shock and variable frequency vibration. However the manufacturers should be consulted for specific applications, because hybrid amplifiers of this generic type have qualified for certain military programs.

Why Use a Hybrid Circuit?

Many engineers can design a circuit with discrete components to do exactly what they want. Selecting a hybrid amplifier from a standard product line results in some compromise, but usually offers several advantages:

Who Uses Them?

Because of their wide bandwidth and linear operation, RF linear hybrids are effective for digital (or pulse) applications as well as for analog waveforms. Their unique combination of high performance over a broad frequency range and low cost make them the ideal choice for a broad spectrum of major markets:

Markets

Communications Networks
Long Haul or Data Bus
Coaxial or Fiber Cable

Communications Radios
HF, VHF, UHF
Commercial or Military

Satellite Ground Stations
High Speed Facsimile
Telemetry
Radar
ECM
Instrumentation

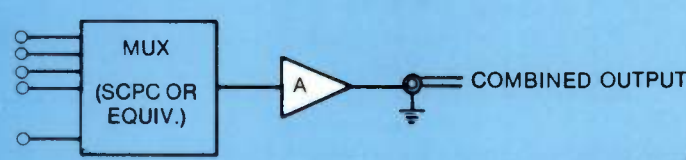
Applications

Antenna Distribution
Cable Drivers (50Ω or 75Ω)
CCD Drivers
IF Amplifiers
Local Oscillator Buffers
Repeater Amplifiers
SAW Filter Amplifiers
Signal Processing Equipment
Swept Measurement Testing
Transmitter Drivers

Key Features

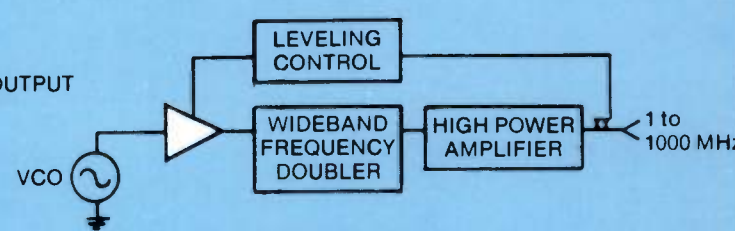
Linear Phase Response
Wide Bandwidth, Low Distortion
High Power Output Capability
Unconditional Stability and Linear Operation into Highly Reactive Loads
Infinite VSWR Protection
High Third Order Intercept
Excellent Impedance Match
Low Noise Figure, Wide Dynamic Range

SATELLITE COMMUNICATIONS EQUIPMENT

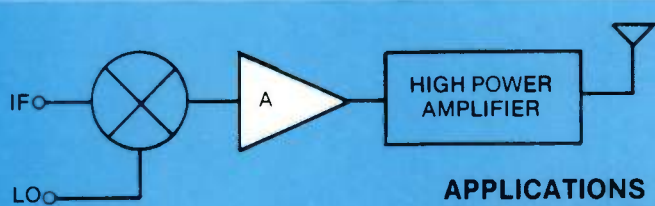


APPLICATIONS
LINEAR POWER AMPLIFIER FOR FM, DIGITAL, DATA, OR VOICE CHANNELS

DRIVER FOR EXTENDED LENGTHS OF COAX

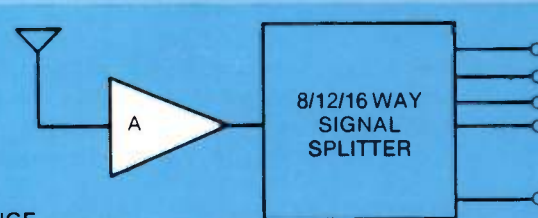


APPLICATIONS
DME, TACAN, IFF APPLICATIONS
RADAR, ECM, DRONE APPLICATIONS
BROADBAND SWEPT INSTRUMENTATION
HF THROUGH UHF TRANSMITTER DRIVERS



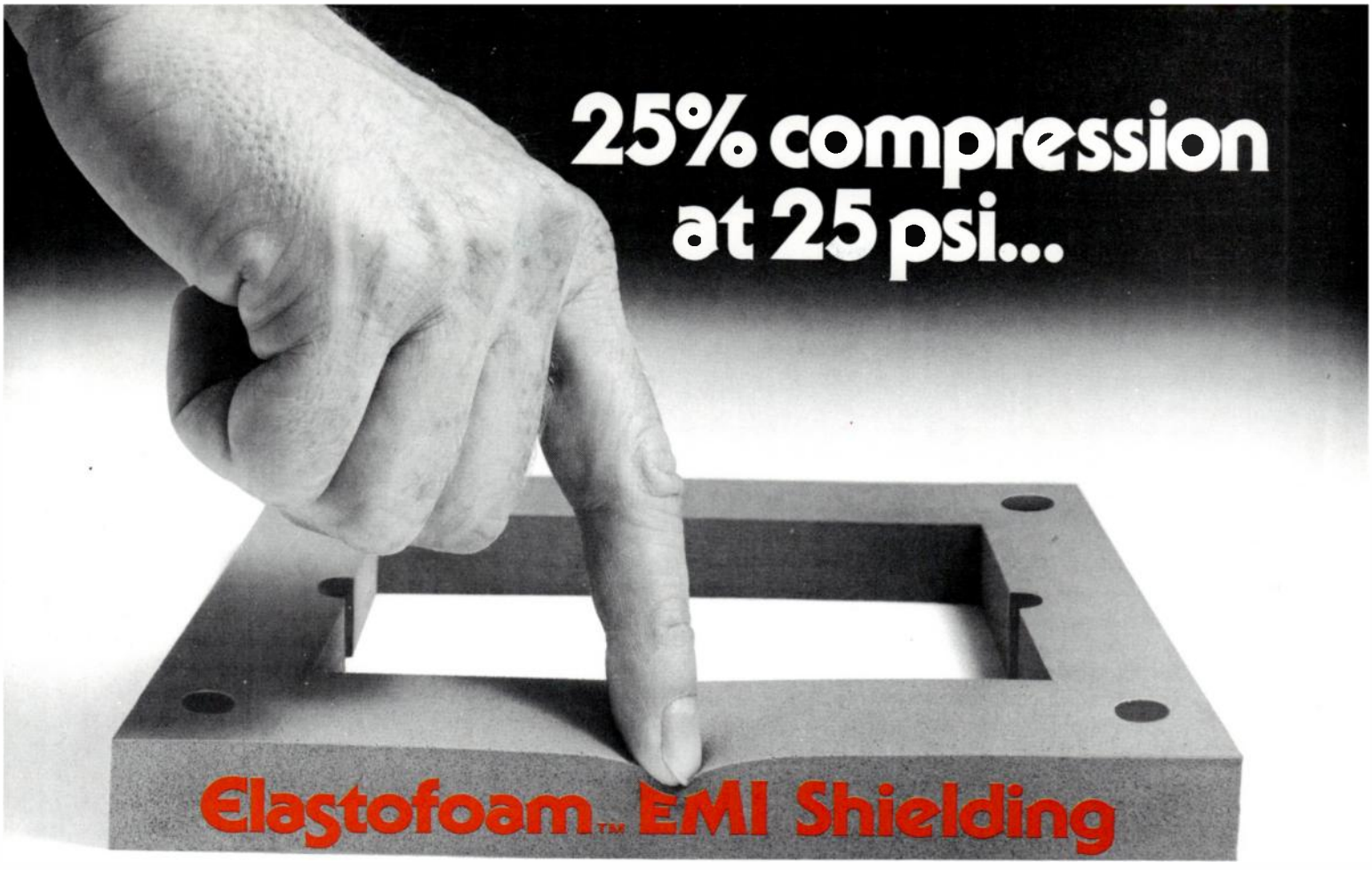
TRANSMITTER DRIVER

APPLICATIONS
HF, VHF, UHF FREQUENCY RANGE
AM OR FM TRANSMISSION
COMMERCIAL OR MILITARY EQUIPMENT
N-WAY POWER SPLITTER



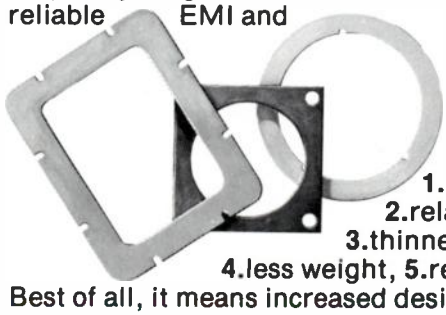
ANTENNA DISTRIBUTOR

(Continued on page 44.)



Does That Give You Any Ideas?

As a designer with tough EMI problems, you need all the good ideas you can get. **Elastofoam,** the newest shielding material from Tecknit, will give scope to your good ideas. How? **Elastofoam** allows reliable EMI and environmental sealing at only 25 psi!



For starters, this means:
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3.thinner sheet metal,
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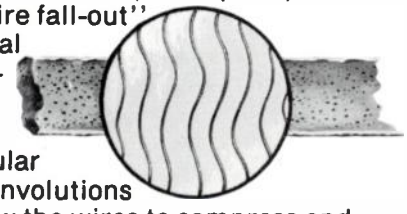

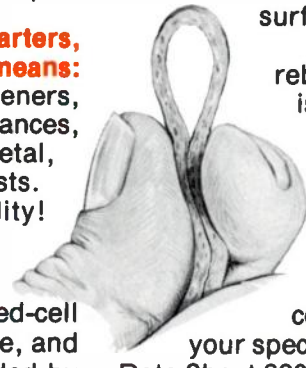

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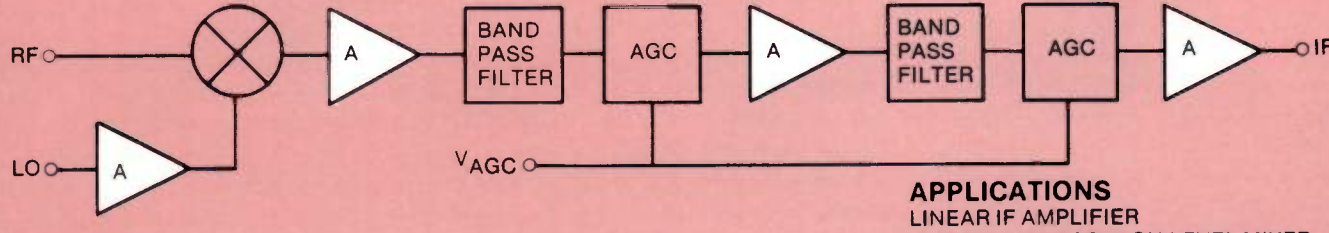
Performance — The product of years of research, the RF linear hybrid offers the design engineer low distortion levels, wide dynamic range, and noise performance that are difficult to achieve in discrete form. This "extra margin" of performance may enhance the overall equipment design or allow more competitive specifications.

Size — If space is a consideration in the equipment design, the added real estate required for discrete circuitry may be prohibitive.

Reliability — The high degree of reliability demanded by the CATV industry has already been discussed. But given equivalent manufacturing and screening methods, hybrid circuits offer improved system reliability over a circuit comprised of multiple discrete components. This reliability improvement is a result of reduced package count, fewer solder interconnects (each interconnect is a potential failure point), and system level testing and screening performed by the hybrid manufacturer. Consequently, the hybrid manufacturer is accepting a larger responsibility for reliability. The delivered product is a combination of many discrete components tested as a complete system. Losses due to individual component interaction or failure are isolated during the manufacturing cycle.

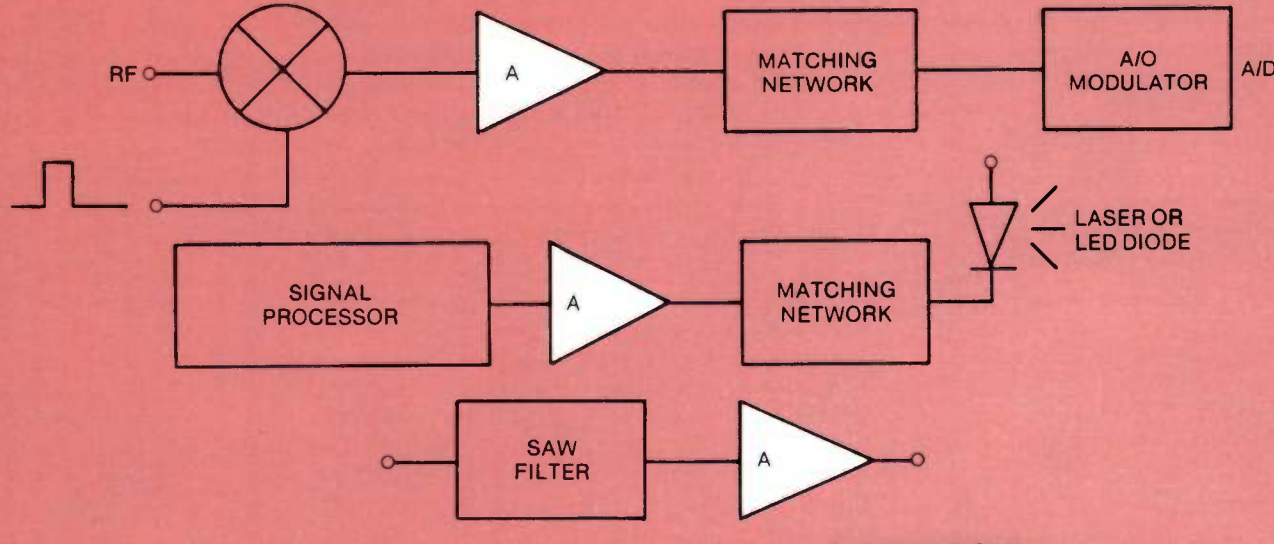
Cost — The raw cost of materials to build a replacement discrete circuit for a particular application is usually less than the initial price of a hybrid. However, the following factors are often overlooked in many equipment designs:

HIGH PERFORMANCE RECEIVER APPLICATIONS



APPLICATIONS
LINEAR IF AMPLIFIER
BUFFER AMP FOR HIGH LEVEL MIXER
REPEATER AMPLIFIER FOR FIBER OR COAXIAL CABLE COMMUNICATIONS
HIGH DENSITY PACKAGING

ELECTRO/OPTICAL EQUIPMENT, SAW APPLICATIONS, FIBER OPTIC APPLICATIONS



APPLICATIONS
ACOUSTO-OPTIC MODULATORS
FIBER OPTIC LASER/LED DRIVERS
SAW FILTER AMPLIFIERS
DRIVERS FOR CHARGE COUPLED DEVICES
SUITABLE FOR ANALOG OR DIGITAL MODULATION, ALL TYPES OF WAVEFORMS

a) The hybrid manufacturer is absorbing the costs of incoming inspection, assembly, and test on the circuit he is providing. Manufacturing costs for equipment using discrete circuitry are always higher than equivalent equipment utilizing commerically available hybrid circuits. This is especially true if any tuning or tweaking of the circuit is required.

b) An equipment manufacturer's cost of procurement and cost of stocking are higher for a multi-component discrete circuit than for a single thin film hybrid amplifier. These higher costs apply not only during the production build cycle, but throughout the lifetime of the equipment (spare parts inventory).

c) Engineering costs to design reliable replacement circuit. Don't forget to include the time spent in debugging and optimizing the circuit, and the time spent in production support. The manufacturers of these RF linear hybrid amplifiers have spread their development costs over more than 1,000,000 units operating in the field.

Is the RF Liner Hybrid The Right Choice For My Design?

In the end, the choice between a standard hybrid amplifier and a discrete circuit must be made by the design engineer. Find out what's available from the various manufacturers, what their prices are, and what it costs your company to implement a discrete design. One thing you can be sure of: the thin film hybrid amplifiers described in this article have been proven in production and will be around for a long, long time. Probably longer than the discrete transistors they are replacing.

References

J.G. Bouchard; "Hybrid Technology — Best Supporting Actor," IEEE Transactions on Manufacturing Technology, Vol. MFT-6, No. 4, Dec. 1977, pp 65-68.

B.T. Joyce; "Hybrids — A Look at the Total Cost"; IEEE Transactions on Manufacturing Technology, Vol. MFT-6, No. 4, Dec. 1977, pp. 69-72.

Bob Kromer, and Mike Turner; "Guide to Military Hybrid Microcircuits", Military Electronics/Countermeasures, June, 1978, pp 56-90.

Jim Eackus, and Al Grant; "Reliability Considerations in CATV Hybrids", IEEE Transactions on Cable Television, Vol. CATV-3, No. 1, Jan. 1978, pp 1-23.

James Humphrey and George Luettgenau; "Reliability Considerations in Design and Use of RF Integrated Circuits", TRW Semiconductors, Feb. 5, 1976.

M.D. McCombs; "Reliability/Performance Aspects of CATV Amplifier Design", TRW Semiconductors, Jan. 24, 1977.

D.M. Feeney; "Mechancial and Thermal Considerations in Using TRW RF Linear Hybrid Amplifiers", TRW Semiconductors, September 1978.

D.M. Feeney; "Extending the Range of an Intermodulation Distortion Test", Electronics, Aug. 3, 1978, pp 121-122.

Craig Wells; "A Layman's Guide to CATV Hybrid Amplifiers", TVC, Dec. 1977. □

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Frequency Counter Cornucopia

A survey of frequency counter specifications.

The data on frequency counters has been collected to save the reader time in surveying the marketplace for the frequency counters that would best meet his needs. Five different lists of counter manufacturers were asked to return a questionnaire on their counter specifications. Over three hundred questionnaires were mailed to the directors of sales of these companies. The collection of specifications found here represents those companies that returned the questionnaires, and does not necessarily represent all of the counters available today.

All the companies represented were asked to adhere to the same format, so that the reader could more easily make a comparison of the various capabilities of the counters. This requirement forced manufacturers to specify their counters somewhat differently than they may on their own data sheets. Furthermore, the sophistication of many counters is beyond the scope of this table. So, if a particular counter interests you, please contact the manufacturer for all the details on the instrument. The contributing manufacturers are listed in box below.

Lectrotech Inc.
5810 N. Western Avenue
Chicago, Illinois 60659
W.S. Grossman (312) 769-6262

John Fluke Mfg. Co., Inc.
P.O. Box 43210
Mountlake Terrace, Washington 98043
Lee Meyer 800-426-0361

Data Precision Corporation
Audubon Road
Wakefield, Massachusetts 01800
Jim Hayes (617) 246-1600

Ballantine Laboratories, Inc.
P.O. Box 97
Boonton, New Jersey 07005
Roger A. Stagnol (201) 335-0900

EIP Microwave
3230 Scott Boulevard
Santa Clara, California 95051
R.C. BLack (408) 244-7975

B&K Precision Dynascan Corp.
6460 W. Cortland Ave.
Chicago, Illinois 60635
Jim Farrell (312) 889-9087

Systron-Donner Corporation
One Systron Drive
Concord, California 94518
Gale Dishong (415) 676-5000

Hewlett-Packard Company
5301 Stevens Creek Blvd.
Santa Clara, California 95050
Tom Nawalinski (408) 246-4300

Phillips Test & Measuring Instruments, Inc.
85 McKee Drive
Mahwah, New Jersey 07430
Bob Grassi (201) 529-3800

Racal-Dana
18912 Von Karman Ave.
Irvine, California 92715
A.W. Conway (714) 833-1234

Sencore, Inc.
3200 Sencore Dr.
Sioux Falls, S.D. 57107
George Carey (605) 339-0100

Simpson Electric Company
853 Dundee Ave.
Elgin, Illinois 60120
Stew Cudworth (312) 697-2260

	DATA PRECISION CORPORATION			EIP MICROWAVE				B & K PRECISION DYNASCAN CORP.			
Model	585	5800	5740	331	351	371	451	1827	1801	1820	1850
Parameter measurement capability A. frequency B. period C. freq. ratios D. time interval E. totalizing F. Other (specify in comments)	A	A	AB DE	A	A	A, F	A, F	A	A	A B DE	A B
Frequency (max.)	10 HZ 250 MHZ	10 HZ 520 MHZ	5 HZ 100 MHZ	825 MHZ TO 18 GHZ	20 HZ TO 18 GHZ	20 HZ TO 18 GHZ	925 MHZ TO 18 GHZ	100 HZ 30 MHZ	20 HZ 40 MHZ	5 HZ 80 MHZ	5 HZ 520 MHZ
Frequency resolution	.1 HZ	.1 HZ	.1 HZ	1 KHZ	1 HZ	1 HZ	10 KHZ	—	—	—	—
Time resolution	—	—	.01 S	1 MS	1 MS	1 MS	100 MS	—	—	.01SEC	.2SEC
Sensitivity (peak to peak)	10 MV RMS	10 MV RMS	10 MV RMS	−25 DBM	−30 DBM	−30 DBM	−10 DBM	100MV	30MV	30MV 50MV	30MV 50MV
Max signal for accurate count (min. attenuator setting) r.m.s.	200 DC 250 AC TO 8AC	200 DC 250 AC TO 8AC	250 AC TO 5 AC	+7 DBM	7 DBM	7 DBM	10 DBM	200V	200V	200V	200V
Input protection Y-yes, N-no	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Max signal prior to permanent internal damage	200 DC 250 AC TO 8 AC	200 DC 250 AC TO 8 AC	250 DC TO 5 AC	20 DBM	2 W	2 W	30 DBM	200V	200V	200V	200V
Input impedance	1MΩ 50Ω	1MΩ 50Ω	1MΩ	50Ω	50Ω	50Ω	50Ω	10KΩ	1MΩ	1MΩ	1MΩ 50Ω
AC coupled mode Y-yes, N-no	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
Number of significant figures including ±1 digit	8	8	7	8	11	11	7	6LED 8	6LED 8	6LED 8	6LED 8
Time base crystal oscillator used RTXO, TCXO OCXO, POXO	RTXO TCXO	RTXO TCXO	RTXO	TCXO	TCXO	TCXO	RTXO	RTXO	RTXO	RTXO	TCXO
Long term time base stability ppm/month	RTXO .6/M	TCXO .3/M		<.3	<.3	<.3	<.3	1/M	1/M	10/YR.	1/YR.
Time base frequency change over 0°C to 50°C temperature range ppm	±5	±5		<2	<2	<2	<30	10	10	10	1
Time base frequency change caused by a 10% change in line voltage, ppm	.1	.1		<.1	<.1	<.1	<.1	—	—	1	1
Portable Y-yes, N-no	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
Battery Y-yes, N-no	Y	Y	N	N	N	N	N	Y	N	N	Y
Rechargable Y-yes, N-no	Y	Y	—	—	—	—	—	Y	—	—	—
Hours of battery operation	4	4	—	—	—	—	—	8	—	—	—
Weight Lbs	1.3 LBS	3.5 LBS	5 LBS	27 LBS	25 LBS	29 LBS	25 LBS	1 LBS	5.5 LBS	5 LBS	5 LBS
Dimensions	5.5" 1.75" 3.5"	8.5" 7.2" 3.5"	8.5" 7.2" 3.5"	3.5" 16.7" 19.6"	3.5" 16.7" 19.6"	3.5" 16.7" 19.6"	3.5" 16.7" 19.6"	1.75" 3.75" 6.6"	3.3" 8.69" 10.5"	3.25" 11.6" 7.5"	3.25" 11.6" 7.5"
Measurement strategy A. direct count B. prescaling C. automatic transfer oscillator D. automatic Heterodyne converter E. Other	A	B	A	D	D	D	D	A	A	A	A
IEEE 488 System Compatibility Y-yes, N-no	N	N	N	Y	Y	Y	Y	N	N	N	N
Meets MIL 461 and/or VDE 0871/0875 Y-Yes N-No	N	N	N	N	N	N	N	—	—	—	—
Warm-up time	—	—	10 MIN	0 MIN	0 MIN	0 MIN	0 MIN	—	—	30 MIN.	30 MIN.
Price	$345	$429	$295	$4295	$5800	$6800	$7200	$120	$200	$285	$480

	RACAL-DANA						BALLANTINE LABORATORIES, INC.					SIMPSON ELECTRIC COMPANY		
	9913	9915	9919	9921	9035	9510 9514	5500B	5500B OPT 35	5720A	5722A	5725C	7016	7026	710
	A	A	A	A	AB CD E	AB CD E	AB CD E PULSE	AB CD E PULSE	AC E	AB CE	AC E	AE	AB CD E	A
	10 HZ 200 MHZ	10 HZ 520 MHZ	20 HZ 1.1 GHZ	10 HZ 3 GHZ	100 MHZ 500 MHZ	500 MHZ	DC TO 110 MHZ	DC TO 1 GHZ	10 HZ TO 80 MHZ	10 HZ TO 1.25 GHZ	10 HZ TO 220 MHZ	5 HZ 50 MHZ	5 HZ 50 MHZ	10 HZ 60 MHZ
	1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ 1 HZ	.1 HZ	.1 HZ	.1 HZ	.001 HZ	.001 HZ	.1 HZ	.1 HZ	.1 HZ	1 HZ
	10 MS	10 MS	.02 S	10 MS	10 NS 10 PS	100 NS 100 PS	100 NS	100 NS	1 μS	1μS	1μS	10μS	10μS	—
	28 MV RMS	28 MV RMS	28 MV RMS	28 MV 50 MV	75 MV 30 MV	75 MV 30 MV	140 MV P-P	140 MV P-P	140 MV P-P	70 MV 50 MV P-P	140 MV P-P	50 MV RMS	50 MV RMS	50 MV RMS
	—	—	—	—	1 V RMS	1 V RMS	25 MV RMS	25 MV RMS	50 MV RMS	50 MV RMS	50 MV RMS	240 V	240 V	240 V
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	25 W	25 W	25 W	25 W	240 V 5V RMS	240 V 5V RMS	400 V RMS	400 V 5V RMS	250 V RMS	250 V RMS	250 V RMS	250 V	250 V	250 V
	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ	1MΩ 50Ω	1MΩ	1MΩ 50Ω	1MΩ	1MΩ	1MΩ	1MΩ
	Y	Y	Y	Y	Y	Y	Y DC	Y DC	Y	Y	Y	Y	Y	Y
	8	8	8	9	9	9	8	8	8	8	6	6	6	6
	TCXO POXO POXO	TCXO POXO POXO	TCXO POXO POXO	TCXO POXO POXO	TCXO POXO POXO	TCXO POXO	TCXO POXO	TCXO POXO	POXO	TCXO POXO	POXO	RTXO TCXO	RTXO TCXO	RTXO
		TCXO 1/M	POXO .003/D	POXO .0005/D	.3/M	.3/M	.3/M .003/M	.3/M	2/M	2/M .3/M	2/M	RTXO .5/Y	TCXO 1/Y	710 ±5/Y
		8	.15	.3	5	5	<2	<2	<25	<25 <2	<25	±10	1	±10
		—	—	—	.1	.1	<±.5	<.5	<.5	<.5	<.5	±1	±.1	±1
	N	Y	N	N	N	N	Y	Y	Y	Y	Y	N	N	N
	N	Y	N	N	N	N	N	N	Y	N	Y	N	N	N
	—	Y	—	—	—	—	—	—	Y	—	Y	—	—	—
	—	4-15	—	—	—	—	—	—	EXT.	—	EXT.	—	—	—
	5.5 LBS	6 LBS	6 LBS	8.4 LBS	19 LBS	15 LBS	7 LBS	7 LBS	2.8 LBS	2.14 LBS	2.14 LBS	6.5 LBS	6.5 LBS	.75 LBS
	3.3" 9.5" 10.6"	3.3" 9.5" 10.6"	3.3" 9.5" 10.6"	3.3" 9.5" 10.6"	16.75" 15.63" 3.5"	16.75" 16" 3.5"	13.5" 18.4" 12.5"	13.5" 18.4" 12.5"	2.4" 8.2" 8.7"	2.4" 8.2" 8.7"	2.4" 8.2" 8.7"	4" 8.5" 8"	4" 8.5" 8"	2" 5.63" 4.6"
	A 30 MHZ B 200 MHZ ÷4	A 60 MHZ B 520 MHZ ÷10	B	A 100 MHZ B 560 MHZ C 3 GHZ	A B	A	A	A B	A	A B	A	A B	A B	A
	TALK Y	N	Y	Y	Y	N/Y	Y OPT.	N	N	Y	N	BCD N	BCD N	N
	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	N
	6-20 MIN	6-20 MIN	6-20 MIN	6-20 MIN	30 MIN	30 MIN	5 MIN	5 MIN	10 MIN	10 MIN	10 MIN	—	—	—
	$450	$395	$650	$1095	$2995	$1995	$825	$1095	$225	$950	$295	$398	$445	$167

	SYSTRON-DONNER CORPORATION							SENCORE, INC.	
Model	6041A	6042A	6043A	6241A	6242A	6243A	6244A	FC45	FC51
Parameter measurement capability A. frequency B. period C. freq. ratios D. time interval E. totalizing F. Other (specify in comments)	A	A	A	A	A	A	A	A	A
Frequency (max.)	100 MHZ	512 MHZ	1250 MHZ	100 MHZ	512 MHZ	1250 MHZ	4500 MHZ	30 HZ-230 MHZ	10 HZ-1 GHZ
Frequency resolution	0.1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ	1 HZ	.01 HZ
Time resolution	— N/A	—	—	—	—	—	—	—	—
Sensitivity (peak to peak)	25 MV RMS	25 MV RMS −13DBM	25 MV RMS	10 MV RMS	10 MV RMS	10 MV RMS	10 MV RMS −13DBM	25 MV	25 MV
Max signal for accurate count (min. attenuator setting) r.m.s.	5V RMS	5V RMS	5V RMS	5V RMS	5V RMS	5V RMS	+20 DBM	250V	250V
Input protection Y-yes, N-no	YES	Y	Y	Y	Y	Y	Y	Y FUSE	Y FUSE
Max signal prior to permanent internal damage	5V RMS	5V	5V	5V	5V	5V	+20 DBM	12 WATTS	.5 WATT
Input impedance	1MΩ	1MΩ 50Ω	1MΩ 50Ω	1MΩ	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω
AC coupled mode Y-yes, N-no	Y	Y	Y	Y	Y	Y	Y	Y	Y
Number of significant figures include ±1 digit	8	8	8	8	8	8	8	8	8+ OVERFLOW
Time base crystal oscillator used RTXO, TCXO, OCXO, POXO.	TCXO	TCXO	TCXO	POXO	POXO	POXO	POXO	OCXO	POXO A
Long term time base stability ppm/month	0.3	0.3	0.3	0.015	0.015	0.015	0.015	.17	.17
Time base frequency change over 0°C to 50°C temperature range. ppm	1	1	1	0.01	0.01	0.01	0.01	1 PPM	.5 PPM
Time base frequency change caused by a 10% change in line voltage. ppm	0.05	0.05	0.05	0.0005	0.0005	0.0005	0.0005	<.1 PPM	<.1 PPM
Portable Y-yes, N-no	N	N	N	Y	Y	Y	Y	Y	Y
Battery Y-yes, N-no	N	N	N	Y	Y	Y	N	Y	Y
Rechargable Y-yes, N-no	N	N	N	Y	Y	Y	N	N	N
Hours of battery operation	—	—	—	4	4	4	—	—	—
Weight Lbs	4.5 KG 10 LBS	4.5 KG 10 LBS	4.5 KG 10 LBS	4.5 KG 10 LBS	4.5 KG 10 LBS	4.5 KG 10 LBS	4.5 KG 10 LBS	6.5	6.5
Dimensions	1.75" 16.75" 13"	1.75" 16.75" 13"	1.75" 16.75" 13"	3.5" 8.4" 13.5"	3.5" 8.4" 13.5"	3.5" 8.4" 13.5"	3.5" 8.4" 13.5"	5.5" 7.8" 9"	5.5" 7.8" 9"
Measurement strategy A. direct count B. prescaling C. automatic transfer oscillator D. automatic Heterodyne converter E. Other								A B	AB D
IEEE 488 System Compatibility Y-yes, N-no	Y STD	Y STD	Y STD	N	N	N	N	N	N
Meets MIL 461 and/or VDE 0871/0875 Y-Yes N-No	—	—	—	Y	Y	Y	Y	N	N
Warm-up time	.15 MIN.	.15 MIN.	15 MIN.	15 MIN.	15 MIN.	15 MIN.	15 MIN.	10 MIN	10 MIN
Price	$895	$1095	$1395	$495	$695	$995	$2395	$448	$975

HEWLETT-PACKARD

5370A	5345A	5354A PLUG-IN	5340A	5341A	5342A	5300B 5305B	5315A 5315B	5314A	5383A	5382A	5381A	5328A	5300B 5308A
AB CD F	AB CD EF	A	A	A	A	A	AB CD E	A, B, C, D E	A, C	A, C	A, C	AB CD EF	AB CD EF
100 MHZ	500 MHZ (18 GHZ W/P.I.)	4 GHZ	18 GHZ (23 GHZ)	4.5 GHZ	18 GHZ (24 GHZ)	1.3 GHZ	100 MHZ	100 MHZ	520 MHZ	225 MHZ	80 MHZ	1.3 GHZ	75 MHZ
20 PS GATE TIME	1μHZ	.01 HZ	1 HZ	1 HZ	1 HZ	.0001 HZ	7 DIGITS PER SEC.	.1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ
20 PS IMPROVE	2 NS	—	—	—	—	—	10 PS	100 NS	—	—	—	100 PS	1 NS
100 MV	20 MV	−20 DBM	−35 DBM	−20 DBM	−25 DBM	60 MV	30 MV	75 MV	75 MV	75 MV	75 MV	75 MV	75 MV
1 VOLT	250 MV	+20 DBM	+7 DBM	+20 DBM	+5 DBM (+20)	—	—	—	—	—	—	—	—
N	N	N	N	N	N	Y	N	N	Y	N	N	Y	N
±5V	24 DBM	25 DBM	30 DBM	30 DBM	25 DBM	250V	500V AC & DC	350V AC & DC	200DC 250VAC	200DC 250VAC	200DC 250VAC	250V	250V
1MΩ 50Ω	1MΩ 50Ω	50Ω	50Ω	50Ω	50Ω	1MΩ 50Ω	1MΩ	1MΩ	1MΩ 50Ω	1MΩ	1MΩ	1MΩ 50Ω	1MΩ
Y	Y	Y	Y	Y	Y	Y	AC DC	Y	Y	Y	Y	AC DC	AC DC
12	11	11	8	10	11	8	8 PLUS EXPONENT	7	9	8	7	9	8
POXO	POXO	POXO IN 345A	TCXO	TCXO	TCXO	RTXO TCXO	RTXO TCXO	RTXO TCXO	RTXO TCXO	RTXO TCXO	RTXO TCXO	RTXO STD OCXO OPTIONAL	RTXO STD TCXO OPTIONAL
.3/M	.0005/D	.3/M	.3/M	.1/M	.1/M	.3/M	.3/M	.3/M	.3/M	.3/M	.3/M	.3/M	.3/M
.007	<.007	<2	<2	<1	<1	±5	±5	±10	±2.5	±2.5	±10	±2.5	±5
.0001	.0001	<.1	<.1	<.1	<.1	±.1	±.1	±.1	±.5	±.5	±1	±.1	±.1
Y/N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	OPTION	OPTION	OPTION	N	N	N	N	OPTION
N	N	N	N	N	N	Y	Y	Y	—	—	—	—	Y
N	—	—	—	—	—	4	4	8	—	—	—	—	4
14.55KG 32 LBS	17KG (37 LBS)	3.6 (8)	11.3 (25)	10.5 (23)	9.1 (20)	2.5/ 5.5	2.9/ 6.4	2.0/ 4.4	2.2/ 4.75	2.2/ 4.75	2.2/ 4.75	8.5/ 18.6	2.4/ 5 1/3
16.75" 5.25" 18"	17" 19.8" 5.28"	—	17" 16.64" 3.52"	17" 16.64" 3.52"	8.52" 20" 5.3"	13.5" 16.25" 19.75"	9.4" 3.4" 10.9"	9.4" 3.4" 10.8"	3.5" 6.25" 9.75"	3.5" 6.25" 9.75"	3.5" 6.25" 9.53"	16.6" 16.6" 3.5"	13.5" 6.25" 9.75"
A INTER-POLATE	E RECIP	D	C	D	HARMONIC HETERDYNE	B	A+ RECIP	A B	A	A	A	A B	A
Y	Y	Y	Y	Y	Y	OPTIONAL	N	N	N	N	N	OPTIONAL	OPTIONAL
N	N	N	N	N	N	N	Y	N	N	N	N	N	N
10 MIN	—	—	—	—	—	—	—	—	—	—	—	—	—
$6500	$4400	$3400	$6200	$4950	$4500	$460 $900	$800 $950	$375	$650	$395	$295	SEE LIST	$460 $450

	PHILLIPS										
Model	6625	6624	6622	6616	6615	6614	6613	PM6610 6612	6664	6661	6650
Parameter measurement capability A. frequency B. period C. freq. ratios D. time interal E. totalizing F. Other (specify in comments)	AB ED AVG MODE	AB ED AVG MODE	AB ED AVG MODE	AB CE	AB CE	AB CE	AB CE	D	A	A	AB CD E
Frequency (max.)	1G	520MHZ	80MHZ	1.3GHZ	1.0GHZ	520MHZ	250MHZ	80MHZ	520 MHZ	80 MHZ	DC TO 512 MHZ
Frequency resolution	.1HZ	.1HZ	.1HZ	.1HZ	.1HZ	.1HZ	.1HZ	.1HZ	1 HZ	1 HZ	.01 HZ
Time resolution	100NS TO 10^{3}S	100NS TO 10^{3}S	100NS TO 10^{3}S	100NS OR 100μS	100NS OR 100μS	100NS OR 100μS	100NS OR 100μS	100NS OR 100μS	—	—	10 NS
Sensitivity (peak to peak)	20 MV	20 MV	20 MV	10 MV	10 MV	10 MV	10 MV	10 MV 500 MV	20 MV	20 MV	50 MV
Max signal for accurate count (min. attenuator setting) r.m.s.	230 AC 250 DC	230 AC 250 DC	230 AC 250 DC	230 V	230 V	230 V	230 V	230 V	—	—	230 AC 300 DC
Input protection Y-yes, N-no	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Max signal prior to permanent internal damage	230 AC 250 DC	230 AC 250 DC	230 AC 250 DC	230 AC 250 DC	230 AC 250 DC	230 AC 250 DC	230 AC 250 DC	230 AC 250 DC	260 AC 300 DC	260 AC 300 DC	230 AC 300 DC
Input impedance	1MΩ 50Ω	1MΩ 50Ω	1MΩ	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ 50Ω	1MΩ	1MΩ	1MΩ	1MΩ 50Ω
AC coupled mode Y-yes, N-no	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Number of significant figures including ±1 digit	9	9	9	9	9	9	9	9	8	8	9
Time base crystal oscillator used RTXO, TCXO, OCXO, POXO	RTXO TCXO POXO	RTXO TCXO POXO	RTXO TCXO POXO	TCXO RTXO POXO	TCXO RTXO POXO	TCXO RTXO POXO	TCXO RTXO POXO	TCXO RTXO POXO	RTXO TCXO	RTXO	TCXO POXO
Long term time base stability ppm/month	TCXO .1/M	RTXO .5/M	.1/M .0015/D .0005/D		TCXO .1/M	RTXO >.5/M	POXO .1/M .0015/D	POXO .0005/D	RTXO 2/Y	TCXO .1/M	.1/M .0015/D .0005/D
Time base frequency change over 0°C to 50°C temperature range. ppm	1	>10	.1 .03 .005		1	>10	.1	.005	15	1	.02 .0005 .0005
Time base frequency change caused by a 10% change in line voltage. ppm	.001	.01	.001 .0005 .0005		.001	.01	.001 .0005	.0005	—	—	.001 .0001 .0001
Portable Y-yes, N-no	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N
Battery Y-nes, N-no	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N
Rechargable Y-yes, N-no	Y	Y	Y	Y	Y	Y	Y	Y	—	—	—
Hours of battery operation	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	—	—	—
Weight Lbs	6 LBS	6 LBS	6 LBS	6.2 LBS	6.2 LBS	6.2 LBS	6.2 LBS	6.2 LBS	3.2 LBS	3.2 LBS	20.9 LBS
Dimensions	8.25" 3.5" 12.8"	8.25" 3.5" 12.8"	8.25" 3.5" 12.8"	8.25" 3.5" 12.8"	8.25" 3.5" 12.8"	8.25" 3.5" 12.8"	8.25" 3.5" 12.8"	8.25" 3.5" 12.8"	8.7" 5.75" 1.75"	— — —	16.16" 12.2" 5.28"
Measurement strategy A. direct count B. prescaling C. automatic transfer oscillator D. automatic Heterodyne converter E. Other	A TO 80 MHZ ÷16B	A TO 80 MHZ ÷4B	A	A 80 MHZ ÷16B	A 80 MHZ ÷16B	A 80 MHZ ÷8B	A 80 MHZ ÷4B	A 80 MHZ	A 80 MHZ B	A	A
IEEE 488 System Compatibility Y-yes, N-no	Y	Y	Y	TALK Y	TALK Y	TALK Y	TALK Y	TALK Y	N	N	Y
Meets MIL 461 and/or VDE 0871/0875 Y-Yes N-No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Warm-up time	STAND BY	STAND BY	STAND BY	STAND BY	STAND BY	STAND BY	STAND BY	STAND BY	25 MIN	—	STAND BY
Price	$1525	$1290	$985	$1430	$1215	$960	$910	$740	$590	$298	$4125

LECTROTECH INC.	JOHN FLUKE MFG. CO., INC.							
TF-50 -512 PRESCALER	1900A	1910A	1911A	1912A	1920A	1925	1952B	1953A
A	AB CE	AB CE	AB CE	AB CE	A	AB CE	AB CD E	AB CD E
10 HZ 50 MHZ 500 MHZ	80 MHZ	125 MHZ	250 MHZ	520 MHZ	1250 MHZ	520 MHZ	80 MHZ	1250 MHZ
1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ	.1 HZ (.001HZ OPT)	.1 HZ	.1 HZ	.1 HZ
—	100 PS	100 NS	100 NS	100 NS	—	100 NS	100 NS	100 NS
100 MV 300 MV	75 MV	45 MV	45 MV	45 MV	45 MV	45 MV	150 MV	90 MV
50 V	250 V RMS	250 V RMS	250 V RMS	250 V RMS	150 V RMS	250 V RMS	150 V RMS	150 V RMS
Y	N	N	N	N	N	N	N	N
250 V 50 V	250 V RMS	250 V RMS	250 V RMS	250 V RMS	150 V RMS	250 V RMS	150 V RMS	250 V RMS
1MΩ 50Ω	1MΩ	1MΩ	1MΩ	1MΩ	1MΩ	1MΩ	1MΩ	1MΩ
Y	Y	Y	Y	Y	Y	Y ABLE	SWITCH-ABLE	SWITCH-
8	6	7	7	7	9	9	8	8
RTXO	PTXO	PTXO	PTXO	PTXO	PTXO	PTXO	PTXO	OCXO POXO TCXO
±1/M	.5	.5	.5	.5	.3	.5	.5	.3
±10	5	5	5	5	2	5	5	2
1	.1	.1	.1	.1	.1	.1	.1	.1
Y	Y	Y	Y	Y	Y	Y	N	N
N	Y	Y	Y	Y	Y	N	N	N
—	Y	Y	Y	Y	Y	—	—	N
—	4	4	4	4	3	—	—	N
4 LBS	2.75 LBS	3.2 LBS	3.2 LBS	3.2 LBS	6 LBS	6 LBS	6 LBS	9.5 LBS
2.5" 8.25" 8.25"	8.5" 2.5" 10.0"	8.5" 2.5" 10.0"	8.5" 2.5" 10.0"	8.5" 2.5" 10.0"	9.0" 3.5" 12.5"	8.5" 3.5" 13.25"	13" 3.5" 9.5"	14" 3.5" 13.5"
A B÷10	A	A B	A B	A B	A B	A B	A	A
N	N	N	N	N	N	N	N	Y
N	N	N	N	N	N	Y	N	N
30 MIN	—	—	—	—	—	—	0	10 MIN
$199.50 $99.50	$345	$395	$495	$620	$1095	$750	$895	$1195

Market Place

While making this survey of frequency counters, *r.f. design* had the opportunity to discuss the future of the market place with many product managers. The general concensus was that the instrument industry had experienced a good year in '78, and was looking forward to another good year in '79. The impact of the microprocessor is just beginning to be felt in the frequency counter market. Future counters will have much greater capabilities in terms of data collection and manipulation. Dedicated IC's are now being made available and should reduce the price of counters.

So, the customer can look forward to less expensive counters with greater capabilities. What could be better news than that?

10 kHz-1280 MHz Synthesized Signal Generator

ADJACENT CHANNEL SELECTIVITY

MEASURE OF RECEIVER'S ABILITY TO DIFFERENTIATE BETWEEN A DESIRED MODULATION SIGNAL AND MODULATION SIGNALS ON ADJACENT CHANNELS

Test Setup

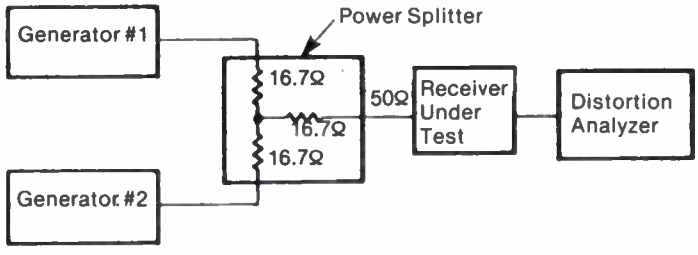


Figure 1. Equipment setup for adjacent channel selectivity test.

IMPORTANCE OF SIGNAL GENERATOR PHASE NOISE IN ADJACENT CHANNEL TESTS.

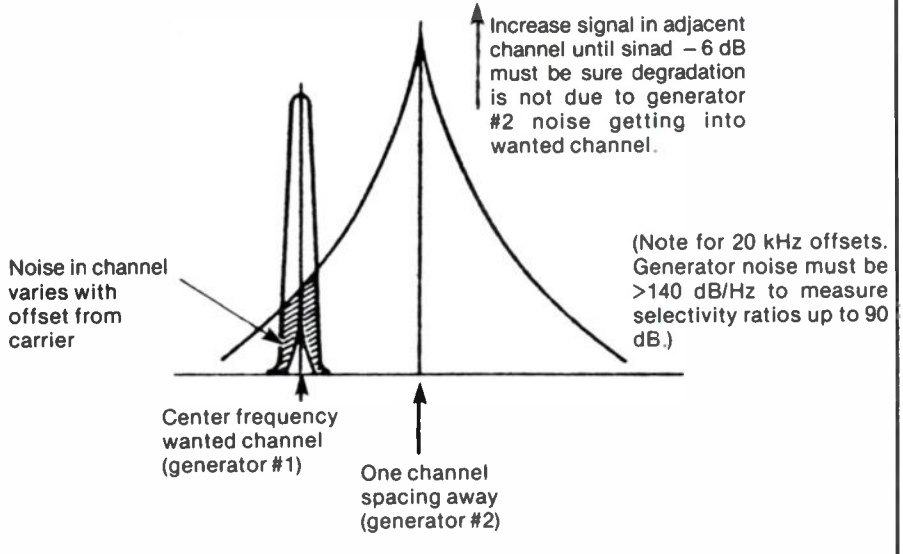


Figure 2. Signal effects of generator SSB noise.

Synthesized signal generators have found applications in many important applications which need their unique performance characteristics, and can justify their relatively high price. High stability receiver testing such as satellite doppler tests need the precision frequency tuning, resolution, and long-term stability of synthesizers. Automatic test systems depend on the ability to program frequencies, amplitudes and modulations with speed and accuracy. Satellite ground stations often use synthesizers as the starting signal for multipliers and up-converter chains to get to the C-band or X-band operating signal and since noise characteristics are also multiplied, the synthesizer noise is critical.

But in spite of this great application range, synthesizer performance has fallen short in areas of single-sideband (SSB) noise and spurious signals. This has limited their usefulness in out-of-channel testing of receivers such as adjacent channel and spurious response testing. The reasons are shown in Figures 1 and 2. Adjacent channel tests are performed by driving a very high level signal into the radio channel only 25 to 50 kHz (in mobile FM) away from the tuned channel. If the generator itself has SSB noise at that carrier offset it comes through the tuned channel at only – 105 dBc/Hz (typical of the HP 8660C/86602A synthesizers), and the test results are limited. Thus, most industry tests are presently run with the HP 8640B cavity-tuned signal generator which is the signal/noise performance leader at this time. 8640B SSB noise is – 143 dBc/Hz at a 20 kHz carrier offset at 256 MHz. But of course,

it is not programmable, thus automatic test systems typically use the synthesizers for in-channel testing (sensitivity, modulation, etc.) and roll up a manual 8640B for the out-of-channel tests.

Radio spurious responses present a similar problem since non-harmonic spurious signals from the 8660C/86602A are from 70-80 dB below the carrier, whereas the manual 8640B essentially has no spurious, being cavity-tuned.

Better SSB Performance For a Synthesizer

With the introduction of Hewlett-Packard's model 8662A synthesized signal generator, signal purity of indirect synthesis now rivals that of the best cavity-tuned generators. Operating in the 10 kHz to 1280 MHz range, this new generator offers 0.1 Hz resolution below 640 MHz, 0.2 Hz above. Single sideband phase noise in the basic 320 to 640 MHz range at 10 kHz offset is specified as – 132 dBc/Hz, even less at lower frequencies (typically – 147 dBc at 160 MHz, for example). Non-harmonically related spurious signals are at least – 90 dBc up to 640 MHz. From 640 to 1280 MHz noise and spurious are both 6 dB higher.

Such spectral performance was achieved by specific design attention to two areas. First, the frequency reference section which includes multipliers, dividers, and phase lock loops has exceptional steps taken to provide spectrally clean, multiplied reference signals. For example, in two separate circuits, crystal filter sections provide very high purity clean-up of reference signals, while still permitting frequency agility. In addition, the 10 MHz reference crystal oscillator itself has been designed for particularly clean characteristics.

Second, the instrument uses a switched reactance oscillator of novel design which provides a quiet, free-running oscillator source before disciplining with the reference signals. Usually oscillators require relatively wide frequency tuning with varactors (2:1) to allow broad frequency coverage. But this means high sensitivity to noise on the control voltage. The HP 8662A uses a special low sensitivity design with a narrow tuning range varactor to control noise. Then a series of separate inductance/reactance elements are switched in with PIN diodes to quickly change ranges (Figure 3). The combination of switched inductance values with narrow-tuning varactors results in a very high-Q oscillator with exceptional spectral purity but with 2:1 tuning range overall. By starting with such a clean oscillator, the indirect synthesis method reaches its highest performance.

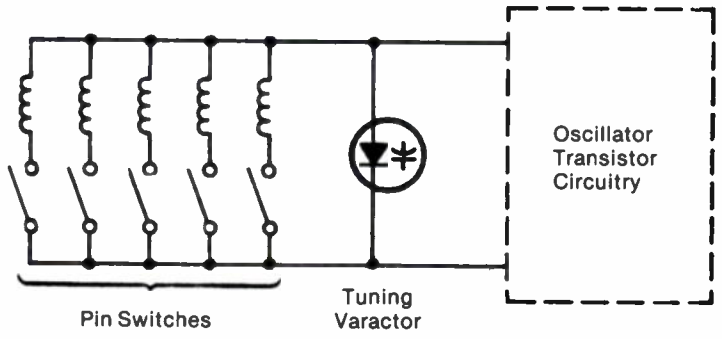


Figure 3. Switched inductance oscillator allows narrower range tuning of varactor.

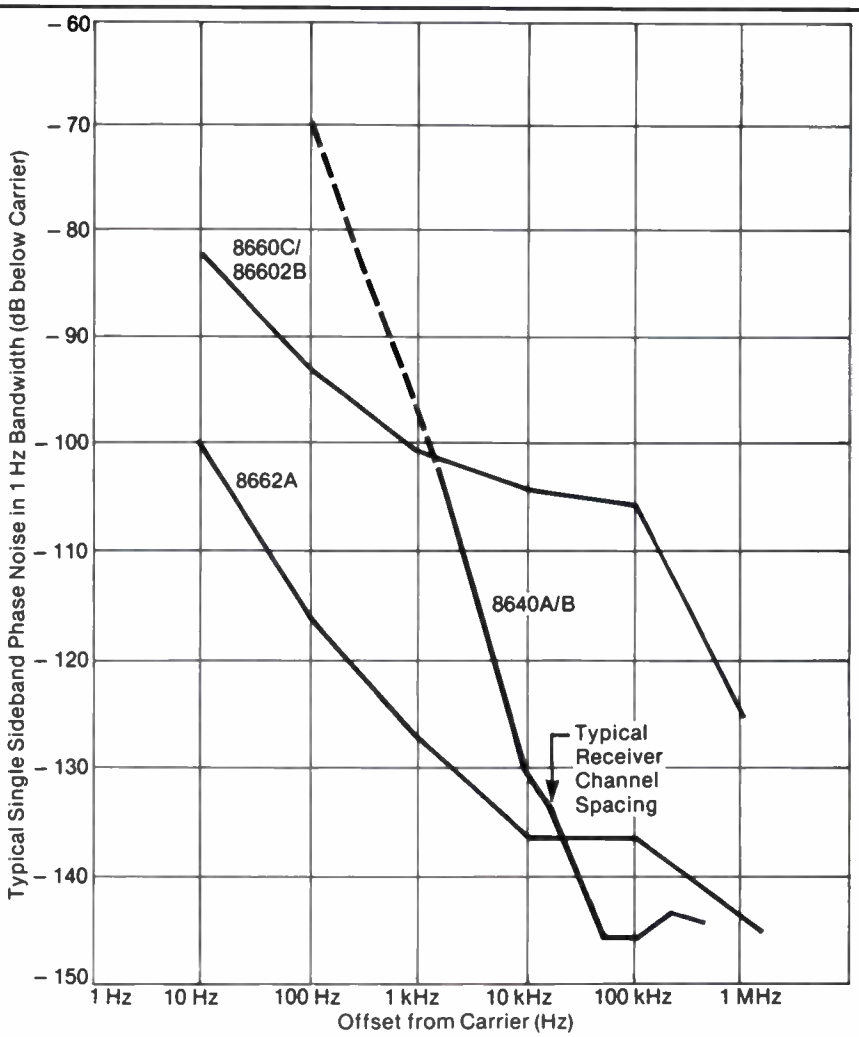


Figure 4. Comparison of SSB noise performance of new HP 8662A with cavity-tuned 8640B and older 8660C/86602A. f_C = 500 MHz.

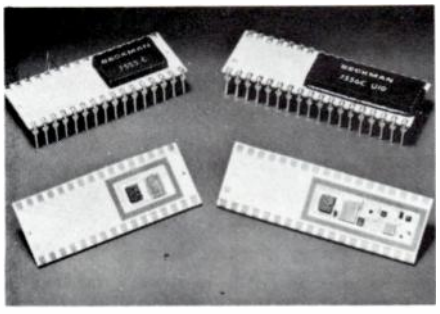
Actual performance results are shown in the SSB noise curves of Figure 4. Output signals of the cavity-tuned HP 8640B are compared with typical previous synthesizers (HP 8660C) and with the new HP 8662A. It is seen that the 8662A substantially exceeds the close-in spectral performance of the cavity and compares favorably at 20 kHz offset. The new synthesizer considerably exceeds the old synthesizer on both counts.

Contact Hewlett-Packard, 1507 Page Mill Rd., Palo Alto, Calif. 94304. Circle INFO/CARD #80.

Microprocessor Compatible A/D Converters

Beckman Instruments has introduced two new CMOS Hybrid 12-bit Successive Approximation Analog-to-Digital Converters, that are believed to be the first converters to offer guaranteed 12-bit accuracy, 8-bit microprocessor compatibility and TTL or CMOS logic output.

Available in both commercial and military models, the series 7555 and 7556 Analog-to-Digital Converters have

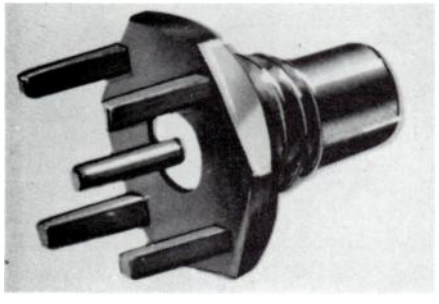


three-state outputs that facilitate a variety of busing schemes for the data bit outputs, as well as a Serial Register Output and an End of Conversion Output. Each data bit output is separated into a 4-bit most significant bit (MSB) and 8-bit least significant bit (LSB) byte.

Contact Beckman Instruments, Inc., Technical Information Section, Advanced Electro-Products Division, 2500 Harbor Boulevard, P.O. Box 3100, Fullerton, California 92634. INFO/CARD #78.

Printed Circuit Jack And RF Jack

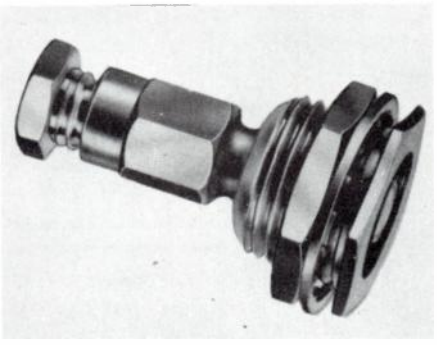
A straight jack receptacle, mating with MIL-C-39012, series SMC plugs, is now available from Sealectro Corporation. The 50-051-0000 has a PC



board mounting termination, with four mounting legs and a center signal straight termination.

Sealectro Part No. 51-033-0000 is an SMB RF receptacle, entirely recessed behind the mounting panel, and features a cable attachment by means of crimp. The bulkheaded jack is designed for low-cost, high production installation on instruments or components requiring a cable termination.

The unique recessed design pro-



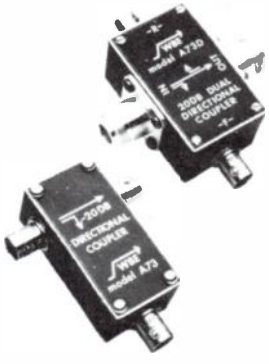
vides protection against accidental knocks or blows. It is made of brass, gold plated, and is 50 ohms impedance. The unit extends 43/64" behind the mounting surface, including the cable crimp ferrule.

Complete details are available by contacting the R.F. Components Div., Sealectro Corp., Mamaroneck, N.Y. 10543. Circle INFO/CARD #81.

Directional Couplers

Wide Band Engineering Company, Inc., has expanded its line of directional couplers to include four new models with 45 dB minimum directivity.

Single and dual 1-100 MHz couplers



and 10-200 MHz single and dual couplers have 50 ohm impedance.

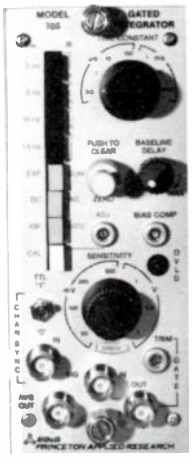
All other specifications for the "P" series coupler remain the same. Impedance is 50 ohm, connectors BNC. Delivery 4-6 weeks. "P" series couplers are available for 75 ohms with power limited to 10W cw.

Wide Band Engineering Company, Inc., P.O. Box 21652, Phoenix, Ariz. 85036, Phone (602) 254-1570. Circle INFO/CARD #82.

Averager Plug-In

The model 165 gated integrator plug-in module enhances the performance and versatility of the popular model 162 dual channel boxcar averager and therefore increases the scope of its applications. The model 165 complements the two original model 163 and model 164 plug-ins. Features such as shortened aperture durations, variable gain, faster response and a unique alternate channel triggering mode are all incorporated into the model 165 plug-in. Such equipment is used primarily to recover fast signals from masking noise.

Aperture durations are selectable from 2 ns to 5 ms to accommodate a variety of signals. Full scale sensitivity is variable over a 100:1 range from ±50 mV to ±5 V. Shorter aver-

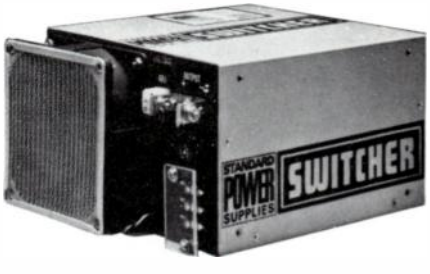


aging time constants are provided to reduce experimental times in cases where signals are relatively noise free. The model 165 fits all model 162 mainframes. The model 165 is $2,995 FOB Princeton. Availability is May, 1979.

Contact EG&G Princeton Applied Research, P.O. Box 2565, Princeton, N.J. (609) 452-2111. Please circle INFO/CARD #83.

Switching DC Power Supplies

Standard Power, Inc. has just introduced an entirely new line of switching regulated DC power supplies.



The model SWS 750, is rated at 750 watts. The units are available in five models, providing 5, 12, 15, 24 and 28 volts DC, from 28 to 150 amps. The

SWS 750 models are priced at $675 each.

For full details contact Standard Power, Inc., 1400 South Village Way, Santa Ana, Calif. 92705. (714) 558-8512. Circle INFO/CARD #84.

Saw Filters

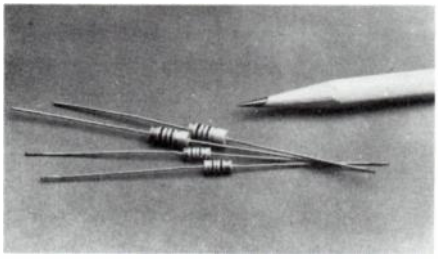
Rockwell International announces the availability of a complete line of surface acoustic wave (SAW) filter devices for use in industrial, commercial and military applications.

SAW filters are fabricated on quartz and lithium niobate substrates, designed to perform in temperatures from −55°C to 85°C, and are produced in microelectronic industry-compatible packages. The devices are available with center frequencies from 20 MHz to 100 MHz, and fractional bandwidths from 0.2 percent to 15 percent. Phase linearity, a flat group delay, controlled amplitude and time response complement design specifications. Typical applications of the SAW devices include satellite communications, radar systems, electronic countermeasures, communication receivers and signal processing. Standard production SAW devices in 100-piece quantities are typically priced in the $100 range.

Specialized requirements for prototype filters and delay lines for center frequencies from 20 to 600 MHz may be obtained from Rockwell Filter Products' Advanced Development Department, 3310 Miraloma Ave., P.O. Box 3669, Anaheim, Calif. 92803. TWX 910-591-1654. Circle INFO/CARD #86.

Low Inductance Choke Series

Two new series of extremely low inductance, fixed RF chokes for higher frequency circuits are now available from Cambion. These new, extremely low inductance RF chokes fill a need long pointed out by engineers. Cambion's new 551-5169 and 551-5172 series provide values from a low of



.022 uH through .100 uH. This low inductance series adds new, lower inductance values to the standard Cambion 550-3640 RF chokes (.15 uH through 33 uH), and to the Cambion 550-3399 RF chokes (.1 uH through 1000 uH).

Contact Cambridge Thermionic Corporation. 445 Concord Avenue, Cambridge, Mass. 02138. (617) 491-5400. Circle INFO/CARD #85.

Digital Capacitance Meter

Dynascan Corp. has introduced a low cost digital capacitance meter with 10 selectable ranges with full

scale values from 999.9 picofarads to 999.9 millifarads. The meter reads from 0.1pF to 1000 millifarads (1 Farad), and has an accuracy of 0.5 percent of full scale, ± digit to 100μF; 1 percent of full scale, ± 1 digit from 1000μF (1 millifard) to 1000mF (1 Farad), with a resolution of 0.1pF. Reading time for the meter is 0.3 sec to 1000μF, increasing to 35 second maximum at 1 Farad, with an overrange indicator for all ranges. All bottom segments of the digits are "ON" when the capacitor value exceeds the value of the range selected.

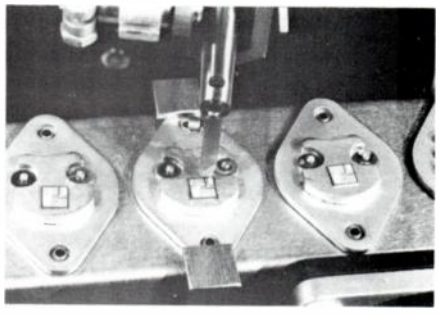
The meter has a 4 digit LED display with front panel controls for 10-position range switch, zero adjust, ON-OFF switch. Power source of the meter is 4 standard "C" size cells operating from 4-6 volts, and weighs 674g. (1.51 lbs.) Optional accessories are BC-28 charger, BP-28 battery pack, LC-28 carrying case, battery.

Contact Dynascan Corp., 6460 W. Cortland Street, Chicago, Ill. 60635. (312) 889-9087. Circle INFO/CARD #87.

Large-Wire Ultrasonic Bonder

The model 20 large-wire bonder bonds 5- to 20-mil wire at throughput rates up to 1000 devices an hour. The system is available in a hand-fed version with a selection of chucks for bonding a variety of packages at rates of 250-300 devices an hour. The system shown in the photo incorporates a parts indexer that automatically feeds devices through the bonder at rates of 500 to 600 an hour.

A soon-to-be-introduced system will include an automatic parts loader and unloader and a fast-track feeding system. Device throughout with this new version is 1000 devices an hour. This fast track feeder also incorpor-



ates an automatic bond pull tester. The system also provides automatic parts storage and handling. Users of the model 20 are reporting bonding

DSI COMMUNICATIONS SERIES

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C1000	10Hz to 1GHz	.1PPM 0° to 40°C	20MV	1MV	>50MV	9	.5 Inch	115VAC-BATT 8 to 15VDC	4"H x 10"W x 7½"D

— All Units Are Factory Assembled, Tested And Carry A Full 5 Year Limited Warranty —

FOR MORE INFORMATION

Call Toll Free (800) 854-2049 *DSI Instruments Inc.*
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53 Old Stone Mill Road, Atlanta, GA 30067

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Model C 1000	**$499.95**
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Opt. 02 .05 PPM 10MHz Double Oven 0° to 50° C Time Base (C1000 only)	**$129.95**
Ant. 210 Telescopic Ant./BNC Adapter	**$11.95**

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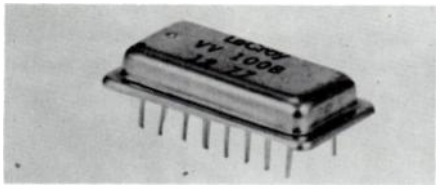
yields of over 98 percent and system payback within a few months operation because of increases in throughput and decreases in scrapped parts.

Contact Orthodyne Electronics, 1599 Superior Avenue, Costa Mesa, Calif. 92627. (714) 646-1616. Circle INFO/CARD #88.

Wideband Pulse Amplifier

The VV100B microcircuit provides exceptional performance for very-high-frequency applications of pulse and video signals in high-speed, low-signal-level instrumentation and data communication systems.

With a rise time of less than 2 nsec and a skew rate of 2500 volts/μsec, the VV100B will drive a 25-ohm load to −5 volts with ±0.1 percent linearity, 3 dB down at 230 MHz. Input noise is less than 4.2 nv/√Hz. Total input drift and offset over a 0-70°C temperature range is less than 1 mV, permitting the VV100B amplifier to be



cascaded to provide gains of up to 1000. (Unit price: $65.00 (>501: $32.00). Availability: Stock to four weeks.

Further details may be obtained by contacting LeCroy, Microcircuits Division, 700 S. Main St., Spring Valley, N.Y. 10977. (914) 425-2000. Circle INFO/CARD #90.

Fixed Attenuators

The 3300 series miniature fixed attenuators cover a frequency range of DC to 2 GHz and are available in 28 standard nominal values from 0.1 dB to 100 dB. Designed primarily for the OEM, the units have a VSWR of only 1.15:1 maximum and are accurate typically to ±0.3 dB of nominal value (up through 30dB).

Consistent performance and reliability of these OEM units are achieved through modern fabrication techniques of injection molding, stamping, broaching, and thick-film printing. A spring contact arrangement eliminates the use of epoxy or solder. Body and connectors are stainless steel. The 3300 series is provided with WPM connectors (male/female) which mate non-destructively with SMA type per MIL-C-39012.

Contact Julian Parker, Product Promotion Coordinator, Weinschel Engineering, Gaithersburg, Maryland. (301) 948-3434 ext. 241. Circle INFO/CARD #89.

Miniature Isolators and Circulators

Innowave now has available, miniature isolators and circulators offering excellent performance across full MIL-SPEC temperature range of −54 to +85 degree C in the 8.0 to 18.0 GHz frequency band. Specifications are: frequency range, 8.0 to 18.0 GHz; isolation, minimum, 15 dB; insertion loss, maximum, 0.8 dB; VSWR, maximum, 1:60:1; operating temperature range, −54 to +85 Degree C; size (LxWxT excluding connectors and load), 0.63 x0.75x0.50 inches; load rating, 2 Watts CW; connectors, standard, SMA Female.

Isolator model 1130IR and circulator model 1130CR are available with a six to eight week delivery at this time and at a unit price of $135.00 each.

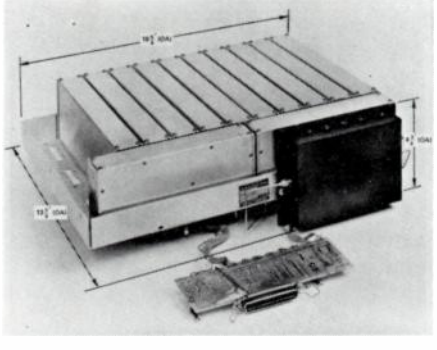
Contact Richard Sanders, vice-president of marketing, 485 Macara Ave. #902, Sunnyvale, Calif. 94086. (408) 737-9622, TWX 910-339-9321. Circle INFO/CARD #91.

Programmable Frequency Synthesizer

In sub-system, build-in form for Satcom, radar, ATE, and other critical system applications the frequency synthesizer provides direct frequency synthesis from 100 kHz to 160 MHz with 0.1 Hz resolution, high spectral purity, 20μsec switching speed, low switching transients.

The necessary controls are normally provided by the "host system", at considerable overall savings in most OEM applications. Further savings are possible at OEM levels by incorporating only as much resolution as required by the application.

The model 5620A is a direct synthesizer (no phase-locked loops), and consequently is far faster than indirect phase-locked VCO designs. Its maximum switching time of 20 microseconds makes computer-programmed frequency sweeping both easy, effective, and smooth, and conveniently



enables digital-feedback stabilization in closed-loop circuits. Spurious harmonic outputs are 10 to 15 dB lower

than indirect designs (>35 dB below fundamental), and close in phase noise is 6 to 10 dB lower (>70 dB below fundamental, minimum). Spurious non-harmonic outputs are >70 dB below fundamental. The instrument is designed for use with an external frequency standard of 5 MHz or 10 MHz.

Contact Rockland Systems Corp., Rockleigh Industrial Park, Rockleigh, N.J. 07647. (201) 767-7900, TWX 710-991-9852. Circle INFO/CARD #92.

High-Power RF Switch

A new switch handles radio-frequency energy at power levels that would cause ordinary RF switches to break down. Although compact, the new component can switch five kilowatts of RF power under difficult high-vacuum conditions.

The high-power switch resembles other RF switches except that all gaps between the RF-carrying conductors are filled with Teflon. The dielectric prevents "multipactor breakdown," in which an electron is released into the vacuum space between coaxial conductors and is accelerated first in one direction and then in the reverse direction by the RF field. If there is a vacuum in the gap, the electron can be accelerated to a high enough speed to free secondary electrons, creating an "avalanching" effect that can erode the switch contacts.

This work was done by Edward R. Caro of Caltech for NASA's Jet Propulsion Laboratory.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Legal Counsel-JPL [see page A8]. Refer to NPO-14229. INFO/CARD #93.

Frequency Counter Time Base

The TCX-20 is a high-accuracy TCXO (temperature compensated crystal oscillator) time base, which features temperature stability of better than ± 1 PPM from 0 to 50 degrees celsius. The maximum aging rate is ± 1 PPM per year. The model 1820, when used with the TCX-20 time base, has instant warm up. As a result, the unit will retain its accuracy under virtually all operating conditions. This increased accuracy allows the 1820 to be used for critical laboratory applications.

The TCX-20 time base is available at local B&K-Precision distributors at a user net of $100.00. For additional information contact B&K-Precision Sales Department, 6460 W. Cortland, Chicago, Ill. 60635. (312) 889-9087. INFO/CARD #94.

Digital Panel Meter

Datel Systems, Inc. has introduced a digital panel meter model DM-3100U3. Features for the new meter are a tiny 3-1/2 digit liquid crystal DPM using 230 VAC power or 9-15 VDC @

3 mA; ± 1.999 VDC input range; autozero, autopolarity; ratiometric for scaling to engineering units; PCB pads for attenuators, current shunts, offset pot, ohmmeter circuits, 200 mV range; balanced differential inputs, transformer isolated: and display descriptor labels for mA, mV, K ohm, AC, DC. Price for the meter is $49 in 100's.

Contact Eugene L. Murphy at Datel Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 828-8000. Circle INFO/CARD #95.

Shielding Paint

A new version of Acme Chemicals' E-Kote 3063 shielding paint is now available with greatly improved resistance to environmental stress. E-Kote 3063 is an electrically conductive coating specifically designed to meet the needs of the electronic industry for a low cost, easily applied EMI/RFI shielding material for plastic and structural foam enclosures.

E-Kote 3063 contains neither silver nor other commonly used substitutes. It is one of a series of new products representing a totally new approach to meeting the industry need for economy and ease of application. The new version of E-Kote 3063 exhibits little or no change in shielding effectiveness after forty days exposure to

95 percent relative humidity at 140°F and thirty days heat at 250°F.

For additional information, contact Vincent Sussman, director of research, Acme Chemicals & Insulation Co., Division of Allied Products Corp., P.O. Box 1404, New Haven, Conn. (203) 562-2171. INFO/CARD #96.

DMM's

The latest Fluke instruments to be sold through distribution are the model 8010A and 8012A bench/portable DMM's. Designed for general test and service work, the new instruments have six functions and 31 ranges, incorporating several features of the 8020A hand-held multimeter that has been a highly popular distributor item. Large, sharp LCD's are used in the readout, conductance is included for leakage measurements to 10,000 Meg Ohms and overload protection has been extended to cover 6000V transients and up to 600V DC (440 RMS) applied across the current input jacks.

Both meters use a new Fluke-manufactured hybrid RMS converter with 50 kHz response.

The 8010A ($239) and 8012A ($299) will be stocked by all distributors in the U.S. and Canada, now numbering more than 100 locations serving a variety of markets from tool catalogs, semiconductor OEM's, education, maintenance/repair organizations (MRO's), and hobbyists as well as both electronic-related and non-electronic industrial markets.

For further data on the 8010A or

8012A, write to the John Fluke Mfg. Co., Inc. at P.O. Box 43210, Mountlake Terrace, Wash. 98043. 800-426-0361. INFO/CARD #97.

Spectrum Analyzer

Using microprocessor control, the new 100 Hz to 22 GHz model 8566A spectrum analyzer from Hewlett-Packard gives the user the ability to more accurately resolve closely spaced signals over a wider range of amplitudes than previously possible. Using the 10 Hz resolution bandwidth, the analyzer's sensitivity is −137 dBm to 1 GHz, −134 dBm to 5.8 GHz, −115 dBm at 22 GHz. This high sensitivity includes the presence of built-in preselection from two to 22 GHz. Related attributes are 80 dB dynamic range and full frequency range amplitude of ±2.2 dB. This performance permits direct measurement on microwave sig-

nals of line-related sidebands that are 50 dB down. In addition, frequency accuracy virtually that of the internal frequency reference error ($1x10^{-9}$ per day) can be achieved. This performance is complemented by features that make the 8566A extremely easy to operate, and easy to set up for automatic operation with HP-IB (IEEE-488).

U.S. price of the Hewlett-Packard model 8566A spectrum analyzer is $47,500. Delivery is 18 weeks. Contact Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, Calif. 94304. Please circle INFO/CARD #98.

Communications Service Monitor

Com-Ser Laboratories Inc., of Bradenton, Florida, announced it began shipping its new BR-1000 communications service monitor in November. The BR-1000 has basically the same specifications as most communication service monitors including 10 kHz to 1,000 MHz frequency range with 1ppm accuracy, AM or FM modulation measurements or generation 10 Hz to 9,999 Hz, calibrated output levels from .1uV to 10mV, and sweep plus or minus 0 to 1 MHz from set frequency.

A special feature allows the operator to lock in all but the last two digits

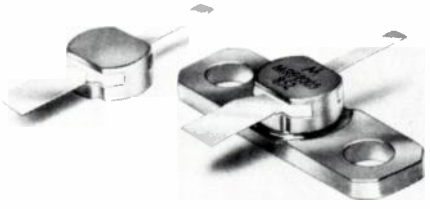
so that the frequency may be moved up or down in 100 Hz steps without re-entering the entire frequency. With electronic tuning, the CB-1000 can, as an option, be supplied for automatic operation with or without provision for connection to the IEEE 488 buss for computer control. The instrument weighs only 19 lbs. Com-Ser supplies the BR-1000 with its exclusive tilt up-tilt down, and color coded function control panel features. List price is $3,500.00.

Contact Com-Ser Labs., 7853 State Route 301, P.O. Box 1766, Bradenton, Fla. 33506. Please circle INFO/CARD #99.

Microwave Power Transistor

With the MRF 2000 series of 1 to 10-watt 2 GHz transistors, Motorola is planning to enter the high-volume microwave power transistor market. The new MRF2001-2010 NPN silicon microwave power transistors, a series of four devices designed for Class B and C amplifier or oscillator applications, are the forerunners of a line of 32 devices to be introduced during 1979. The goal is to reach a 250-watt output in the gigahertz region by the end of that year.

All units are 100 percent tested for load mismatch at all phase angles with 10:1 VSWR. In addition, the devices offer gold metallization and emitter ballasting for long life and



resistance to metal migration. Minimum gain ranges from 9 dB for 1-watt types to 6 dB for the MRF2010 @ 10 watts. All MRF 2001/10 series are

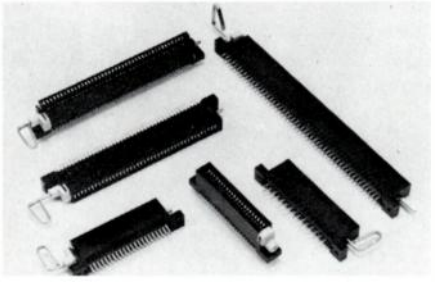
now available from distributor and OEM warehouse stock. Either pills (Motorola case 328-01) or flange mounts (Motorola case 328A-01) are available.

Contact Alan Wagstaffe, P.O. Box 20912, Phoenix, Ariz. 85036. (602) 244-6900. Circle INFO/CARD #100.

Sequential ZIF Edgeboard Connector

Note: This appears to be the only sequential ZIF connector on the market, according to Amp Inc. Approximately 25 percent of this connector's applications will be due to the sequential feature. The other 75 percent will be because of the connector's other features.

The new sequential ZIF (zero insertion force) connector from Amp includes a contact timing mechanism to ensure that signal, power, and ground circuits make and break in the proper sequence during PC board mating and unmating. Placement of the rotary-cam actuator, combined with an open board slot at one end of the connector housing permits entry of the PC board for packaging ver-



satility. Top-entry versions are also available. A safety lock prevents the contacts from closing unless the board is properly positioned and helps hold the board in place.

Gold-over-nickel plated phosphor bronze contacts are rated at 3 Amperes and have a life expectancy greater than 5000 mating cycles. Operating temperature range is −55° to +105°C. In large-volume, production quantities the cost is approximately $0.05 per contact position.

Further information on Sequential ZIF Edgeboard Connector is available from AMP Incorporated, Harrisburg, Pa. 17105. Circle INFO/CARD #101.

Six-Channel Demodulators

Watkins-Johnson Company, a major manufacturer of surveillance receiving equipment, announces the development of the WJ-9518 Demodulator.

The WJ-9518 contains six completely independent SSD demodulators which are capable of processing signals with a 4 kHz BW in the frequency range from 200 Hz to 15 MHz (tuned in either 1 or 4 kHz increments). The front panel controls and display are shared by each of the six demodulators. The unit may be controlled either remotely or locally. Group delay

equalization is also offered and is designated as the model WJ-9518E.

For further information or specifications, please contact the Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, Calif. 94304. (415) 493-4141. Circle INFO/CARD #102.

Switch Deck

Designated the series 500, Electro-Mech Components, Inc., has introduced a new improved switch assembly to its family of standard switches. The units provide attractive chrome barriers between each switch or indicator in a unitized modular assembly to improve display appearance and mounting simplicity on test equipment, instrumentation or consumer/appliance applications.

Additional features of the 500 series design include independent or interlocking switch action with ten types of tracking action and switch sequences and up to 12 inches in a single or dual row, on 7/8" or 1" centers. Switch functions range from SPST to 6PDT. 30 volts DC or 115 volts AC. 2 AMPs resistive, 1 AMP inductive.

Contact Electro-Mech Components, Inc., 1826 N. Floradale Avenue, S. El Monte, Calif. 91733. (213) 442-7180. Circle INFO/CARD #103.

R.F. Impedance Bridges

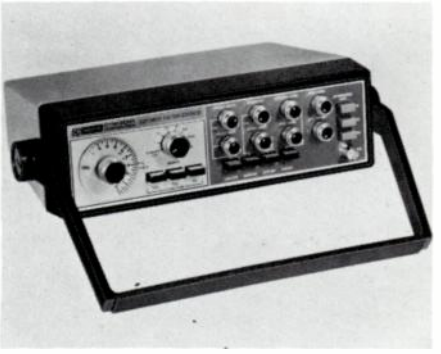
Wide Band Engineering Company, Inc., has expanded its line of RF Impedance Bridges to include two fixed bridges with a range of 1-900 MHz. These are the A57U with RF In, RF Out, test, and reference ports and the A57TU which is internally terminated. All other specifications are identical to those for the A57 and A57T bridges. Impedance 50 or 75 ohms with BNC connectors.

Wide Band Engineering Company, Inc., P.O. Box 21652, Phoenix, Ariz. 85036, (602) 254-1570. INFO/CARD #79.

Sweep/Function Generator

The sweep/function generator, designated the model 3020, can actually replace a function generator, sweep-generator, pulse generator and tone-burst generator. The instrument's wide frequency coverage spans from 0.02 Hz to 2 MHz in seven ranges. Each range provides linear 1000:1 frequency control. The operating frequency of the 3020 can be varied on each range by either the front panel frequency control or by applying a control voltage to its voltage-controlled oscillator external input.

Almost any wave shape can be generated by the 3020. By utilizing the variable symmetry control, the duty cycle of any waveform can be changed over a 40:1 range. The square-wave output can generate conventional square waves or be shaped to produce



rectangular waves or pulses. A triangle wave can be transformed into a sawtooth or ramp, and even sine-wave distortion can be simulated. All waveform types can be inverted. Sine-wave distortion is typically less than 0.5 percent.

The B&K Precision model 3020 is now available from local distributors at a price of $325.00. The unit comes complete with a text-like 75-page users manual. For additional information, contact B&K Precision, Dynascan Corporation, 6460 W. Cortland Street, Chicago, Ill. 60635. (312) 889-9087. Circle INFO/CARD #104.

Five New Types of "REN"

Three transistors and two IC's have been added to Raytheon's popular line of "REN" replacement semiconductors for home entertainment equipment. The new transistors include two PNP silicon audio frequency power amplifiers, the REN187A that compliments the REN186A, and the REN281 that compliments the REN280 and is used primarily in top end amplifiers. The third new transistor, the REN283, is a NPN silicon high voltage-high current device used in switching and

Even a quick glance at the face of our new Model 3003 tells you it's no ordinary signal generator.

Right away you can see the unique internal and external modulation features, such as the provision for complex or simultaneous modulations with AM-AM, AM-FM or FM-FM.

The 3003 gives you twice as many modulation frequencies as most other generators. Besides the standard frequencies of 400 Hz and 1 KHz, you can choose and pre-set two more frequencies between 100 Hz and 10 KHz. And like other models in the 3000 Series, this one is

accurate to 0.001% over the entire 1 MHz to 520 MHz range. (We also have a unit that goes down to 1 KHz.)

But the main thing you'll notice is how convenient the Model 3003 is to use: internal or external FM deviation and AM modulation are easily set on the big front-panel meter. For extra readability and accuracy, you get *two* AM scales and *four* FM scales. Everything is so clearly labeled that learning to operate the instrument takes only a matter of minutes.

One thing you can't see on the face of the 3003 is the price. At a low $3,350, we're really hiding one of its most attractive features.

Wavetek Indiana, Inc.,
66 N. First Ave., P.O. Box 190, Beech Grove, Indiana 46107. Telephone (317) 783-3221, TWX 810-341-3226.

WAVETEK®

Performance is written all over our face.

TV horizontal output applications.

New IC's are the REN1189 color processor and the REN1190 horizontal oscillator driver and vertical driver. Both are used primarily in Sharp, Hitachi, Truetone, Eatons, Montgomery Ward and other private label TV's. "REN" replacement semiconductors cover 95 percent of all home entertainment service needs with minimum inventory, and provide distributors with top quality products at the lowest prices in the industry.

Contact Burlington Company, Distributor Products Operation, Fourth Avenue, Burlington, Mass. 01803. Circle INFO/CARD #107.

New Monolithic CMOS A/D Converter Series

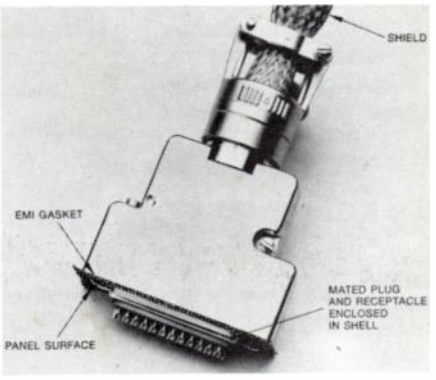
A new series of high performance, monolithic CMOS A/D converters from Datel Systems features typical linearity of ±1/4 LSB for 8, 10, and 12 bit resolution models. The ADC-ET series converters employ the quantized feedback integration technique to achieve accurate conversions with excellent noise immunity. Conversion times are 1.8, 6.0, and 24 milliseconds maximum for the 8, 10, and 12 bit models respectively. With CMOS circuitry the power requirement is only ±5 VDC with 5 mA maximum current drain. The digital outputs are latched three-state outputs controlled by an enable input for interfacing to data buses.

The ADC-ET series employ an operational integrator, comparator, CMOS switch, clock, two counters, latching output buffers, and digital control circuitry on the single silicon chip. Externally the units require a voltage reference, two metal film resistors and several compensation components for operation. Connection and application is simple and straightforward.

Contact Eugene L. Murphy, Senior Applications Engineer, Datel Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 828-8000 X141. Circle INFO/CARD #106.

Backshells

A family of split backshells which provide complete EMI isolation are now available from Glenair, Inc., for use with the popular D-subminiature connector series (MIL-C-24308) which is produced by several connector manufacturers. The new backshell was designed specifically to provide EMI integrity from the cable through the connector panel, here-to-fore not attainable with existing D-subminiature connector accessory hardware. The split shell design which incorporates overlapping joints provides complete enclosure of the mated cable



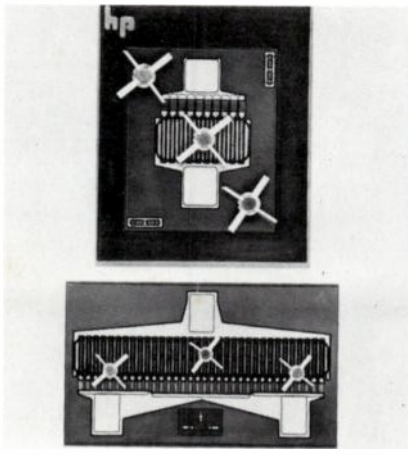
plug and panel mounted receptacle. The plug is entrapped within the shell and captivated male screw locks provide attachment to the receptacle.

Features include positive internal shield termination, EMI panel gasket, silicone grommet for moisture sealing and a choice of straight or 90-degree entry. Contact John Merrell, Dir. Mktg., Glenair, Inc., 1211 Air Way, Glendale, Calif. 91201. (213) 247-6000. Circle INFO/CARD #105.

Microwave Transistors

Two new microwave transistors, offering high linear power, gain and

power-added efficiency for use in RF and IF applications in radar, ECM, space, and other commercial and military communications up to 5 GHz are introduced by Hewlett-Packard. Both devices offer low thermal resistance



and meet MIL-S-19500 and MIL-STD-750/883.

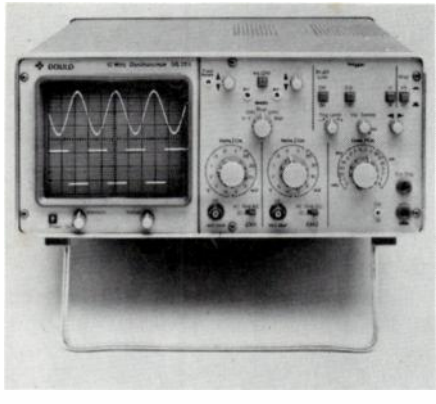
HXTR-5103 has a guaranteed 1 dB compressed gain of 11 dB at 2 GHz, with associated P_{1dB} linear output power of 23 dBm typical at 2GHz. This transistor has typical power-added efficiency of 34 percent.

HXTR-5104 provides typical linear output power of 29 dBm at 2 GHz and is useful in amplifier applications ranging up to 4 GHz. Associated P_{1dB} gain is 9 dB typical at 2 GHz, and power-added efficiency of 35 percent.

Contact Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, Calif. 94304. Circle INFO/CARD #108.

Dual-Trace Oscilloscope

A new 12 MHz oscilloscope that offers unusual value for an instrument in its low price range is announced by Gould Inc., Instruments Division.



Priced at only $695, the 0S253 boasts dual-trace and X-Y display capability; 2 mV/cm vertical sensitivity with AC, ground and DC coupling; channel sum and difference with channel 2 inversion; bright-line operation; DC coupled Z-modulation input; calibrator output and a front-panel trace-rotate control. Triggering is AC coupled from an internal or external source with positive or negative slope and level selected by a variable control.

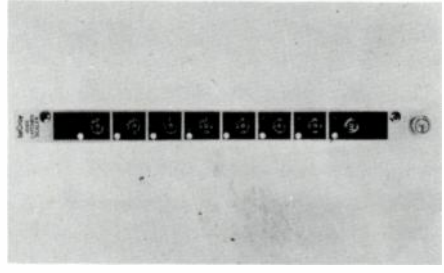
For more information contact Marketing Services, Gould Inc., Instruments Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. (216) 361-3315. Circle INFO/CARD #109.

High-Speed Octal Counter

New octal latching counter designed for use in high-speed counting applications features high density, high speed, low-input threshold, and low deadtime. Containing eight identical 18-bit binary counters with parallel storage latches in a compact single-width Camac module, the new model 8588 can count fast pulses at a rate of 50 MHz.

Each channel has a low-threshold input discriminator, adjustable from −60 mV to −580 mV, permitting direct use with a variety of primary detectors. The counter's low minimum threshold is particularly useful where input signals may be degraded by long cables from the source.

Counting continues until the unit is inhibited externally, after which time the data is latched and the counter can be cleared and counting resumed within 650nsec. Because of its 18-bit capacity, the 8588 can also



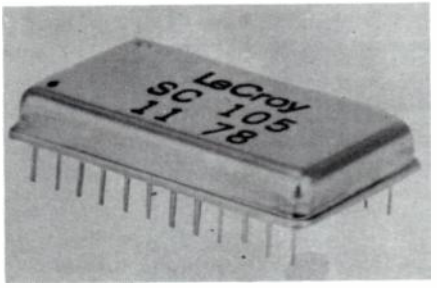
be used in an integrating mode where the unit is not recleared.

Further details may be obtained by contacting LeCroy Research Systems of California, 1806 Embarcadero Road, Palo Alto, Calif. 94303. (415) 328-3750. Circle INFO/CARD #110.

Wideband Dual Ultra-High-Speed Counter

New dual ultra-high-speed counter, especially suited for analog converter applications, is announced by the Microcircuits Division of LeCroy Research Systems Corp. The new model SC105 counter combines two 12-bit 80 MHz ripple counters in a single 24-pin DIP hybrid integrated circuit

package. Hybrid construction allows extremely high speed in this small package with the unusually low worst-



case power dissipation of 600 mW at +5 VDC.

Guaranteed 80 MHz input capability permits a minimum clock pulse width of 5 nsec. The counter will resolve pulse pairs spaced 12 nsec apart. The tri-state output multiplexer permits direct connection to data buses, while separate clock, reset, and carry connections allow complete design freedom in counting and data conversion applications. Unit price: $67.00. (>501: $42.70.) Stock to 4 weeks.

Further details may be obtained by contacting LeCroy Microcircuits Division, 700 S. Main St., Spring Valley, N.Y. 10977. (914) 425-2000. Circle INFO/CARD #111.

Portable DMM

The model ME-521DX multimeter is a 3 1/2-digit battery-powered unit. It features a high-low ohm switch for all ranges, five function modes, automatic zero adjustment, automatic polarity, and overload protection. Low current drain assures long battery life and thousands of measurements without the need for battery replacement. This accurate and completely portable device (27 ounces) has (1) a voltage measurement capability to 1000 VDC and 600 VAC, (2) a current measurement range to 1000 ma (AC or DC),

and (3) a resistance measurement range to 20 megohms. Accuracy is 0.5 percent (typical). Price: $115.00. Delivery: From stock.

Contact Soar Electronics Corp., 813 2nd Street, Ronkonkoma, N.Y. 11779. (516) 981-6444, Telex No. 144638. Circle INFO/CARD #112.

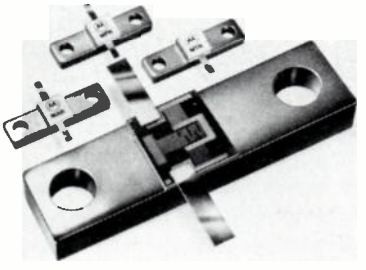
RF Attenuators, Resistors And Terminations

Motorola has introduced three new series of RF modules that provide attenuator, resistor and termination functions at frequencies up to 1 GHz. All three module series are designed for RF operation with input power capability up to 50 watts.

The MAR series of 50-watt, 50-ohm RF attenuators offer six attenuation values ranging from 1 to 20 dB. They are specifically designed and packaged for high power RF applications in stripline circuits.

The MFR series of 50-watt RF resistors offer five resistor values, from 12.5 to 100 ohms for use in high-power splitting and combining networks and similar applications.

The MTR series of 50-watt RF terminations offer five values, from 12.5 to 100 ohms. MTR devices are used



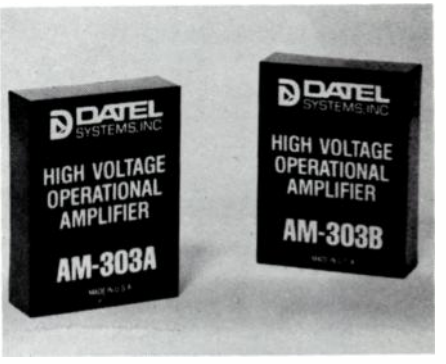
to terminate RF transmission lines and circulators, and may be used to establish a reference impedance mismatch.

Prices for all parts described above are $12.00 each, in 100-up quantities. Contact Motorola, P.O. Box 20912, Phoenix, Ariz. 85036. Circle INFO/CARD #113.

FET OP Amp

Model AM-303 from Datel Systems is a new FET input amplifier module with an extremely wide operating voltage range. The output range is ±10V to ±140V when using a power supply range of ±15V to ±150V. Output current capability is ±20 mA with internal power dissipation limiting. The input common mode voltage range is also ±10V to ±140V with a common mode rejection ratio of 100 dB minimum.

The AM-303 is specifically designed for high speed, high voltage applications such as electron beam deflectors, beam intensity modulators, automatic test circuits, and high voltage pulse drivers. Output settling time to 0.01 percent of final value is 2.5 μsec. for a 10V step. The slew rate limitation is 100V/μsec. minimum and gain bandwidth product is typically 10 MHz. The AM-303 also exhibits excellent in-



put characteristics with 10^{12} ohms input impedance and 100 pA maximum input bias current.

Contact Datel Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021, (617) 828-8000, TWX: 710-348-0135, Telex: 92-4461. Circle INFO/CARD #114.

Spectrum Analyzer

A spectrum analyzer with simplified controls has been introduced by Cushman Electronics. The CE-15 Spectrum Monitor, originally developed for the two-way radio maintenance market, also has many other applications including production and quality control, CATV service, classroom instruction, and general laboratory work.

The analyzer, with a continuously tuneable range of 1 to 1000 MHz, has many of the features of more expensive laboratory instruments, but with fewer controls. For example, sweep rate and IF filter controls have been

eliminated and are automatically set to their optimum values depending on the scan width selected.

Unique to the Cushman instrument is its ability to receive AM or FM transmissions so they can be listened to on a built-in speaker. A sensitivity of 0.5 microvolts allows it to monitor transmitters off the air with a simple whip antenna. Contact: Cushman Electronics, Inc., 830 Stewart Dr., Sunnyvale, Calif. 94086. Circle INFO/CARD #115.

Your life may not depend on modulation accuracy.

With the Boonton 82AD Modulation Meter you get FM and AM accuracy specified to a constant 2% of reading—from 10 MHz to 1200 MHz—over the full modulation bandwidth of 30 Hz to 100 kHz, within a temperature range of 0 to 55°C... and with a special close-tolerance AM specification for air navigation applications.

That's the Boonton difference: a difference in accuracy.

You can check the 82AD's accuracy advantage in the resolution of the 4-digit display. Get results fast with the automatic feature that tunes and levels without manual adjustments. Or, control the 82AD through a field-installable IEEE-488 bus option.

Supported by true peak responding detectors and selectable, closely-defined, post-detection bandpass filtering, the 82AD's accuracy advantage adds up in every way except price.

Sure, you can spend less... or much more. But either way, you'll "pay the price" when accuracy is important.

But we built our 82AD as if it did.

Call or write for details or a demonstration:
Boonton Electronics, Rt. 287 at Smith Rd.,
Parsippany, NJ 07054; (201) 887-5110.

BOONTON

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Solid-State

A new full-color brochure that describes Raytheon Company's expertise in the design and manufacture of high-performance solid-state modulators, airborne emitters, and radar subsystems for commercial and military applications is now available. In addition to product information, the 12-page brochure provides technical data on several areas on microwave technology including magnetron injection priming, precise control of RF pulse shape in low-frequency coaxial magnetrons, and achievement of continuously variable pulse widths in multi-frequency band transmitters.

A free copy of "Electronic Equipment Experience at Raytheon" is available from Raytheon Co., Electronic Equipment Group, 190 Willow Street, Waltham, Mass. 02154. Please circle INFO/CARD #116.

Transient Power of Zener Diodes

Motorola has prepared an application note, AN-784, dealing with the power-handling capabilities of zener diodes, and pointing out how zeners can be used as a transient suppressor. Entitled, "Transient Power Capabilities of Zener Diodes", the application note covers the transient characteristics of zeners in terms of a mathematical model and from the standpoint of circuit design.

The application note AN-784 is available from all Motorola sales offices and distributors, or by writing to Motorola Semiconductors, P.O. Box 20912, Phoenix, Ariz. 85036. Circle INFO/CARD #117.

EMI Filter Catalog

Stanford Applied Engineering announces the release of their new EMI filter catalog. This catalog describes SAE's line of electromagnetic interference (EMI) filters. These devices are designed to suppress undesirable electrical impulses or disturbances in power lines. They are used extensively to allow equipment to operate compatibly on a common power source. EMI filters limit the amplitude of interferring voltages on AC power lines and prevent them from propagating into or out of the filtered equipment.

The devices offered in this catalog are designed to satisfy a wide range of mechancial and electrical requirements. This catalog covers general application, high performance, switching transient, connector types and three-phase filters.

For more information, contact C. Jean Littrell, SAE, 340 Martin Avenue, Santa Clara, Calif. (408) 243-9200. Circle INFO/CARD #118.

Miniature Potentiometer

A new six-page brochure describing in detail series 100 miniature potentiometers designed for use in mobile radios, laboratory instruments, telecommunication equipment, business machines and computers, is now available from Centralab. The new brochure includes complete design specifications and how to order information. Copies of the brochure are available by writing Centralab Electronics Division, Globe-Union Inc., 5757 North Green Bay Avenue, P.O. Box 591, Milwaukee, Wisconsin 53201. Circle INFO/CARD #119.

1978-79 Instrument Catalog

A new 1978-79 catalog describing Weinschel Engineering's line of microwave measuring and generating instruments is now available. This updated edition includes the company's newest product developments and their uses. The catalog also contains useful information such as applications, techniques, theory of microwave sweepers, attenuation measurements and RF power measurements. Other data includes a decibel-to-milliwatt conversion table and bibliography of technical articles that have been published by Weinschel's engineering staff.

Contact Don Krivos, (301) 948-3434, ext. 208, Gaithersburg, Maryland. Circle INFO/CARD #120.

Measuring SWR/Return Loss

Wiltron *Technical Review* No. 8 describes new easy-to-use methods for accurately measuring reflected signals over the 5 MHz to 18 GHz range. The paper also discusses the impact that recent advances in precision SWR autotesters, terminations, air lines, and detectors have had on SWR measurement techniques.

The techniques discussed yield SWR measurement accuracies previously unobtainable, even with computer-aided systems. Frequently overlooked errors and ambiguities are identified. Removable conversion tables are included for determining and correcting measurement errors. A simple method for measuring SWR Bridge or Coupler directivity using inexpensive Wiltron precision components is described.

Copies of this eight page technical paper are available at no charge from Wiltron. Contact Walter L. Baxter, Wiltron Company, 825 E. Middlefield Road, Mountain View, Calif. 94043. (415) 969-6500. Circle INFO/CARD #121.

Ceramic Capacitor Catalog

Centralab's new Ceramic Capacitor Catalog No. 501 covers CK05 and CK06 series molded monolithic ceramic capacitors qualified to MIL-C-11015. The CK05/CK06 series capacitors are designed for general purpose bypass and coupling applications in telecommunications, instrumentation, and other types of industrial equipment. The new Centralab catalog also includes CKR05 and CKR06 series military type capacitors which meet MIL-C-39014 specifications. CKR05 and CKR06 series capacitors serve as the industry standard for high reliability applications within the communications, computer and aerospace fields.

Copies of the new catalog are available by writing Centralab Electronics Division, Globe-Union Inc., 5757 N. Green Bay Avenue, P.O. Box 591, Milwaukee, Wis. Circle INFO/CARD #122.

VHF Filters

High power low pass, band-pass and band reject filters for the 10-1000 MHz band are described in 16-page brochure (Catalog VI). An extensive series of low pass filters for incorporation in VHF-UHF transceivers is included. Microwave Filter Company, Inc., 6743 Kinne St., East Syracuse, N.Y. 13057. (315) 437-3953. Circle INFO/CARD #123.

IF/RF Amplifiers Catalog

A new comprehensive catalog telling you all you want to know about IF/RF amplifiers, pre-scaler amplifiers, solid-state switch drivers and custom thick-film hybrid circuits is available from the Optimax Division of Alpha Industries, Colmar, Pa. The 95-page catalog fully characterizes the Optimax product line of IF/RF amplifiers with typical performance curves over various temperature extremes.

Included are four (4) application notes covering "The Understanding

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XR-1500

the all new 1500 MHz phase lock-

sweep signal generator

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of Linear Amplifier Specification", "Designing with Thick-film RF Modules", "GHz Pre-scaler Design", and "Solid-State Switch Drivers." In addition to numerous photographs and diagrams the catalog contains ordering and warrenty information along with a general description of Optimax.

Complimentary copies of the new catalog are available from the Sales Department, Optimax Div. of Alpha Industries, Inc., P.O. Box 105, Colmar, Pa., 18915. (215) 822-1311. Please circle INFO/CARD #124.

Training Aid Teaches Microprocessor Hardware, Software and Troubleshooting

This new model 5036A Microprocessor Lab from Hewlett-Packard is a first entry-level microprocessor learning program that includes three fundamental areas: hardware, software and troubleshooting. Troubleshooting and service have not been covered to any great extent in previously available microprocessor teaching systems. Hewlett-Packard's 5036A consists of a 20 lesson textbook/lab manual and a briefcase-contained operating microcomputer. It is designed to give 'hands on' experience with the topics covered. The time required to complete the course is typically 50 hours.

Adding the Hewlett-Packard model 5004A Signature Analyzer and the model 5024A Troubleshooting Kit to the Lab gives the user extensive training in microcomputer fault location. Jumpers are used to introduce faults and program failures into the system. The models 5004A and 5042A can also be used in lab, production of service departments for troubleshooting a wide variety of digital logic circuitry.

Contact Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, Calif. 94304. Circle INFO/CARD #125.

Magnetic Shielding Material And Application Guide

A new magnetic shielding material guide features CO-NETIC AA alloy in metric and English units. Includes complete magnetic and physical data, application notes and fabrication methods. Catalog MG-5. Magnetic Shield Div., Perfection Mica Co., 740 N. Thomas Dr., Bensenville, Ill. 60106. (312) 766-7800. Circle INFO/CARD #126.

Power Supplies

A 88-page catalog describing Sorensen Company's full line of modular power supplies. power assemblies and power instruments is now available. Included in the Sorensen modular line are switching and linear supplies. More than 500 input/output configurations are available from the Sorensen modular power supply line.

Details are also given on Sorensen's power assemblies. In addition, data is included on the Sorensen line of industrial and laboratory power supplies in voltage ranges from 0-10VDC to 0-600VDC, and power levels up to 20 kW.

The catalog provides features, operating specifications and dimensions for each power supply. Copies are available from Sorensen Company, 676 Island Pond Road, Manchester, N.H. 03103. INFO/CARD #127.

RF & IF Hybrid Circuits

High-reliability hybrid circuits for RF and IF signal processing applications are illustrated and described in a new eight-page brochure available from Raytheon Company. The brochure gives application information and specifications for a wide variety of hybrids including two and three-way power dividers, double balanced mixers, RF switches, phase modulators, 180° and quadrature hybrids, bi-directional couplers, and amplifiers. Composite hybrids, which incorporate two or more functions on a single substrate, are described in a separate section.

Copies of the brochure are available free of charge from Raytheon Company, Industrial Components Operation, 465 Centre Street, Quincy, Mass. 02169. INFO/CARD #128.

Quite Line Filter Handbook

New 16-page booklet from the Capitron Division of AMP Incorporated is a valuable asset to anyone involved in eliminating and/or preventing electromagnetic interference (EMI).

The handbook includes information on regulatory agencies and EMI prevention methods including grounding, shielding, balanced lines, twisted pairs, coaxial cables, etc. Ferrite filters are discussed in detail, with emphasis on proper filter testing, installation and application. Considerations for digital circuits are given special attention. Directed at the application of AMP Quiet Line low-pass subminiature filters, the booklet also includes a Filter Selection Guide and charts indicating full electrical performance characteristics of AMP Incorporated's EMI filter products.

A copy of the AMP filter handbook and additional information on the Quiet Line filter series are available from the AMP Capitron Division, Elizabethtown, Pa. 17022. Circle INFO/CARD #129.

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A four-page bulletin on a new series of bus interfaces which provides complete compatibility between three families of Rockland instruments and any system based on the IEEE Std 488 (1975) instrumentation bus.

Each interface, according to the bulletin, rigorously conforms to the specified constraints of IEEE Std 488 (1975) and is specifically tailored to its particular Rockland instrument, without unnecessary hardware and with all requisite auxiliary circuitry for full control of all programmable parameters. Each is in a stand-alone enclosure plugging in to the instrument and the bus via two cables. And each may be field-retrofitted to instruments already in use.

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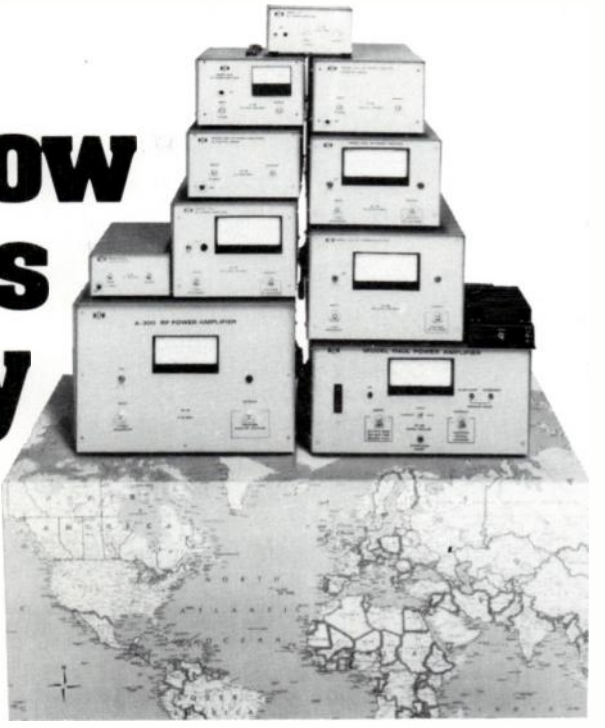

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