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900 MHz	MOBILE APPLICATIONS				30 to	BASESTATIONS					
Туре	Power (W)	Freq. (MHz)	Gain (db) min.	VCC (V)	Package	900 MHz	BASE STATIONS				
BLU98	0.5	900	90	12.5	SOT-103 E1	Туре	Power (W)	Freq. (MHz)	Gain (db) min.	VCC (V)	Package
BLV90	1	900	7.5	12.5	SOT-172	BLW96	200	30	13.5	50	SOT-121
BLV91	2	900	6.5	12 5	SOT-172	BLV25	175	108	10.5	28	SOT-119
BLU99	4	900	7 3	12 5	SOT-122	BLV80 28	80	175	6.5	28	SOT-119
BLV92	4	900	8.0	12.5	SOT-171	BLV33F	85	225	10.5	28	SOT-119
BLV93	8	900	6.0	12 5	SOT-171	BLV36	120	225	10.0	28	SOT-161
BLV94	15	900	6.0	12.5	SOT-171	BLU53	100	400	6.5	28	SOT-161
						BLV97	30	860	6.5	24	SOT-171
						BLV57	38	0.08	6.5	25	SOT-161

400 to 512 MHz		мов	ILE APPLICATIONS					
BLU60 12	60	175	4.8	12.5	SOT-119			
BLU45 12	45	175	5.1	12 5	SOT-119			
BLU30 12	30	175	60	12 5	SOT-119			
BLU20 12	20	175	6.5	12.5	SOT-119			
BLW82	30	175	5.0	12 5	SOT-119			
BLW81	10	175	6.0	12.5	SOT-122			
BLU99	5	175	10.5	12.5	SOT-122			
ELW80	4	175	8.0	12.5	SOT-122			
BLW79	2	175	9.0	12.5	SOT-122			
BLX65	2	175	6.0	12.5	TO-39			

175 MHz		MOBILE APPLICATIONS							
BLV75 12	75	175	7.0	12.5	SOT-119				
BLV45 12	45	175	6.5	12.5	SOT-119				
BLV30 12	30	175	8.2	12.5	SOT-119				
BLW60C	45	175	5.0	12.5	SOT-120				
BLW31	28	175	9.5	12.5	SOT-120				
BLY89C	25	175	6.0	12.5	SOT-120				
BFQ43	4	175	12.0	12.5	TO-39E				
BFQ42	2	175	10.5	12.5	TO-39				

66 to 870 MHz	AMPLIFIER MODULES FOR LAND MOBILE									
Туре	Freq (MHz)	P In (MW)	P Out (W)	VCC	Package					
BGY32	68-88	100	20	12.5	SOT-132					
BGY33	80-108	100	20	12.5	SOT-132					
BGY35	132-156	150	20	12.5	SOT-132					
BGY36	148-174	150	20	12.5	SOT-132					
BGY43	148-174	150	13	12.5	SOT-132B					
BGY40A	400-440	100	7.5	12.5	SOT-132C					
BGY41A	400-440	150	13	12.5	SOT-132C					
BGY40B	440-470	100	7.5	12.5	SOT-132C					
BGY41B	440-470	150	13	12.5	SOT-132C					
BGY40A	470-512	100	7.5	12.5	SOT-132C					
BGY41C	470-512	150	13	12.5	SOT-132C					
BGY45A	68-88	150	30	12.5	SOT-301-A-03					
BGY45B	144-175	150	30	12.5	SOT-301-A-03					
BGY46A	400-440	30	1.5	9.6	SOT-26NC					
BGY47A	400-440	45	2.2	9.6	SOT-26NC					
BGY47B	430-470	45	2.2	9.6	SOT-26NC					
BGY47C	460-512	45	22	9.6	SOT-26NC					
BGY22	380-512	50	29	12.5	SOT-75A					
BGY23	380-480	2.5 WATTS	7	12.5	SOT-75A					

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September/October 1983



Feature Product, P. 48

XEQ	"ANP"
ENTR CMND	6-CHNG YPAR
1-LSF	7-K-STERN
2-OPT TERM	8-YS/L FOR K
3-GRINS	9-S/Y CONV
4-YIN/OUT	10-NOISE
5-CHNG YS/L	CHND?

Low Noise Amplifier Design, P. 10



GP Ladder Analysis, P. 32

Cover

September/October Cover - The front cover is a dot-1 matrix printer plot of the passband impedance of a 30 MHz lowpass filter using a new circuit design/analysis program written for the IBM personal computer. See feature product coverage on page 48 for details.

Features

- Low Noise Amplifier Design A low-noise program in-10 tended as an addition to a general RF Amplifier design program which was published in March/April 1983 issue.
- General Purpose Ladder Analysis with the Hand-Held 32 Calculator - A general purpose calculator program offered that analyzes the performance of filters that can be treated as ladder networks.
- Computer Analysis of C Band Thin Film Attenuators A 44 CAD program developed specifically to accurately analyze microwave integrated circuits, can now also accurately predict the phase, VSWR and attenuation of lossy thin film MIC networks such as used in attenuators.

Departments

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Dear Sir:

We very much appreciate having had a nice review of our book 70 Years of Radio Tubes and Valves in your recent issue, but a typographical error has caused us to have to write some rather embarrassing letters — I thought you'd want to know about this.

Harvey Roehl The Vestal Press Ltd Vestal, New York 13850

Unfortunately, the magazine made a typographical error in the price of the book, and it is not \$12.95, it is \$21.95. Ed.

Feedback on PLL Article

Several readers have commented on Andrzej Przedpelski's article on PLL. Specifically on the subject of "divide by N delay." The following is the author's response to these questions. ED.

The divider delay concept has been bothering several people for some time now. The delay, as presented in the *r.f. design* PLL article, has been arrived at by at least two investigators: Scott Wetenkamp of Watkins-Johnson (as referenced in the article) and Stan Goldman of Texas Instruments.

Let me comment on some of your comments:

1). There seems to be a general agreement that there is a delay in the divider circuit. The most valid approch, in my opinion, is that any transition (at the output frequency) does not "arrive" at the phase comparator until N transition later. Let's take a conceptual example: a 10 MHz synthesizer with N = 10,000. The delay in the divider is 1 millisecond. This delay, at a loop frequency of let's say 1 KHz, would be equivalent to 360 degrees of phase shift; at 100 Hz, 36 degrees, etc. The phase margin would be decreased by the same amount.

2. The expression e^{-sT} expresses a delay T in the frequency domain. It satisfies the assumed conditions: the gain is unity at all frequencies and the phase changes continuously with frequency (as shown in Figs. 19 and 20). This is confirmed by your correct statement that the above expression can be expressed as an infinite series with an infinite

number of poles (as done by Wetenkamp in a truncated form). The fact that there are an infinite number of poles is taken into account in the article. Any PLL has a very large number of spurious poles, such as the op-amp and VTO response, stray reactances, etc., not usually accounted for in the more common PLL analyses. As I stressed before, there is no such thing as "second order" PLL, although that seems to be the usual example used. Your comment that these poles would make the loop hard to stabilize is correct in cases of loops with large bandwidths and large N, if this effect is not taken into account. The consideration of all these effects, not usually taken into account, and their use in optimizing the loop, were the main reason for these articles.

Your comments are appreciated and comments from other readers would be also welcome, whether positive or negative. I hope that the above analysis could be someday confirmed exactly by rigorous experimental tests. So far, some of the latest actual designs indicate that the overall analysis is correct. Andrzej B. Przedpelski

QSL Cards

Dear Editor:

Help ! I've been buried in a pile of coupons requesting free QSL cards (Ad:Mar/Apr 83). Please tell your readers RCA is making every effort possible to promptly fill all requests. My initial QSL card print order will not be sufficient and I've had to increase the order eightfold. This will cause some delay in our ability to respond to the requests. Please pass my apologies on to your readers for the extended waiting time they may experience.

Sincerely,

Tom Bluesteen

RCA Government Communications

"Basic, The Universal Language"?

Dear Sir:

Occasionally you publish programmable calculator programs to solve particular design problems. At the risk of impertinence, may I suggest the programmable calculator is obsolete, having been replaced by the personal computer. You should

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September/October

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publish program listing in BASIC, the universal language of personal computers. From a purely practical point of view, an article with HP-41 or TI-59 listing is of interest to only a small subset of your readers, while a BASIC program is available on all personal computers and nearly all time-sharing systems, and usually requires trivial translation for any machine from Apple to ZX-81. At the same time, few journals have pro-vided a forum for publishing RF design programs, and your magazine could continue its leadership by filling this lack - but not by publishing calculator programs; these belong with the "short cuts on your slide rule" articles! Sincerely.

V.P. O'Neil II Member of Technical Staff Motorola, Inc.

Errors in Stub Matching Article

Dear Sir:

I would like to express my thanks to Mr. Lev for the feedback (Letters July/August 1983) pointing out that several errors are present in the article, "Calculator Aided Stub Matching." Please inform your readers of the following typographical mistakes and the corrections.

$$\frac{Y(x)}{Y_{o}} = \frac{Y_{T}/Y_{o} + j \tan \beta x}{1 + j(Y_{T}/Y_{o}) \tan \beta x}$$
(4)

This error does occur in the program "MAT", and as pointed out by Mr. Lev causes a very small error to occur for the calculation of the stub lengths. The program should be modified as follows: Lines 142 thru 155 should be deleted and the following lines 142 thru 154 inserted in their place.

Program Corrections For "MAT"

	140	Xt2	
	141	+	
г	142	1	
	143	÷	
	144	RCL	84
	145	RCL	89
l	146	*	
	147	CHS	
L	148	+	
	149	RCL	89
L	150	*	
L	151	RCL	04
L	152	-	
L	153	RCL	0 4
l	154	/	
	155	SORT	Г

I apologize for any inconvenience.

Sincerely,

Alan Victor

$$X = \frac{\lambda \tan^{-1}}{2\pi} \left\{ \frac{\frac{G(x)}{Y_{o}} B_{Tn} \pm \sqrt{G_{Tn} \left[\frac{G(x)}{Y_{o}} |Y_{Tn}|^{2} - (\frac{G(x)}{Y_{o}})^{2} - G_{Tn} + \frac{G(x)}{Y_{o}}\right]}{\frac{G(x)}{Y_{o}} (|Y_{Tn}|^{2}) - G_{Tn}} \right\}$$
(6)

Neither of these errors appear in the program. Equation (7) is in error and should read as follows:

$$\frac{B(x)}{Y_{o}} = \pm \sqrt{\frac{G(x)\left[1 + \left|Y_{Tn}\right|^{2} - \frac{G(x)}{Y_{o}} - G_{Tn}\right] - G_{Tn}}{G_{Tn}}}$$
(7)

September/October

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Low Noise Amplifier Design

This low-noise program for the HP-41 calculator is intended to be an addition to the general amplifier design package previously published in the March/April 1983 issue. Also a version of the program is now offered for the TI-59 calculator.

By D. R. Hertling and R. K. Feeney School of Electrical Engineering Georgia Institute of Technology Atlanta, Georgia 30332

B oth TI-59 and HP-41 programs are given to calculate termination admittances, as shown in Figure 1, for low noise devices whose Y or S parameters are known. The programs work with both inherently stable and potentially unstable devices.

Background

For optimum low noise performance, both the source conductance and susceptance must be specified. Most manufacturers, however, specify only the source conductance. Sometimes, although rarely, both G_s and B_s are given. If neither low noise termination is given, the procedure developed by Nielsen, can be used to find the optimum source conductance. The optimum source susceptance can then be determined experimentally. Several other references describe procedures for calculating both the source conductance and susceptance for low noise 2.3.4. These procedures, however, are tedious and depend upon experimentally determined quantities.

Even if both G_s and B_s are known, the designer may choose to also calculate the B_s which yields maximum gain. The overall noise figure of a multistage system is a function of both the noise figure and gain of the first stage. It is therefore possible that even if the noise figure of the first stage is increased by altering B_s , its gain could be increased by a large enough factor to decrease the overall noise figure of the system. The designer may therefore choose to use the value of B_s which maximize the gain of the stage. If the device is inherently stable, the designer is only concerned with optimizing either the noise performance or gain of the amplifier. If, however, the device is potentially unstable, the designer must first provide an adequate degree of stability.

A device is inherently stable if the Linvill stability factor,

C, is less than one or greater or equal to zero. In terms of Y parameters, the Linvill stability factor is given by

$$C = \frac{\left| y_{f}y_{r} \right|}{2g_{i}g_{0} - \operatorname{Re}(y_{f}y_{r})}$$
(1)

If the device is inherently stable, there are two cases to consider: (1) only G_s specified, and (2) both G_s and B_s specified for low noise performance. For both cases the designer will want to find the unspecified terminations which optimize the amplifiers's performance.

Design for the second case is straightforward since, with G_s and B_s specified, the designer need only conjugately match the output port to maximize the gain. The calculator programs handle this case as follows; after the Y parameters of the device are entered, the Linvill stability factor is calculated. Even if the device is potentially unstable, it is possible that the mismatch at the input port caused by the low noise terminations will make the circuit stable. The programs, therefore, then calculate the output admittance of the amplifier and check to see if its real part is greater than zero. If the output conductance is positive, then the optimum load termination is simply found by taking the complex conjugate of the output admittance. If the real part of the output admittance, G_{put} , is negative, a different procedure which is described later must be used. Next, the input admittance is calculated to check if its real part, G_{in} , is negative. Finally, the transducer gain, G_{τ} , is calculated in decibels.

Design for the first case requires slightly more work. It can be shown that the source susceptance, B_s , for maximum gain is the same as it would be if the source conductance, G_s , had not been specified. The expression for this optimum value for B_s is:

$$B_{s} = -b_{i} + \frac{Im(y_{f}y_{r})}{2g_{0}}$$
 (2)

The programs handle this case as follows; after calculating the Linvill stability factor, the source susceptance is calculated from equation (2). Then with both G_s and B_s now known, execution is identical to the second case. Again both the input and output admittances are calculated to check if their real parts are negative.

If the output conductance with the low noise source termination is negative, an approach must be taken which first ensures stability. Stern developed a procedure using Y parameters for designing amplifiers with potentially unstable devices. The Stern stability factor, K is given by:

$$K = \left[\frac{2(g_{i} + G_{s})(g_{o} + G_{L})}{|y_{t}y_{r}| + Re(y_{t}y_{r})}\right]$$
(3)

If K is greater than unity the circuit is stable. The larger the K, the more stable the amplifier, however, the lower the amplifier gain. In other words, gain is exchanged for stability. A Stern factor from approximately 4 to 10 is adequate for most situations.

The source conductance for optimum noise performance is given by the manufacturer. With G_s known, the designer can choose a Stern factor, K, and then solve equation (3) for the load conductance G_L . Similar to the design procedure for inherently stable devices, there are two cases to consider: only G_s specified, and both G_s and B_s specified for low noise performance.

Design for the second case is straightforward since with both G_s and B_s known, the output admittance of the amplifier can be calculated. The real part of Y_L is no consequence since the load conductance has already been determined from equation (3) to yield the chosen degree of stability. The desire load susceptance, B_L , is the one which yields maximum gain. B_L should therefore be chosen to be the negative of the imaginary part of the calculated output admittance.

It should be noted that both ports of this amplifier have been purposely mismatched. The input port is mismatched to yield optimum low noise performance and the output port has been mismatched to ensure an adequate margin of stability.

Design for the first case requires more work since the source susceptance must also be determined. The programs use a modified Stern's procedure involving an iterative method of successive approximations. The real part of the source and load terminations are determined as in case two. The imaginary parts are determined as follows; B_L is first chosen to be the negative of b_0 . (b_0 is the imaginary part of y_0 .) Next, using the previously determined value

of G_L and the first guess for B_L , the input admittance of the amplifier is calculated. B_s is then taken to be the negative of the imaginary part of the input admittance. Using the given value for G_s and the first guess for B_s , the output admittance for the amplifier is calculated. The second guess for B_L is then taken to be the negative of the output susceptance. This procedure continues until the new value for B_L is within .1 percent of its value from the previous iteration. A very appealing feature of this iterative procedure is its similarity to experimental optimization of an amplifier. Experimentally the circuit would be optimized by alternatively adjusting B_s and B_L until maximum gain is realized.

The TI-59 Software

The TI-59 software is split into three programs. The first one is for inherently stable devices and requires only the Y parameters, the source conductance, and if known, the source susceptance for low noise. If the output conductance or the net input conductance (G_{in} + G_s) is negative then the second program should be run. The second program requires the device Y parameters, G_s, B_s (if known), and a Stern factor. Both programs use the same registers for the Y parameters and the source and load terminations. Thus it is unnecessary to re-enter this data when going from one program to the other. Also direct addressing is not used in any of the programs to facilititate any program additions or modifications. If the designer wishes to use S parameters, the third program which converts $S \rightarrow Y$ parameters should be executed first. This program is compatible with the other two in that the device parameters are entered in the same order and the resulting Y parameters are automatically stored in the proper registers for execution of either of the other two programs.

The following examples illustrate the use of the programs.

Example 1 (TI)

Find the unknown terminations for the device whose Y parameters are given. The optimum source termination is $Y_s = 2.0 - j25.0$ mmhos.

$$[y] = \left[\frac{8.5 + j3.5 \ 0 - j.2}{40 - j20 \ .35 - j.75}\right] \text{ all mmhos}$$

This example will be solved two ways. The first solution will assume that only G_s is known. For the second solution it will be assumed that both G_s and B_s are known. Procedure:

(1) Read side 1 and side 2 of magnetic card #1. (Inherently stable device program.)

(2) Press E to initialize the program.

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(3) Enter y_i , y_r , y_f and y_o in order using the following procedure:

- Enter g, Press A Enter b, Press A . Enter b, Press A (4) Enter G, Press B
- (5) Press A' if a printout is desired.
 (6) Press C

The following printout is obtained.

8. 3.	5		0 Ü	33
Ū	L.		Û	Ŭ
-2			Û	4
- 4		-	Ū	2
-2	3 - 10		Û	2
З	5	-	Ũ	4
-7.	5		Ü	4

0.8989218	Ū.
0.002	GS.
.0149285714	BS
.0001447849	GL
.0002114586	BL
20.59568013	GT

If the printer is not used, the calculator will stop with C displayed. Successive pressings of R/S will display G_s , B_s , G_t , and G_T in dB in that order.

To do this example for both G_s and B_s known, all that is necessary is to enter B_s , press B' and then press C. The way the program is written, flag 2 is set when B_s is entered. Therefore flag 2 should be reset if it is desired to again run the program with only G_s given. For $B_s = -25.0$ mmhos, the following printout is obtained:

0.8989218	C
0.002	68
-0.025	BS
0001229258	GL
.0004530568	BL.
17.54641583	GT

[It should be noted that flag 1 is set if a printout is desired, therefore, if RST is pressed, which resets all flags, the program will also not print the results.]

Example 2 (Ti)

This example illustrates design using a potentially unstable device which is not stabilized by the low noise mismatch at the input port.



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CENTER-TAPPED DC ISOLATED PRIMARY & SECONDARY	Model No. Imped. Ratio Freq. (MHz) T. Model (10-49) TMO model (10-49)	T1-1T TMO1-1T 1 .05-200 \$3.95 \$6.45	T2-1T TMO2-11 2 .07-200 \$4.25 \$6.75	T2.5-6 TMO2.5 2.5 .01-10 \$4.25 \$6.75	T -6T T 0 .	T3-1T MO3-1T 3 05-250 \$3.95 \$6.45	T4-1 TMO4 4 .2-350 \$2.95 \$4.95	T4-1H 4 0 8-350 5 \$4.95	T5-1T TMO5-11 5 .3-300 \$4.25 \$6.75	T13 TMO 1 .3-1 \$4 \$6	11 13-11 120 25 75
UNBALANCED PRIMARY & SECONDARY	Model No. Imped. Ratio Freq. (MHz) T model (10-49) TMO Model (10-49)	T2-1 TMO2-1 2 .025-600 \$3.45 \$5.95	T3-1 TMO3-1 3 .5-800 \$4.25 \$6.95	T4-2 TMO4-2 4 .2-600 \$3.45 \$5.95	ד אדד 15 \$ \$	18-1 108-1 8 5-250 3.45 5.95	T14-1 TMO14-1 14 .2-150 \$4.25 \$6.75	I			
FT FTB	Model No. Imped. Ratio Freq. (MHz) (1-4)	FT1.5-1 1.5 .1-400 \$29.95	FTB1-1 1 .2-500 \$29.95	FTB1-6 1 .01-200 \$29.95	FTE _! \$	31-1-75 1 5-500 29.95	lini	i-Ci	rcu	its	5

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$$[y] = \begin{bmatrix} 1.5 + j3.5 & 0 - j.3 \\ 56 - j11 & .1 + j.75 \end{bmatrix} \text{ all mmhos}$$

(3) Press C

 $G_s = 2.0 \text{ mmhos}, B_s \text{ unknown}$

To do this example, simply repeat steps (1) through (6) of Example 1.

$$\begin{array}{c} 1.5-03\\ 3.5-03\\ 0.00\\ -3.-04\\ 5.6-02\\ -1.1-02\\ 1.-04\\ 7.5-04 \end{array}$$

-.0000980193 GOUT

The calculator prints a negative value for G_{out} . Thus, with the given source conductance, the real part of the output admittance is negative indicating that the circuit is potentially unstable. If the printer is not used, this negative value for G_{out} would be displayed. The second program should now be run. Procedure:

(1) Read side 1 and side 2 of the second magnetic card. (Potentially unstable device program.)

(2) Since the Y parameters and G_s are already stored in the proper registers, simply enter a Stern factor (4 is used for this example.)



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The following printout is obtained.

	4.	K
	0.002	-68
-	.0053394657	BS
	0.007797737	GL
	.0048994022	EL.
	24.66890426	GT

If B_s is also known, simply enter its value and press B' prior to entering K and running the program. Assuming $B_s = -10.0$ mmhos, the following printout is obtained.



Example 3 (TI)

This example uses S parameters to demonstrate the $S \rightarrow Y$ parameter conversion program.

$$[S] = \boxed{\frac{.792 \angle -107.4^{\circ} .07 \angle 26^{\circ}}{1.995 \angle 81.1^{\circ} .659 \angle -60.8^{\circ}}}$$

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(Example 3 continued)

The chosen device is an HP 2N6680 GaAs FET and the parameters are for 4 GHz. The optimum reflection coefficient $\Gamma_o = .618 \angle 98^\circ$ which corresponds to an optimum source termination $Y_{s \text{ opt}} = 10.22 - j20.23$ mmhos. This termination should yield a noise figure $F_{min} = 1.6$ dB (1.45).

Procedure:

(1) Read side (1) and side (2) of the third magnetic card. (The S \rightarrow Y conversion program.)

(2) Press E to initialize the program.

(3) Enter S_{11} , S_{22} , S_{23} , and S_{22} in order as follows.
IS
Press A
4S.,
Press A
ΔS_{22}
Press A
(4) Press B
(5) After execution halts, read side (1) and side (2) of the
first magnetic card. (Inherently stable program.)
(6) Enter G
Press B
(7) Enter B
Press B'
(8) Press A' if a printout is desired.

(9) Press C

The following printout is obtained.



0.792	
-107.4	
0.07	
26.	
1.995	
81.1	
0.659	
-60.8	
1.287686117	C.
0.01022	GS
-0.02023	BS
0.006749021	GL
0142927572	BL
:1.84801243	GT

In order to see if the $\rm B_{s}$ which yields maximum gain would possibly provide better overall performance, rerun the program as follows.

(1) Press INV SF 2 (this resets flag 2 so that the value of B_s which yields maximum gain is calculated.)
 (2) Press C

The following printout is obtained.

1.287686117	C
0.01022	GS
0349985274	BS
.0024186614	GL.
-0.014608277	BL
14.67647499	GT



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In order to see which solution provides the best overall noise figure, calculate the new noise figure of the device from:

$$F = F_{min} + \frac{R_N}{G_s} [(G_s - G_o)^2 + (B_s - B_o)^2]$$
(4)

 F_{min} = 1.44, G_s = 10.22 mmhos, B_o = -20.23 mmhos.

 R_n is given in the data sheet. $R_n = 23.14$ ohms. From equation (4):

The designer therefore has the choice between:

$$F = F_{min} = 1.44$$
 and $G_{T} = 11.85$ dB (15.31)

and

F = 1.93 and $G_{\tau} = 14.68$ dB (29.37)

The overall noise figure of a two stage system is given by:

$$F = F_1 + \frac{F_2 - 1}{G_1}$$
(5)

where F_1 and G_1 are the noise figure and gain of the first stage and F_2 is the noise figure of the second stage expressed as ratios. Using equation (5) it can be shown that the lower noise figure and gain are superior as long as the noise figure of the second stage is less than or equal to 16.97 (12.3 dB).



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INFO/CARD 15

The HP-41 Software

The low-noise program for the HP-41 is intended to be an addition to the general amplifier design package previously described in r.f. design⁵. One additional subroutine is added to the software and minor modifications are made to two existing subroutines. One of the minor changes adds a new item (NOISE) to the "menu" while the other change is in the Stern stability factor routine.

Since the user will probably wish to make gain and other calculations in addition to finding the best termination for noise performance, he will probably wish to modify the previous programs and add the extra routines to the calculator. If this is done, the S-parameter routine cannot be simultaneously loaded into the HP-41CV main memory. If S-parameters are used, one of the longer routines, say, the gain calculation subprogram, should temporarily be deleted or copied to extended memory. With the S-parameter module deleted and the noise program in place, a minimum size of 030 is needed leaving 43 registers unused.

The details of using the program were discussed previously. All routines are executed by entering the appropriate command from the command menu. If a printer is not present, it is recommended that flag no. 21 be set manually before using the programs. If this flag is set, the calculator will stop whenever a print or prompt command is executed. Pressing R/S will continue the program. The HP-41 program is almost completely automatic. If both G_s and B_s are known, they should be entered. When B_s is not known, enter zero.

The program tests for the various cases and automatically does the appropriate calculations.

Example 1 (HP)

Start the calculator by executing program AMP. The command menu is printed.

XEQ "AMF" ENTR CMND 1-LSF 2-OPT TERM 3-GAINS 4-YINZOUT 5-CHNG YSZL 6-CHNG YSZL 7-K-STERN 8-YSZL FOR K 9-SZY CONY 10-NOISE CMND?

Enter command number 10. The program requests the device y-parameters. The Linvill stability factor is automatically calculated.

ENTER	Y-PARAMS	
GI=?		
01-2	8.5-03	RUN
01*:	3.5-03	RUN
GR=?	9	DHM
	6	5 (FA



BR=?			OPERATING GAIN
	2-03	RUN	GP= 20.14E0 dB
GF=?			
	46-03	RUN	AVAILABLE GAIN
BF=?			GA= 20.60E0 dB
	-20-03	RUN	
G0=?			TRANSDUCER GAIN
	.35-03	RUN	GT= 20.60E0 dB
80=?			
	75-03	RUH	
			CMND?
L. S. I	F. = 898.9E-3		After completing the calculations, the calculator prompts for another command. Again, enter 10 to do the second

Next, enter the optimum source termination. Since B_s is not known, enter zero.

GS=?			
	2-03	RUN	
BS=?			
	6	RUN	

Once the source termination is entered, the HP-41 program proceeds automatically and prints the results including all of the amplifier gains.

GS= 2.000E-3 BS= -14.93E-3

GL= 144.8E-6 BL= 211.5E-6





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part of example one.

L. S. F. = 898.9E-3

10

2-03

-25-03

RUN

RUN

RUN

CHND?

GS=?

BS=?

GS= 2.000E-3

BS= -25.00E-3

GL= 122.9E-6 BL= 453.1E-6

Specifications

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CHNB?

This completes example one. Examples two and three, done using the same procedure, are summarized in Figure 2.



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PF804	215-320	27	4.0	+ 35
PF7410C	406-512	16.5	4.5	+ 35
PF797A	800-960	19.5	5.0	+ 35

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3* 10UMI1Z 10-200MHz	20 HSEC	400B	SMA Connectors	100C1041
IV LOOMITE	59 11350	SP2T		
100-500MHz	25 nsec	45dB	16 PIN DIP	DS0142
2-500MHz	40 nsec	40dB	SMA Connectors	100C 1052
BROADBA	ND SWITCH	ES		
FREQUENCY	SPEED	ISOLATION	PACKAGE	PART NO
			CONFIGURATION	
15 1000414*	20 μερε	60dB	SMA Connectors	1000 1291
13-1000WITZ	20 0360	0000	UNIA COMPECTORS	thru
				100C 1296
		SP2T		
20-1000MHz	1 usec	30dB	14 PIN DIP	DS0052
500-2000MHz	U.4 USEC	SPAT	14 PIN UIP	v3023/
500-2000MHz	0.4 usec	35db	24 PIN DDIP	DS0259
HIGH POV	NER SWITCH	IES		
FREQUENCY	POWER	SPEED	ISOLATION	PART NO
00.000414-	100.0 Matte CH	SP2T	60-4P	1000 1142
20-OUMPIZ	3000 Watts Peak	20 USEC	0000	1000 1142
100-400MHz	1000 Watts CW	15 usec	80d8	100D 1569
	2000 Watts Peak	INCHIT /RYDAG	2	
225-400MHz	600 Watts CW	50 usec	30dB	100C 1545
7		SEND F	OR	
	<u> </u>	CATA	.0G	
DAIC	O INE		RIES,	
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DAIC	O INC t Del Amo E e: (213) 631	UA CATAI	RIES, 1 npton, Calif. TWX 910-34	90220 6-674

Figure 2A HP-41 Example 2 XEQ "AMP" ENTR CHND OPERATING GAIN GP= 25.25E0 dB 1-LSF 2-OPT TERM AVAILABLE GAIN 3-GAINS DOES NOT EXIST 4-YIN/OUT 5-CHNG YSZL TRANSBUCER GAIN 6-CHNG YPAR GT= 24.67E8 dB 7-K-STERN 8-YS/L FOR K CHND? 9-SZY CONV 10 RUN 10-NOISE L. S. F. = 4.756E0 CHND? 18 RUN. GS=? RUN. 2-03 ENTER Y-PARAMS 8S=? RUN -10-03GT=? K=? 1.5-03 RUN RUN 4 BI=? 3.5-03 RUN GS= 2.000E-3 GR=?BS= -10.00E-3 RUN Ø. BR=? GL= 7.798E-3 RIIN -.3-03 BL= -2.222E-3 GF=? 56-03 RUN BF=? -11-03 RUN OPERATING GAIN G0=? GP= 24.13E0 dB .1-03 RUN 80=?AVAILABLE GAIN .75-03 RUN DOES NOT EXIST L. S. F. = 4.756E0TRANSDUCER GAIN GT= 28.00E0 d8 GS=? 2-03 RUN BS=? CMND? 9 RUN K=2. Å RUN GS= 2.000E-3 BS= -5.339E-3 GL= 7.798E-3 BL= -4.899E-3

Figure 2B. HP-41 Example 3.

XEQ "AMP"

ENTR CHND 1-LSF	i Add		OPERATING GAIN GP= 14.48E0 dB	
3-GAINS 4-YINZOUT			AVAILABLE GAIN Ga= 11.85E0 d6	
6-CHNG YF 7-K-STERN 8-YS/L FC	YAR I I IR K		TRANSDUCER GAIN GT= 11.85E0 dB	
9-5/Y CON	ŧ4		08480	
10-NUIDE			10	RUM
CMND?	9	RUN	L. S. F. = 1.288E0	
n511-:	.792	RUN	GS=?	
AS11=?	-167.4	RUN	10.22-03 BS=?	RUF
MS12=?	97	PHN	0	RUN
A\$12=?	•01		GS= 10.22E-3	
MS21=?	26	RUN	8S= -35.00E-3	
0001-0	1.995	RUN	GL= 2.419E-3	
H951-(81.1	RUN	BL= -14.61E-3	
MS22=?	.659	RUN		
AS22=?	-60.8	RUN	OPERATING GAIN GP= 17.36E0 dB	
CHND?			AVAILABLE GAIN	
	18	RUN	GA= 14.68E0 d6	
L. S. F.	= 1.288E0		TRANSDUCER GAIN GT= 14.68E0 dB	
6S=?				
89=2	10.22-03	RUN	CNND?	
00.	-20.23-03	RUN		
GS= 10.2 BS= -20.	22E-3 . 23E-3			
GL= 6.74 BL= -14	49E-3 ,29E-3			



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Stability vs Temp. (PPM°C)	±1, (0 to	±5 + 55°C)	±1 (0 to +70°C)	±3 (-40° to +85°C)	±1 (-40° to +85°C)
Case Style	Ероху		Metal with	Hermetic Sea	1

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$\begin{array}{c} 0001\\ 0002\\ 0003\\ 0004\\ 0006\\ 0007\\ 0012\\ 00112\\ 0013\\ 0112$	91 R/SL A 799 999 999 299 76 A 71 200 999 999 200 200 900 200 2	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	154 22 INV 155 77 GE 156 23 LNX 157 43 RCL 158 18 18 159 42 STD 160 01 01 161 43 RCL 162 29 29 163 42 STD 164 02 02 165 53 (166 43 RCL 167 16 16 168 85 + 169 43 RCL 170 25 25 171 54) 172 42 STD 173 03 03 174 53 (177 85 + 178 43 RCL 179 26 26 180 54) 182 04 04 183 36 PGM 184
063	55 ÷	140 04 04	217 85 +
064	53 (141 17 B'	218 43 RCL
065	02 2	142 42 STD	219 24 24
066	65 ×	143 25 25	220 54)
067	43 RCL	144 42 STD	221 42 STD
068	10 10	145 35 35	222 02 02
069	65 ×	146 32 X:T	223 53 (
070	43 RCL	147 42 STD	224 43 RCL
071	16 16	148 36 36	225 16 16
072	75 -	149 94 +/-	226 85 +
073	43 RCL	150 42 STD	227 43 RCL
074	18 18	151 26 26	228 25 25
075	54)	152 00 0	229 54)
076	54)	153 32 X:T	230 42 STD

Stable Device

12334567890123445678901234567890123456789012345678901234 22222222222222222222222222222222222	03 03 (43 RCL 17 + 43 RCL 26 2 42 STO 42 STO 43 RCL 42 STO 42 STO 4	$\begin{array}{c} 308\\ 309\\ 310\\ 312\\ 314\\ 316\\ 322\\ 322\\ 322\\ 322\\ 322\\ 322\\ 322\\ 32$	65 × 00 0 54) 42 STD 327 IF01 24 CE 420 R/SL 327 IF01 24 CE 420 R/SL 327 IF01 24 CE 420 R/SL 327 IF01 24 CE 420 R/SL 327 R/SL 327 R/SL 327 R/SL 328 R/SL 329 A3 R/SL 329 A3 R/SL 321 R/SL 322 P 422 IEE V 423 R/SL 321 R/SL 321 R/SL 321 R/SL 321 R/SL 321 R/SL 321 R/SL 322 P 423 R/SL 321 R/SL 322 P 423 R/SL 321 R/SL 321 R/SL 322 P 423 R/SL 329 P 420 P 42	5667899012345678990123456789001234567890122345678901234567893333333333333444444444444444444444444	07 7 69 DP 04 04 43 RCL 69 DP 02 2 02 3 7 P 04 02 2 03 7 69 DP 04 22 02 3 7 P 04 82 04 RCL 26 0P 04 RCL 26 0P 04 RCL 277 22 RCL 23 2 7 P 04 CP 04 CP 0
2756 227789 22222222222222222222222222222222	$\begin{array}{c} 53 & (\\ 53 & \text{RCL}\\ 27 & \text{RC}\\ 27 & \text{RC}\\ 33 & \text{RC}\\ 43 & \text{RC}\\ 35 & \text{RC}\\ 43 & \text{RC}\\ 53 & \text{RC}\\ 28 & \text{LOG}\\ 28 & \text{LOG}\\ 28 & \text{LOG}\\ 30 & \text{RC}\\ 28 & \text{LOG}\\ 30 & \text{RC}\\ 28 & \text{LOG}\\ 30 & \text{RC}\\ 30 & RC$	352 3556 35567 35567 3559 3661 3667 3667 3667 3667 3773 3775 37789 3775 37789 3881 3883 3881 3883	02 2 03 3 06 0P 04 04 43 RCL 23 23 69 0P 04 23 06 06 01 1 04 4 03 6 04 04 24 04 04 RCL 24 09 02 2 02 2 02 2 02 2 02 2 02 2 02 2 0	901234567890123456789012345678901 444444444444444455555678901 444444444444444444444444444444444444	04 04 43 RCL 25 25 69 DP 06 06 91 R/S 00 0 35 1/X 76 LBL 22 INV 02 2 02 2 02 2 02 2 04 4 03 1 69 DP 04 04 43 RCL 33 83 98 ADV 69 DP 06 06 91 R/S 76 LBL 15 E 01 1 00 0 42 STD 09 81 RST





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Program #2(TI) Potentially Unstable Device

$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0777 87 IFF 0789 39 CDS 079 39 CDS 080 61 GTD 081 23 LNX 082 76 LBL 083 33 X2 084 53 (085 53 (085 53 (085 53 (086 43 RCL 087 20 20 088 65 × 099 43 RCL 091 19 19 092 85 + 093 43 RCL 094 18 18 095 53 (097 55 + 098 63 (2 1001 53 (1 102 43 RCL 103 10 10 104 85 + 105 43 RCL 106	154 42 STD 155 03 03 156 43 RCL 157 11 11 158 42 STD 159 04 04 160 36 PGM 161 04 04 162 10 E* 163 36 PGM 164 04 04 165 17 B* 166 32 X+7- 168 42 STD 169 24 24 170 76 LBL 173 18 18 174 42 STD 175 01 01 1778 42 STD 180 53 (181 43 RCL 185 53 (186 54) 187 42 STD 188 03 03 191 11 11 192 <th>231 54) 232 50 1×I 233 32 X:T 233 32 X:T 233 32 X:T 233 32 X:T 234 93 0 0 237 01 1 238 22 239 34 FX 241 43 RCL 240 34 FX 242 30 30 243 76 LBL 244 38 SIN 245 94 +X- 246 42 STD 246 42 STD 247 26 26 249 35 1/X 255 42 STD 256 26 26 26 26 26 257 61 GTD 249 35 1/X 258 42 STD 26 26 26 259 76 LBL X 27 26 26 26 260 35</th> <th>$\begin{array}{cccccccccccccccccccccccccccccccccccc$</th> <th>$\begin{array}{cccccccccccccccccccccccccccccccccccc$</th>	231 54) 232 50 1×I 233 32 X:T 233 32 X:T 233 32 X:T 233 32 X:T 234 93 0 0 237 01 1 238 22 239 34 FX 241 43 RCL 240 34 FX 242 30 30 243 76 LBL 244 38 SIN 245 94 +X- 246 42 STD 246 42 STD 247 26 26 249 35 1/X 255 42 STD 256 26 26 26 26 26 257 61 GTD 249 35 1/X 258 42 STD 26 26 26 259 76 LBL X 27 26 26 26 260 35	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
068 22 22 069 43 RCL 070 16 16 071 42 STD 072 21 21 073 71 SBR 074 33 X ² 075 42 STD 076 25 25	145 26 26 146 54) 147 42 STD 148 04 04 149 36 PGM 150 04 04 151 18 C* 152 43 RCL 153 10 10	222 53 (223 24 CE 224 85 + 225 43 RCL 226 26 26 227 54) 228 55 ÷ 229 43 RCL 230 26 26	299 13 C 300 42 STD 301 27 27 302 32 X;T 303 42 STD 304 28 28 305 43 RCL 306 12 12 307 42 STD	376 43 RCL 377 23 23 378 91 R/S 379 43 RCL 380 24 24 381 91 R/S 382 43 RCL 383 25 25 384 91 R/S	453 15 E 454 01 1 455 00 0 456 42 STO 457 09 09 458 81 RST

WRH

Program #3	$(TI) S \rightarrow Y$	Parameter
Conversion		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1034 36 36 1054 36 36 1056 352 X:T 1086 352 X:T 1087 322 INV 110 372 STU 1113 372 STU 1113 372 STU 1113 372 STU 1114 372 STU 1115 42 STU 1115 42 STU 1115 42 STU 1117 42 STU 1118 373 PCL 1119 42 STU 1121 439 39 1224 43 7 PCL 1223 394 42 STU 1212 42 STU 1212 42 STU 1223 43 PCL 1223 43 PCL 1223 43 PCL 1224 43 PCL 1225 443 SUL 1226 433 PCL 1237 8CL 1238 43 PCL 1238 43 PCL 1245 444 SUM 1257 42 STU 1310 444 SUM 1328 38 1344 43 RCL 1377 43 RCL 1378 42 STU 1379 444 SUM 1441 343 RCL 1449 344 SUM 1441 343 RCL 1449 344 SUM 1441 343 RCL 1441 343 RCL 1441 343 RCL 1442 344 SUM 1442 343 RCL 1443 354 36 1444 544 SUM 1444 544 SUM 1444 544 SUM 1444 544 SUM 1444 544 SUM 1444 544 SUM 1445 54 CE 1633 32 X:T 1556 328 CE 1631 357 F2/R 1557 327 F2/R 1559 323 CE 1667 524 CE 1663 357 STU 1778 42 STU 1778 42 STU 1778 42 STU 1778 42 STU 1778 42 STU 1778 42 STU 1778 53 (CL 1679 53 (CL 1670 53 (CL 1671 554 35) T 1778 42 STU 1778 42 STU 1778 53 (CL 1670 53 (CL 1671 554 35) T 1778 42 STU 1778 53 (CL 1670 53 (CL 1671 554 35) T 1778 42 STU 1778 53 (CL 1671 554 35) T 1778 42 STU 1778 53 (CL 1671 554 35) T 1778 42 STU 1779 53 (CL 1778 42 STU 1779 53 (CL 1779 53 (CL 1770 554 CE 1670 224 CE	2000 43 RCL 2003 14 14 2014 35 PCL 2111 35 35 2113 32 X:T 2114 35 15 2115 43 RCL 2116 43 PCL 2116 43 PCL 2116 43 PCL 2116 43 PCL 2117 75 15 2118 43 PCL 2119 36 43 PCL 2119 36 43 PCL 2119 36 42 STU 2120 44 22 STU 2120 44 22 STU 2120 44 22 STU 2120 43 PCL 2121 44 SUN 2122 42 STU 2120 44 SUN 2122 43 PCL 2121 44 SUN 2122 43 PCL 2122 44 44 SUN 2122 44 44 SUN 2122 44 147 17 2122 44 147 17 2122 44 147 17 2122 44 147 17 2143 44 SUN 2145 44 SUN 2145 44 SUN 2145 44 SUN 2145 44 SUN 2146 43 PCL 2151 44 SUN 2148 42 STU 2153 428 PCL 2154 22 ST 42 2154 32 PCL 2154 32 PCL 2155 43 PCL 2155 44 SUN 2155 44 SUN 2156 53 PCL 2157 54 ST PCL 2158 43 PCL 2158 43 PCL 2158 43 PCL 2159 37 ST 2258 43 PCL 2150 32 X:T 2151 54 ST 2256 44 SUN 2258 43 PCL 2257 35 PCL 2258 43 PCL 2258 43 PCL 2258 43 PCL 2258 43 PCL 2258 43 PCL 2259 37 ST 2258 43 PCL 2258 42 STU 2258 43 PCL 2259 37 ST 2258 43 PCL 2258 43 PCL 2259 37 ST 2258 43 PCL 2259 39 PCL 2258 42 ST 2259 39 PCL 2260 32 ST 2260 32 ST 2270 32 ST 2271 ST 2272 ST 2272 ST 2272 ST 2274 ST 2274 ST 2274 ST 2275 ST 2275 ST 2275 ST 2275 ST 2276 ST 2276 ST 2276 ST 2276 ST 2276 ST 2276 ST 2277 ST 2278 ST 2278 ST 2278 ST 2278 ST 2279 ST 2278 ST 2278 ST 2279 ST 2278 ST 2279 ST 2279 ST 2270 ST 2



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HP-41 Main Program AMP

This program has been modified by the addition of the NOISE calculation to the menu.

40+i Bi 92

41 FC? 83

44 GTO 88

45+L8L 83

46 FC? 83

48 FC? 84

47 XEQ "PARA"

49 XEQ "YS/L"

56 XEQ *Y1/0

51 XEQ -GP-

52 XEQ "GA"

53 XEQ "GT"

54 GTG 00

55+LBL 84

56 FC? 83

58 FC? 84

61 "GIN= "

62 ARCL 23

65 ARCL 22

- = TU02- 86

69 ARCL 25

71 *BOUT= *

72 ARCL 24

73 AVIEW

75 GT0 00

76+LBL 05

78 GTO 66

77 XEQ "YS/L"

74 QBV

70 RVIEW

66 AVIEW

67 ABV

63 AVIEN 64 "BIN= "

57 XEQ "PARA"

59 XEQ "YS/L"

60 XEQ "YI/O"

42 XEQ "PARA"

43 XEG -OPT-

BI+LBL "AMP-02 CF 04 03 CF 03 84 ABV R5 PENTR CHNE-66 AVIEN 07 "1-LSF" 88 AVIEN 89 *2-OPT TER#* 10 AVIEW 11 *3-6918S* 12 AVIEN 13 *4-YIN/OUT* 14 AVIEN 15 "5-CHNG YS/L" 16 RVIEW 17 *6-CHNG YPAR* 18 AVIEN 19 *7-K-STERN* 20 AVIEN 21 *8-YS/L FOR K* 22 AVIEW 23 "9-S/Y CONV" 24 AVIEN 25 *10-HOISE* 26 AVIEw 27+LBL 00 28 ABV 29 FIX 0 30 "CMHD? 31 PROMPT 32 ENG 3 33 GTO IND X 34+LBL 81 35 FC? 03 36 XEQ "PARA" 37 ADV 38 KEQ "LINV" 39 GTO 00

79+LBL 86 88 XEQ *PARH* 81 GTO 88 82+LBL 87 83 FC? 03 84 XEA "PARA" 85 FC? 84 86 XEQ "YS/L" 87 XEQ "STN" 88 ABV 89 *K-STERN= 98 BRCL 17 91 AVIEN 92 GTO 00 93+LBL 08 94 FC? 83 95 XEQ "PARA" 96 XEQ "ITR" 97 ADV 98 XEQ "S/LPR" 99 GTO 68 100+LBL 09 101 XEQ "SPAR" 102 XEQ "PARI" 103 GTO 00 194+LBL 10 185 FC? 83 106 XEQ "PARA" 107 XEQ "NOISE" 188 ABV 109 XEQ -S/LPR-118 ABV 111 XEQ -YI/0-112 XEQ "GP" 113 XEQ "GA" 114 XE0 "GT" 115 ABV 116 GTO 00 117 END

HP-41 Subroutine NOISE

This routine determines the source and load terminations for the best noise figure according to the equations in the text. Various situations, such as potential instability, are handled automatically.

	,	
01+LBL "NOISE"	25 X=0?	49 RCL 12
02 SF 04	26 GTO 04	50 +
03 ABY	27 XEQ "YI/0"	51 RCL 17
04 XEQ "LINV"	28 FC? 02	52 *
05 °GS=?"	29 GTO 03	53 RCL 03
06 PROMPT	30 XEQ 06	54 RCL 19
07 STO 19	31 RCL 24	55 +
08 "BS=?"	32 CHS	56 /
09 PROMPT	33 STO 20	57 2
10 STO 18	34 RTH	58 /
11 FS? 00	35+LBL 04	59 RCL 05
12 GTO 01	36 XEQ 05	60 -
13 RCL 18	37 XEQ "YI/O"	61 STO 21
14 X=0?	38 FC? 02	62 RTN
15 XEQ 05	39 GTO 03	63+LBL 05
16 XEQ "YIZƏ"	40 XEQ 06	64 RCL 10
17+LBL 03	41 SF 08	65 RCL 05
18 RCL 24	42 XEQ "ITR"	66 /
19 CHS	43 RTN	67 2
20 STÚ 20	44+LBL 06	68 /
21 RCL 25	45 *K=?*	69 RCL 02
22 STO 21	46 PROMPT	70 -
23 RTN	47 ST0 17	71 STO 18
24+LBL 01	48 RCL 11	72 .END.

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HP-41 Subroutine STN

This subroutine calculates the Stern Stability Factor or specifies terminations for a given K. The routine has been modified for the NOISE program. One additional flag, no. 8, has been added. This allows the noise routine to skip the part of the calculation that generates G_s and G_L .

01	LBL "STN"	22	RTN
02	CF 07	23	ABS
63	RCL 03	24	CHS
04	RCL 19	25	STO
05	÷	26	RIN
06	XK0?	274	LBL
87	SF 97	28	F5?
30	RCL 05	29	GTŨ
09	RCL 21	30	"ik≡
10	+	31	PRO
11	802	32	310
12	SF 07	33	RCL
13	*	34	RCL
14	2	35	÷
15	31.	Зъ	*
16	RC1 11	37	2
17	RCL 12	38	1
18	+	39	Rûl
19	1	48	RCL
20	ST0 17	41	*
21	FC7 07	42	ABS

43 7 44 ST0 27 45 RCL 03 TO 17 46 RCL 05 47 * BL HITR 48 848? 49 GTO 02 \$? 88 50 RCL 03 TO 06 51 X(8? $\mathbf{j}_{\mathbf{k}} \equiv 2^{|\mathbf{k}|}$ 52 GTO 03 ROMPT 53 RCL 27 TO 17 CL 11 54 SERT CL 12 55 1 56 -57 GTO 05 58+LBL 02 59 RCL 27 CL 03 66 1 CL 05 61 +

62 SQRT

63 GTC 05

83 RCL 02

84 ST0 22

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General Purpose Ladder Analysis With The Hand-Held Calculator

A programmable calculator allows analysis of a circuit before it is built. Analysis takes a little time up-front but it can save considerable amounts in the long run.

By Wes Hayward Tektronix, Inc. Beaverton, Oregon

Many filters encountered by the rf designer may be treated as ladder networks of alternating series impedances and shunt admittances. There is frequently a need to analyze the performance of these filters, usually as a means of confirming the synthesis methods used during design. A general purpose program is offered in this paper to calculate filter transducer gain as a function of frequency.

Owing to the frequent occurrence of ladder networks, programs for their analysis have special requirements. The programs should be easy to use without external documentation. Of greater significance, the programs should be efficient, offering rapid execution. It is tempting to generate programs that will evaluate as many circuit element types as possible. However, this will often compromise the speed and ease-ofuse goals. The program presented here is kept purposefully simple.

Complicated ladder circuits may be evaluated with ROM based software available for the HP-41C calculators. One suitable program is the ladder analysis in the "Circuit Analysis" pack, offered by Hewlett Packard. Another is Handy-Compact¹. Both programs are powerful and very useful. Both are also slow.

A Basis for Analysis

The concept used in this program, "General Purpose Ladder Analysis", (GPLA), is illustrated by the 5th order low pass filter shown in Fig. 1. The circuit is segmented into planes, marked "a" through "f" in the figure. The immittance (impedance or admittance) at any plane looking toward the load is easily calculated. An infrequently used, but essentially trivial form of the so called ladder method shows that the output voltage is given as a product of the calculated immittances.² For the example of Fig. 1., $V_{out} = V_{in}Z_aY_bZ_cY_dZ_eY_f$. A simple rule makes this form especially convenient: An impedance is used in the product when looking into a shunt element. Conversely, an admittance appears in the product to correspond to planes looking into a series element. All planes from the generator to the load are included. This simple rule allows the transfer function of an arbitrary LC ladder to be written by inspection.

Although GPLA is written for the HP-41C calculator family, similar forms are easily written for other



Figure 1 — Fifth order low pass filter illustrating the method used for ladder analysis. The network response is given by $V_{out} = V_{in} Z_a Y_b Z_c Y_d Z_e Y_f$ where immitance is evaluated from the defining plane looking toward the load.



Table 1. Subroutines used for construction of the "User Defined" portion of the General Purpose Ladder Analysis program.

"machines" including the desk top computer. The writer will supply versions for the HP-15C and the TI-58/59 calculators to interested readers³. The rules presented are used to generate the programs. Further, the method may be adapted to existing software. For example, the ladder analysis available with Handy-Compact is designed to find only the input impedance of a ladder. Gain is limited to lossless filters using $|S_{21}|^2 = 1 - 1$ |S₁₁|². However, the immittance is available during program execution for each plane of a network. Lossy networks may be analyzed for gain by multiplying the immittance magnitude into a register at each plane. Additional modifications will supply angle information with GPLA (at the cost of speed).

Program Structure

The program presented is a collection of subroutines. This is followed by a short program segment written by the user to correspond to the filter being studied. The main subroutine resides at LABEL 05 and serves to convert an impedance to an admittance, or an admittance to an impedance. The magnitude of the immittance, after conversion, is multiplied into a register (R_{09}), forming the required products. The common way to write this subroutine uses the polar to rectangular (and back) conversions.

Data is maintained in rectangular form in this program. The subroutine is longer and less obvious but execution speed is significantly shorter.⁴

Four subroutines serve to add to the immittance of capacitors or inductors, series or shunt, to the existing immittance in the x and y registers. Four additional routines are identical except that they also initiate the immittance conversion routine. An appropriate resistive term is also added to account for losses when an inductor is included in the ladder. A uniform, frequency independent Q_u is assumed for all inductors.

One of two available routines are

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33

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used to initialize filter evaluations at each frequency. One corresponds to a filter with a series first reactive element while the other is used for a parallel reactance adjacent to the load. After all reactive elements have been assembled during a calculation, a final routine adds the effect of the source resistance and calculates the network transducer gain. The display is prepared and the frequency is incremented before looping back for the next evaluation. Besides the operational routines needed for calculation, the program contains a modicum of "window dressing." This allows the program to be used without extra notes. This feature is available only for the HP-41C version of GPLA.

Application

The program, listed at the end of the paper, is loaded into the calculator and the circuit to be analyzed is sketched. The components are labeled with arbitrary indicies of 11 or higher, corresponding to data registers. See the examples that follow. The component values are manually placed in memory at the proper locations using units of Farads and Henrys. The value of Q_u is placed in R_{03} . A very large Q_u value (1 × 10⁹) is used for lossless filters. Source resistance is placed in R_{00} while the load is in R_{10} , both in ohms. The program is then run using XEQ "GPLA".

The first section is a series of prompts that remind the user of the



September/October

application rules. This section is viewed with repeated pressing of the Run/Stop key. Finally, the user is prompted to write the "user defined" portion of the program. The program mode is entered and the following steps are used:

1) The first program step is XEQ 00 if the first reactance at the load is a parallel element. XEQ 11 is used if the first reactance at the load is a series connection.

2) The first L or C at the load end is recalled from memory. This is followed by XEQ nn where nn is a code from Table 1. Note that nn will be from 01 to 04 if the immittance is to be added without a following Y-to-Z or Z-to-Y conversion. Code nn will range from 06 to 09 if the conversion is desired. The conversion is required whenever a transition from a series branch to a parallel one is encountered.

3) Step 2 is repeated for each network element.

4) The user defined part of the program is finished with XEQ 10 when all elements have been taken into account.

5) Flag 00 should be set at the beginning if each data point is to be read for an extended time. The program is then continued with a Run/ Stop. Normally, with Flag 00 cleared, the program displays results while doing the calculation for the next frequency. The display shows the frequency in MHz and the transducer gain in dB.

6) The immittance looking toward the load may be evaluated with a R/S in the user defined program immediately following the calculation that adds the corresponding reactance at that plane. Note that the program uses the "x" register for the imaginary part of the immittance with "y" containing the real part.

7) Exit the program mode after writing the user defined part of the program. Enter the user mode and press user "F" to enter the frequency in MHz, a R/S, the frequency step in MHz, and another R/S to begin calculations. User F may be used at any time after a R/S in the program to change a frequency. This routine is slightly different than the traditional HP-41C "Prompt". The user is prompted for frequency. However, during the viewing of the alpha command, the user may press CLX, causing the present frequency or step to be viewed.

Program application is illustrated with the following examples.

Example 1.

The first filter evaluated is the 5th order low pass presented earlier, now shown in Fig. 2A. A symetrical circuit is assumed with equal end capacitors and equal inductors. The first reactance adjacent to the load is a parallel element, so the user defined program begins with XEQ 00. Figure 2 is labeled with the planes used for immittance inversion and with the appropriate subroutines. Execution time is about six seconds per frequency for this example.

Example 2.

Another 5th order low pass filter is examined. This circuit, Fig. 2B, is



Figure 2B — Fifth order low pass filters analyzed in Examples 1 and 2. The planes of immittance inversion are shown, "a" through "f". Program subroutines used in analysis are presented above the circuit at the points in the circuit where they are utilized. All immitances are looking toward the load end, R_{10} .

XEQ 11 RCL 11 XEQ 08 RCL 12	XEQ 06 RCL 15 RCL 13 XEQ 03 XEQ 08 X<>Y RCL 14 CLD XEQ 06	STOP R-in X<>Y STOP X-in XEQ 10 G _t , dB	
--------------------------------------	---	--	--

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Figure 3—Third order bandpass filter analyzed in Example 3. Series resonators are used in this circuit.

XEQ 00	RCL 13	RCL 16	RCL 19
RCL 11	XEQ 08	XEQ 08	XEQ 08
XEQ 06	RCL 14	RCL 17	RCL 20
RCL 12	XEQ 06	XEQ 06	XEQ 06
XEQ 02	RCL 15	RCL 18	XEQ 10
	XEQ 02	XEQ 02	



Figure 4. Diplexer network analyzed in Example 4.

XEQ 11 RCL 16 XEQ 07 RCL 15 XEQ 09 RCL 14 XEQ 87	STO 18 X<>Y STO 17 XEQ 11 RCL 11 XEQ 08 RCL 12 XEQ 06	RCL 13 XEQ 08 RCL 18 + X<>Y RCL 17 + X<>Y	XEQ 05 CLD X<>Y STOP X<>Y STOP XEQ 10
--	--	--	---



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Figure 5—Elliptic low pass filter analyzed in Example 5.

the dual of the first and requires a slightly different user defined program segment. The first step is XEQ 11, for the first reactive element next to the load is a series one. The last reactance, at the source end of the filter, is also a series component. But, the impedence of the source is yet to be taken into account when the filter input is encountered. XEQ 03 follows RCL 15 (to recall L_{15}) rather than XEQ 08 which would perform an undesired Z-to-Y conversion.

Two R/S steps are included within the program to allow the filter input resistance and reactance to be viewed. The display must be cleared with a "CLD" statement in the order defined

XEQ 00	STO 21	XEQ 06
CLST	X<>Y	RCL 21
RCL 12	STO 20	+
XEQ 04	XEQ 00	X<>Y
RCL 13	RCL 11	RCL 20
XEQ 06	XEQ 06	+
STO 19	RCL 19	X<>Y
X<>Y	+	XEQ 05
STO 18 CLST RCL 15 XEQ 04 RCL 16 XEQ 06	X(>Y RCL 18 + X(>Y XEQ 05 RCL 14	RCL 17 XEQ 06 XEQ 10



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Example 3.

The next circuit examined is the third order bandpass filter using coupled series resonators shown in Fig. 3. The tuned circuits consist of series elements with no intervening shunt capacitors. The program required nine seconds per frequency for evaluation. An earlier version of GPLA using the polar to rectangular conversions took 16 seconds per frequency for the same filter.

Example 4.

The program is generally used for simple LC ladder networks. More complicated circuits may be examined though. Figure 4 shows a diplexer consisting of combined low pass and high pass filters. The high pass filter is considered to be a parallel branch with the low pass being the through path. The program begins as if the response of the high pass filter were being evaluated. Once the branch point is reached, the resulting admittance is stored in memory. The program is again initiated at the load for the low pass branch. When the high pass branch is reached, the data in memory is recalled and added. Program stops provide the composite input impedance as well as the transfer response of the low pass branch.

Example 5.

The final example further illustrates the utility of GPLA with more complicated filters. An elliptic low pass circuit, Fig. 5, is examined. The first step in the user defined program segment is XEQ 00. This is required only to calculate the angular frequency. The stack is then cleared with a CLST command to ensure that a termination will not alter the calculated impedance of a series element. The admittance of L_{12} and C_{13} is calculated. The result is converted to an impedance and stored in memory. The procedure is repeated with L_{15} and C_{16} . The program then begins again with XEQ 00. The "trap" impedances are added when encountered. Note that XEQ 05 is used explicitly for Z-to-Y conversion in this and the previous example. It is usually called only from other subroutines with simple filters.

Conclusion

The program presented is rather simple with only 143 lines of HP-41C code. It is still extremely useful for the evaluation of many networks encountered in rf design. The utility of the program comes from the use of



a modified form of the traditional ladder method. Program speed is enhanced with a careful choice of programming methods. Results correspond well with those obtained with more exhaustive computer methods.

While GPLA is limited in application, the method may be expanded to describe networks of a more complicated nature. For example, a similar program has been written for the analysis of crystal ladder filters. The concepts are identical to those presented here. Execution speed is much faster than obtained with more versatile programs using scattering parameters or the ABCD matrix. Speed is the reward of the worker willing to write programs that are no more complicated than really required.

Acknowledgements

The writer gratefully acknowledges the comments of R. Culter and Dr. D. Morton. He also would like to thank his sons, Ron and Roger, who translated the program to the HP-15C and TI-58/59 formats.

References

1. Handy-Compact is the registered trademark of CGIS, a COMSAT Company.

2. W.H. Hayward, Introduction to Radio Frequency Design, PrenticeHall, 1982. See Chapter 2 for a discussion of the ladder method.

3. GPLA is available from the author for HP-15C and the TI-58/59 calculators. The interested reader should specify the calculator type and write to the author at 7700 S.W. Danielle Ave., Beaverton, OR 97005. A self-addressed stamped envelope would be apprecited.

4. T.R. Cuthbert, Jr., *Circuit Design Using Personal Computers*, Chapter 4, Wiley Interscience, 1983.

Table 2. HP-41C Program Listing for GPLA

01	LBL "GPLA"	15	PROMPT
0 2	SF27	16	*SER:11*
03	SF27(alpha space)	í7	PROMET
84	ASTO 05	18	"TERM:00.10
05	•LBL E	19	PROMPT
0 6	"PCY=01,06"	20	"Q=03"
07	PRONPT	21	PROMPT
68	"SCZ=02,07"	22	GTO 12
09	PROMPT	234	LBL F
10	"SLZ=03,08"	24	RCL 01
11	PROMPT	25	"F, HHZ"
12	"PLY=04,09"	26	PROMPT
13	PROMPT	27	STO 01
14	"PAR:00"	28	RCL 04

Model	Impedance	Frequency		UNIT PR	ICE (4) EI	FFECTIVE	8-15-82	1
Number (2)	Ohms (Power W)	Range	BNC	TNC	N	SMA	UHF	PC
Fised Attenuate	ors. 1 to 20 dB							
AT-50(3)	50 (5W)	DC-15GHz	14.00	20.00	20.00	18.00		10.00
AT-51	50 (5W)	DC-15GHz	11.00	15 00	75 00	14.00	-	12.00
AT-52	50 (1W)	DC 1 SGH2	14.00	17.00	20.90	15.00	_	
AT-53	50 (25W)	DC-3 DGHZ	14 00	17.00	_	18.00	-	-
AT-26 ST-00	75 ~ 07 (5)//)	DC-15GH2(750)	MH2H4.00	20.00	20.00	18.00	_	_
Delector Zero I	lias Schottky							
CD-51	50	01-4.2GHz	-	-	-	54.00	-	-
Resistive Imped	lance Transformers	Minimum Loss	Pads					
RT-50 75	50 to 75	DC-15GHz	10.50	19.50	19.50	17.50	-	-
RT-50 93	50 to 93	DC-10GHz	13.00	19.50	19.50	17.50	-	-
Terminations								
CT-50 (3)	50 (5W)	DC-4 2GHz	11.50	15.00	15.00	17.50	-	-
CT-51	50 (5W)	DC-4 2GHz	9.50	12 00	12.00	9.50	-	-
CT-52	50 (1W)	DC-2 5GHz	10.50	15.00	15.00	13.00	15 50	-
CT-53 M	50 (SW)	DC-4 2GHz	5.80	0 PC1-	-	5.60.10	Pc =	-
CT-54	50 (2W)	DC-20GHz	14.00	15.00	15.00	17.50	-	-
CT-75	75 (25W)	DC-2 5GHz	10.50	15.00	15.00	13.00	15.50	-
CT-93	93 (25W)	DC-2 5GHz	13.00	15 00	-	-	15 50	-
Mismatched Te	rminations 1 05 1	o 3 1. Open Circu	H. Short Ci	reuit				
MT-51	50	DC-30GHz	25.50	25.50	25.50	25.50	-	-
MT-75	75	DC-10GHz	-	-	25.50	-	-	-
Feed thru Term	inations, shunt res	stor						
FT-50	50	DC-10GHz	10.50	19.50	19.50	17.50	the	-
FT-75	75	DC-500MHz	10 50	19.50	19.50	17.50	-	-
FT-90	93	DC-150MH2	13.00	19.50	19.50	17.50	-	-
Directional Cou	oler, 30 dB							
00.600	60	250-500MHz	80.00	-		-	-	
Beaustine Decou	nier series resistor	or Capacitive Could	ler series C	apacitor				
BD of CC-1000	1000 (1000PF)	DC-1.5GHz	12.00	18.00	18.00	17.00	-	-
Adaptara								
CA-50 (N to SM/	N 50	DC-4 2GHz	-		13.00	13.00	-	-
Inductive Deco	unlers series indui	lor						
LD.R15	0.17µH	DC-S00MHz	12.00	18.00	18.00	17.00	-	-
LD-6R4	6 8 MH	DC-55MHz	12.00	18.00	18.00	17.00	-	-
Email Attenuete	s Sala 1 6 10 an	d 20 dB in plasti	C 85.0					
AT.50.8FT (3)	50	DC-15GHz	60.00	84.00	84.00	76.00	~	-
AT-51-SET	50	DC-15GHz	48.00	6-4 00	64 00	60 00	-	-
Bearline Multur	ouplers 2 and 4 or	tout ports						
TC-125-2	50	1 5-125MHz	54.00	-	57 00	57.00	-	-
TC-125-4	50	1 5-125MHz	57 00	-	81 50	81.50	-	-
Resistive Roma	Deviders 3 4 an	a 9 ports						
Resistive - Owe	60	DC.20GHz	54.00	-	-	54.00	-	-
BC-3-30	50	DC-500MHz	54.00	_	-	54.00	-	-
BC-8-30	50	DC-500MHz	-	-	-	84.50	-	-
Dauble Balance	and Advances							
Double Balanc	FO MILEPIS	5-1000MHz	61.00	_	71.00	61.00	-	-
DBM-5008C	50	2-500MHz	-		-	-	-	34.00
0011-3001-0								
HE PUSE, 1/8 A	mp and 1 16 Amp	DC.15 CH	17.00	18.00	-	17.00	-	-
FL-30	75	DC-15 GHz	12.00	18.00	-	17.00	-	-
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33+LBL 00	61 XEQ 01	89 CHS	119 10	133 GTG A
34 RCL 01	62 X()Y	90 RTN	128 *	134+LBL 11
35 2 F6	63 LASTX	91+LBL 06	121 STO 06	135 SF 01
76 *	64 PCI 07	92 XEQ 01	122 CLA	136 XER 00
37 PT	25 /	93 XEQ 05	123 CLD	137 PTN
38 *	66 +	94 RTN	124 ETY 2	138+1 BL 12
39 STO 02	67 X()Y	95+LBL 07	125 DRCI 01	139 CF 27
49 4	68 RTN	96 XEQ 02	126 ARCL 05	140 HISEP PCH-*
41 STO 89	69+LBL Й4	97 XEQ 05	127 ARCL 06	
42 CI ST	70 YEO 02	98 RTN	128 OVIEW	
47 PCI 10	71 9/19	99+LBL 08		User
44 179	72 LOCTY	100 XEQ 03		Defined
45 9739	77 Pri 07	101 XEQ 05		of
42 EC2 01	74 /	102 RTN		Program
40 F3: 01	75 1	103*LBL 09		END
47 AEW 03	EU T 72 0710	104 XEQ 04	0	
40 KIN 404151 01	10 AV/1 22 DTV	105 XEQ 05	Storage:	
474LDL 01	CENT	107*1 BL 10	01 Frequenc	
JO KUL UZ	70 ENTERA	108 X<>Y	02 Angular F	reg., rad.
51 *	79 ENIERT	109 RCL 00	03 Unloaded	Q of inductance
52 +	00 ATZ	110 +	04 Freq. Step	o, MHz
53 RTN	BI ENIEKT	111 X<>Y	05 alpha spa	ce
54+LBL 02	82 RUL 1	112 XEQ 05	U6 G-t, dB	
55 RCL 02	83 Xt2	113 RCL 09		
56 *	84 +	114 RCL 10	LUAUN	



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Computer Analysis of C Band Thin Film Attenuators

Computer Aided Design (CAD) is used to accurately predict the phase, VSWR and attenuation of thin film attenuators

By Paul Schneider Norden Systems

M eeting the difficult phase balance requirements of today's phased array antenna systems places ever more difficult requirements on phase sensitive components such as low-loss step attenuators, switch-line phase shifters, and switchable filter banks. To meet the technical challenge of these components Norden has investigated the use of computer aided design (CAD) to accurately predict the phase, VSWR, and attenuation of thin film attenuators.

To accomplish this a microwave circuit design software program called Super-Compact* was used. This CAD program, developed specifically to accurately analyze microwave integrated circuits, can now also accurately predict the phase, VSWR and attenuation of lossy thin film MIC networks such as used in attenuators. It is believed that Norden was the first company to evaluate Super-Compact's ability to accurately predict microwave characteristics of thin film attenuator networks.

Analysis of 6 dB and 12 dB Step Attenuators

The physical dimensions of Norden designed 6 dB and 12 dB thin film step attenuators were carefully measured using a shadowgraph instrument. Using these measured dimensions a data file was written on Super-Compact for the Norden attenuators. The data file and schematic for a typical microstrip attenuator is shown in Figure 1 and Figure 2. When the analysis was performed on SuperCompact there was close correlation between computer predicted results and laboratory measurements proving that Super-Compact could accurately analyze thin film attenuators for phase, amplitude, and return loss. The phase of these step attenuators is defined as the difference in phase between the attenuator line and the low loss lines which are connected by two PIN diode SPDT switches. The computer-predicted phase differences between the low loss and attenuator lines were within 2 degrees of the measured results, as shown below.

Optimization of the 6 dB, 12 dB And 24 dB Attenuators

In addition, 6 dB, 12 dB and 24 dB step attenuators were also optimized using Super-Compact for VSWR, attenuation and phase difference between the low loss line and the attenuator line. The chart below summarizes the results of computer optimization of these attenuators indicating maximum phase difference, VSWR, and attenuation flatness expected for a C band step attenuator.

In the process of optimizing the step attenuators, the ground return dimensions for the shunt resistors of the attenuators were varied by computer. It is interesting to note that, without the computer, this task would have been time consuming and costly requiring many prototypes of different ground plane dimensions to be built and tested. In-*(Continued on page 47.)*

Maximum Phase Difference of the 6 dB and 12 dB Thin Film Attenuators					
	Frequency				
		F ₁ GHz F ₂ GHz			GHz
Maximum Attenuation	Film Resistor Material	Measured Phase Difference	Computer Predicted Phase Difference	Measured Phase Difference	Computer Predicted Phase Difference
6 dB 12 dB	100 ohms/square 100 ohms/square	1° 6°	2° 8°	2° 12°	3° 13.5°

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Maximum Deviation of Attenuation	+ .06 dB	+ .05 dB	+ .12 dB – .09 dB
Maximum Phase Difference Between Low Loss and Attenuator Line	+ 1°	+ 2°	+ 1°

(Continued from page 44.)

stead, in less than one hour the computer analysis showed how the ground plane dimensions for the shunt resistors of the optimized attenuators affected the return loss and phase response of the attenuators.

To achieve on the bench, computer predicted performance, it is very important to undertake a tolerance study of the device under development. A successful completion of this tolerance study allows the engineer to select device dimensions with maximum tolerance dimensions and pin point those dimensions which are most critical for success.

A computer analysis of another Norden designed attenuator whose dimensions were measured with a shadowgraph measurement instrument showed a flat 23 dB of attenuation which agreed with the measured results. The phase between low loss and attenuator line was ± 4 degrees maximum compared to ± 5 degrees when the step attenuator was measured on the bench. One of the reasons for the differences in phase results could be the fact that Super-Compact is not capable of analyzing the phase differential due to the coupling between the low loss and attenuation lines.

Conclusion

It is obvious from these results that Super-Compact is able to predict attenuation and phase performance accurately and thus should be considered an important tool in the design of microwave step attenuators, time delay phase shift networks, and other thin film networks where accurate phase response is required.

Acknowledgements

The author would like to thank Steve March and Les Besser of CGIS for their technical advice and assistance and Larry Gross and Harold Shnitkin of Norden for their support. Thanks also to Walter Macie, Charlie Brown, and Mary Nault for their expertise.

* Super-Compact is the registered trademark of CGIS, a COMSAT Company.

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S22

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 Frompts which are accompanied with a 'beep'sound may be answered with any of 14 command words (which are listed when you respond with the 'HELP' command' even though numerical data is expected.
 Most prompts may be answered by depressing only the ENTER key if you desire to move ahead into the program or avoid an action.

Do you need more information, Y/N?

SIGNET UDITE: MHZ. OHMS. HENRYS. FARADS. CENTIMETERS SWEEP PROMPT MAY BE ANSWERED WITH ANY ONE OF THE FOLLOWING:

- MAP to use constant freq, component value scan mode XMAP to exit MAP mode SAVE to save circuit data file LIST to list current circuit data file HELP to get this information NEW to erase circuit data file

- NEW to erase circuit data file CALC to do some common circuit calculations FILT to design filters PLOT to enter plot/graphics mode XPLOT to exit PLOT mode EDIT to modify current circuit file SFILE to save calculated data TITLE to add date, time, and title to display QUIT to exit SIGNET

Enter circuit file names using A: or B: as required; do not add an extension, this is done automatically. MORE Y/N? Y

- CIRCUIT ELEMENT LIBRARY:
- series or shunt resistor series or shunt inductor series or shunt capacitor RSE, RSH SE, LSH
- CSE. CSH
 - т XSE
 - XSH
 - R
- Series of shuft inductor transformer by impedance ratio; EX-'T50/300'(50 T0 300) transformer by impedance ratio; EX-'N4'(1:4) parallel combination of R, L, and C used as a series circuit element; EX-'XSEIE4/.22E-6/470E-12' (R=10K, L=.22UM, C=470PF) C=0 is DK here meries combination of R, L, and C used as a shuft circuit element; EX-'XSHI0/.22E-6/470E-12' attenuator; EX-'R3'(3DB) S-parameter file; up to three different files may be used in a circuit. Open files with an 'S'' command at the beginning of the circuit list, EX-'S/MRF901/D1' (opens files MRF901 and D1). S1 and S2 will then represent the respective devices. represent the respective devices.

V1, V2, or V3 precedes a circuit element, referring to one of the three parameters of that element which is to be varied while in the 'MAP' mode. Dnly one 'V' may be used in a circuit file (ignored when not in MAP).

MORE Y/N? Y

- WSE series transmission line WTS shunt transmission line; shorted at end WTO shunt transmission line; open at end WSS shorted transmission line used as a series element WSD open transmission line used as a series element
- EX-'WSE75/15' (series 75 Ohm line, 15cm long in air)

HOLD, USE and F circuit file operators:

- н groupings of one or more circuit elements may be saved
- U
- groupings of one or more circuit elements may be saved by following that grouping with HO, HI, ... or H9. The main circuit model is zeroed after an H command. circuits which have been saved by an H command may be recalled by UO, UI, ... or U9. the feedback command forms a new circuit element by combining two circuits which have been saved by H comman Classical Series or Parallel feedback connections are allowed. EX-'FPO1' (parallel combination of HO and H1) EX-'FS27' (series combination of H2 and H7) E commands.

MORE Y/N? Y

OUTPUT OPTIONS:

- MA
- G
- IONS: magnitude of S-parameters angle of S-parameters magnitude of S-parameters in DB group delay (omitted for first freq in a scan) stability factor D

Desired output options must be grouped on a single line, without the use of commas. SIGNET will ignore any file entrys beyond that point, allowing you to add a title or any other text on subsequent lines in the file.

An '*' in the printout indicates that SIGNET has had to use interpolated S-parameters in its calculations.

HIT <RETURN> WHEN READY

CIRCUIT START/SI	FILE NAME (or enter IT (mhz)?	'HELP')? 20/40/2	SIGI

FREQ mhz	S11	S21	S12	S7	
20	-12.877	-0.354	-0.354	-13.123	DB
22	-0.031	-0.781	-0.781	-9.052	DB
24	-5,829	-1.554	-1.554	-5.979	DB
26	-4.347	-2.318	-2.318	-4.506	DB
28	-5.916	-1.812	-1.812	-7.392	DB
30	-1.084	-8.261	-8.261	-1.723	DB
32	-0.155	-20.923	-20.923	-0.295	DB
34	-0.076	-31.691	-31.691	-0.128	DB
36	-0.055	-41.800	-41.800	-0.076	DB
38	-0.043	-52.455	-52.455	-0.050	DE
40	~0.036	-66.422	-66.422	-0.035	DB

07-29-1983 LOW PASS FILTER

frequency doublers

to $+15 \, dBm$ input



+1

to 1000 MHz only \$2195 (5-24) AVAILABLE IN STOCK FOR IMMEDIATE DELIVERY

- micro-miniature, 0.5 x 0.23 in.
- flat pack or plug-in mounting
- high rejection of odd order harmonics, 40 dB
- low conversion loss, 13 dB
- hermetically sealed
- ruggedly constructed MIL-M-28837 performance*

*Units are not QPL listed

SK-2 SPECIFICATIONS

FREQUENCY RANGE, (MHz) INPUT 1-500 OUTPUT 2-1000		
CONVERSION LOSS, dB	TYP.	MAX.
1-100 MHZ	13	15
100-300 MHz	13.5	15.5
300-500 MHz	14.0	16.5
Spurious Harmonic Output, dB	TYP.	MIN.
2-200 MHz F1	-40	-30
F3	-50	-40
200-600 MHz F1	-25	-20
F3	-40	-30
600-1000 MHz F1	-20	-15
F3	-30	-25

For complete specifications and performance curves refer to the 1980-1981 Microwaves Product Data Directory, the Goldbook or EEM.



A Division of Scientific Components Corporation World's largest manufacturer of Double Balanced Mixers 2625E. 14th St. B'klyn, N.Y. 11235 (212) 769-0200

"Chip" Crystals

A broad range of leadless quartz crystals for surface mounting and capable of utilizing fully automated soldering techniques has been introduced by Statek Corporation. They withstand temperatures used in vapor



phase reflow soldering processes at 215°C and wave soldering processes up to 260°C. Designated the CX-1-SM series, these crystals are available in any frequency in the range 10 kHz to 2.0 MHz. Statek Coproration, Orange, CA 92668, or INFO/CARD#124.

High Power Lowpass Harmonic Rejection Filter

CIRQTEL Inc. announces the introduction of a full range (2MHz to 2GHz) lowpass harmonic rejection filter. Models are available for 100.



200, 500W, 1, 2.5 and 10KW continuous power. CIRQTEL Inc., Kensington, Maryland 20795 or INFO/CARD #123.

Capacitor Arrays

United Chemi-con Inc. has announced the introduction of a new packaging concept for its capacitor products known as Capacitor Arrays. This new product is a resin molded package which utilizes insert molding techniques to place 2 to 5 aluminum electrolytic elements into a capacitor array to maximize the concept of high density board mounting. Units are de-



signed for automatic insertion on PC boards. Electrically, these capacitor arrays have a capacitance range of 0.1 to 10 uF and are available with a voltage range of 6.3 to 50V. Price: Typical cost; .28 each for unit with 3 capacitors, 50 VDC working voltage, in 1000 quantity. United Chemi-con Inc., Rosemount, IL 60018, or INFO/CARD #122.

Mini-Amplifier

Trilectric introduces a series of miniature RF power amplifiers. The Mini-Amps are available in VHF (140-174 MHz) and UHF (450-512 MHz). Designed for applications that have limited mounting space, the amplifiers



measure 5-3/4"Lx 3"Wx1-3/4"H. Power output on VHF is 20-40 watts with 2-4 watt input. UHF is 10-20 watts output with 2-4 watt input. The amplifiers feature sturdy annodized aluminim alloy case construction housing an advanced single stage microstrip amplifier design. **Trilectric, Las Vegas, NV 89109, or INFO/CARD #121.**

RF/Microwave Amplifier in Flatpack Configuration

Alpha Industries, Inc., Microelectronics Division now offers a complete line of RF/Microwave Amplifiers in flatpack packages as well as our standard TO-8, TO-12, TO-3 and 4 PIN DIP enclosures. These new products will be designated as the FP Series and will cover the ranges of 5 to 4200 MHz in numerous design configurations with output powers up to + 24 dbm and noise figures as low as 2db. The units are designed to provide broad frequency coverage, flat gain response, unconditional stability and low input/output VSWRS for a wide variety of applications. As with all of our modular products they can be cascaded to fulfill various system requirements. Alpha Industries, Inc., Colmar, PA 18915, or INFO/CARD#120,

Coaxial Attenuators, DC to 18.0 GHz, up to 100 Watts!

Weinschel Engineering announces new additions to its high power attenuator line. The model 46 has a power rating of 25 watts, 200 watts peak and is available in the following standard attenuation values: 3, 6, 10, 20, 30 and 40 dB. Models 47 and 48

...or this even narrower strip...



have standard attenuation values of 10, 20, 30 and 40 and are rated for 50 watts, 500 watts peak and 100 watts, 1000 watts peak, respectively. Weinschel Engineering, Gaithersburg, Maryland 20877, or INFO/CARD #119.

RF Transformers

Synergy Microwave has announced the availability of its new line of RF transformers for all broadband impedance matching applications. Forty-five standard models appear in the Synergy Microwave Master Catalog, covering impedance ratios of 1:1, 1:1.5, 1:2 and 1:4, in all possible balanced/unbalanced configurations. Each model is additionally available in three package types . hermetic 8-pin miniature headers, hermetic tinplated flatpacks, and non-hermetic plastic flatpacks. Synergy Microwave Corp., Fairfield, N.J. 07006, or please circle INFO/CARD #118.

Low-Cost Frequency Counters

Two new frequency counters from Hewlett-Packard, the HP 5384A and HP 5385A, offer new levels of accuracy and resolution in economy-priced systems counters covering the frequency range of 10 Hz to 1 GHz. High input sensitivity coupled with extensive input-signal conditioning



result in enhanced performance in R&D testing. Additionally, low-priced systems capability is available in either HP-IB (Hewlett-Packard Interface Bus), which is standard, or HP-IL (Hewlett-Packard Interface Loop), which is optional. Frequency range for the HP 5384A is 10 Hz to 225 MHz. For the HP 5385A, it is 10 Hz to 1 GHz. Key specifications common to both units include: measurement resolution is 9 digits per second minimum; fourto 11-digit display resolution is frontpanel selectable to simplify readings; input sensitivity is a high 10 mV rms (typical); and three gate time selections (0.1, 1.0 and 10 seconds) are provided. The HP 5384A is priced at \$1,400 and the HP 5385A is priced at \$1,700. Delivery for both counters is four weeks ARO. Hewlett Packard Co., Palo Alto, CA 94303, or please circle INFO/CARD #117.

High -"Q" GaAs Tuning Diode Chips

Alpha Industries now offers passivated abrupt gallium arsenide tuning diodes in chip form. Manufactured by Alpha's Semiconductor Divison, these GaAs Chips are ideally suited for frequency tuning applications from X through KA band. They can be used to tune filters, phase shifters, Gunn-Impatt-transistor oscillators, upconnectors, and low order multipliers. Passivation, in conjunction with other processes, results in high reliability and leakage currents less than 10 nanoamps. Variations from square law are minimized while maintaining high tuning ratios and highest Q by a careful selection of eqitaxial GaAs and by tightly controlled anode REF LEVEL

10 d8m

10 JB ATTEN

INPUT ATTEN

10 38|

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diffusions. Alpha Industries, Inc., Woburn, MA 08101, or INFO/CARD #116.

High Output RF Linear Hybrid Amplifiers Offered In Single-In-Line Packages

17 RF linear hybrid amplifiers offered in a new hermetic single-inline package are available from TRW Semiconductor Division. Known as the SIP series, these hermetic hybrids exhibit output power up to 2 watts with bandwidths up to 1 GHz and noise figures as low as 3dB. A second series, the GPA's (general purpose amplifiers) are low cost, high performance cascadable amplifiers in TO-8 packages. With output as high as +20dBm and bandwidths up to 1500 MHz, the GPA's supply internal bias as well as external bias components. The GPA series may be cascaded alone or in tandem with the SIP series for higher output capability without sacrificing bandwidth. Both series are designed for a wide variety of receiver, transmitter and instrumentation applications. The SIP series are priced from \$50-65 in quantities of 100. Prices range from \$25-86 in quantities of 100 for the GPA series. TRW Semiconductor Division, Lawndale, CA 90260 or INFO/CARD #115. **Optical Infrared System**

Recent advances now allow transmission of excellent quality color or black and white video signal and audio signal to distances increased by 25% and with greater reliability on a free space optical infrared transmission system. The model 761, consisting of one transmitter and one receiver, transmits line of sight on an invisible infrared beam of light with-



out the need for FCC licensing. Built-in alignment telescopes assist in quick and easy installation for temporary or permanent sites. New circuitry insures dependable, highquality transmission. For broadcast applications, NTSC, PAL, and SECAM quality signals can be attained at distances of 2500 FT. (.8KM) with a signal to noise ratio of 54DB. Applications include ENG, microwave to studio, camera to microwave and more. American Laser Systems, Inc., Goleta, CA 93117, or please circle INFO/CARD #105.

Series 541 380" wide

eries 521

.512" wide

Series 515 .760" wide

*Pat. No. 3504095

RF/Digital Modulators

Synergy Microwave has announced the availability of its comprehensive line of Bi-phase and QPSK (quadriphase) modulators. The Bi-phase modulators are broadband (5-1250 MHz) and exhibit excellent amplitude balance (typically 0.1 dB) and phase balance (typically, 0.5° to 100 MHz, 1.0° to 500 MHz, and 3° to 1250 MHz). The QPSK modulators are specified at 10% bandwidths and are available at frequencies up to 1500 MHz. Catalog models are listed with center frequencies of 30, 60, and 70 MHz. Aside from excellent amplitude and phase balance (typically, 0.1 dB



power splitter/ combiners

4 way 0°



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IMMEDIATE DELIVERY

- rugged 11/4 in. sq. case
- BNC, TNC, or SMA connectors
- low insertion loss, 0.6 dB
- hi isolation, 23 dB

ZFSC 4-1W SPECIFICATIONS

FREQUENCY (MHz) 10-500		
INSERTION LOSS, dB (above 6 dB)	TYP. 0.6	MAX. 1.5
10-500 MHz		
AMPLITUDE UNBAL., dB	0.1	0.2
PHASE UNBAL. (degrees)	1.0	4.0
ISOLATION, dB	TYP.	MIN.
(adjacent ports)	23	20
ISOLATION, db (opposite ports)	23	20
IMPEDANCE	50 ohn	ns.

For complete specifications and performance curves refer to the 1980-1981 Microwaves Product Data Directory, the Goldbook or EEM.



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83-3 REV ORIG

INFO/CARD 48

1 degree) the Synergy QPSK's offer absolute "insertion phase" balance. This is critical in a QPSK device yielding (when used as a demodulator) maximum DC output when both input signals (modulated and CW) are exactly in-phase. Both Bi-phase and QPSK modulators are available with standard 10 mA DC current logic, or with integral ECL drivers. Other integral logic is available on request. The catalog QPSK models are listed in Flatpacks, the Bi-phase models in Flatpacks and TO-8 packages. Synergy Microwave Corp., Fairfield NJ 07006, or INFO/CARD #104.

Bandpass Filter Suppresses TVRO Interference

The model #4352 coaxial bandpass filter passes the 3.7-4.2 GHz TVRO band with less than 0.8 db insertion loss (maximum) and 1.5 VSWR (maximum). Attenuation is at least 20 dB at 3.5 and 4.4 GHz, the closest allocated interference. Typical suppression is approximately 30 and 50 dB on the public carriers, 2.1 and 6.5 GHz, respectively. The weather-sealed filter has type N connectors and inherent D.C. passing for LNA power. Price and delivery are \$115 and 5 days, respectively. Microwave Filter Co., Inc., East Syracuse, NY 13057, or please circle INFO/CARD #103.

SPDT Diode Switch

Engelmann Microwave, a KDI Company, has announced the addition of a SPDT Diode Switch which operates over the full frequency range of 0.1 to 18 GHz. The Model SW 2218 has a speed of 30 nsec. max. for 10-90% points. It is priced at \$350 per unit and is available from stock. Engelmann Microwave, Whippany, NJ 07981, or INFO/CARD #102.

SPDT Coaxial Switch

Teledyne Microwave provides full band performance over the DC-18 GHz range, now with special inboard





mounting configuration. These SPDT, latching and failsafe switches are mounted conveniently by holes between the ports in the RF portion of the switch. Both inboard and outboard mounting can be provided on the same switch for increased versatility. Insertion loss performance is 0.5 dB max., isolation is 60 dB min., and VSWR is 1.50 max. across the full band with improved performance in the DC-6 GHz range. Actuators can be supplied with 12, 15, 24-30 VDC, and 115 VAC coils. Teledyne Microwave, Mountain View, CA 94043, or please circle INFO/CARD #101.

High Power Coaxial Switches

RLC Electronics announces an improved series of high power coaxial switches. By the use of heat conducted dielectrics, the SRP Series of electro-mechanical switches have the ability of handling high CW power levels in a frequency range of DC-6GHz. Typical power capability would be 1500 watts CW @ 1000MHz. These switches are available with SC, HN or Type N connectors with standard options of indicator circuits, latching operation, and TTL drivers. They are available in singlepole, double-throw through singlepole, six-throw. Prices start at \$425 in unit quantity for the single-pole, double-throw. Delivery is from stock to eight weeks. RLC Electronics, Inc., Mount Kisco, N.Y. 10549, or please circle INFO/CARD #100.

Ultra Low Phase Noise Oscillator

Greenray has announced a new ultra low phase noise oscillator Model YH1202-1. It features the combination of low phase noise, low aging and high stability in one oscillator. Specifications include: Frequency range, 25 MHz to 100 MHz; Output Type, Sine Wave; Output power, 0 dBm (minimum) into 50 ohms; Temperature range, 0 to 50°C; Temperature stability, 5x10⁻⁸ppm; Aging, 1x10⁻⁹/day; Input voltage, + 15 vdc.

Phase Noise: (At 100 MHz)

Offset From Carrier	db/Hz
100 Hz	-120
1kHz	-130
50 kHz	-140

Greenray Industries, Inc., Mechanicsburg, PA 17055, or INFO/CARD #99.

Micro-Coax Low Pass Filters

Higher frequency capabilities for Low Pass Filters in semi-rigid coaxial



cable have been achieved by the MicroDelay Division, Uniform Tubes, Inc., Collegeville, PA. In 0.0865" O.D. cable, the frequency range is 1.0 GHz to 30.0 GHz. In 0.141" O.D. cable, the range is 200 MHz to 18.5 GHZ. In 0.250" O.D. cable, the range is 200 MHz to 8.0 GHz. Uniform Tubes, Inc., Collegeville, PA 19426, or INFO/CARD #114.

Chipless[™] Circuits for RFI/EMI Suppression

KDI Pyrofilm's Chipless[™] Capacitor Circuits and Chipless[™] RC Circuits can provide effective interference suppression. These low cost circuits, available in both Single-in-Line and Dual-in-Line configurations can be effective in helping designers meet FCC Article 15 requirements. KDI Pyrofilm Corporation, Whippany, NJ 07981 or INFO/CARD #113.

16-Pin Dual-In-Line Attenuator

A new dual-in-line attenuator package from EMC Technology offers a unique approach to obtaining the correct attenuation values for adjust at test applications, and is said to be the first microwave attenuator offered



in a standard DIP configuration. The Model 1248 attenuator plugs into an ordinary 16-pin dual-in-line socket, and operates from DC to 1 GHz (usable to 2GHz). Four separate attenuators are incorporated in the package, each of which may be used independently or jumpered to achieve desired attenuation up to 15dB in increments of 1dB. Cost for the new DIP attenuator is \$25, and delivery is from stock. EMC Technology, Inc., Cherry Hill, NJ 08034, or please circle INFO/CARD #111.





5 to 1000 MHz only \$31⁹⁵ (5-24)

IN STOCK ... IMMEDIATE DELIVERY

micro-miniature, pc area only 0.5 x 0.23 inches

- RF input up to +14dBm
- guaranteed 2 tone, 3rd order intermod 55 dB down at each RF tone 0dBm
- flat-pack or plug-in mounting
- low conversion loss, 6.2dB
- hi isolation, 40 dB
- MIL-M-28837/1A performance*

• One year guarantee •Units are not QPL listed

TFM-2H SPECIFICATIONS

FREQUENCY RANGE LO, RF 5-100 IF DC-100	E, <i>(MHz)</i> 00 00	
CONVERSION LOSS	, dB TYP.	MAX.
One octave from ban	dedge 6.2	7.0
Total range	7.0	10.0
ISOLATION, dB	TYP.	MIN.
LO-RF	50	45
LO-IF	45	40
LO-RF	40	30
LO-IF	35	25
LO-RF	30	20
LO-IF	25	17

SIGNAL 1 dB Compression level + 14 dBm min



r.f. design

New Literature

Ceramic Capacitor Catalog

PACCOM recently announced the availability of an 8-page ceramic Capacitor Catalog describing the company's full range of miniature ceramic capacitors. Included in the catalog are complete electronic and mechanical specifications for temperature compensating, high dielectric, semi-conductor type, high voltage, and taped ceramic capacitors.Paccom, Redmond, Wa 98052, or INFO/CARD #150.

Attenuator Catalog

JFW Industries announces a new Attenuator Catalog containing specifications and prices on wide range of units, including fixed attenuators, coaxial switches rotary attenuators, solid state programmable attenuators and others. JFW Industries, Indianapolis, IN 46203, or INFO/CARD #149..

Millimeter Wave Components and Subsystems Catalog

Alpha Industries announces its new comprehensive Active Millimeter Wave Components and Subsystems catalog. The 40-page catalog de-



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scribes Alpha's latest developments in millimeter wave technology.Featured are detailed specification charts, graphs, and complete ordering information for balanced mixers, upconverters, harmonic mixers, detectors, frequency multipliers, phaselocked sources, PIN diode switches, and modulators. Alpha's capabilities of custom-developed millimeter wave subsystems and radar antennas are also included. Alpha Industries, Woburn, MA, 01801 or INFO/CARD #148.

Electromagnetic Delay Lines

A 16-page illustrated catalog describing a broad line of active (TTL and DTL-compatible) and passive electromagnetic delay lines has been published by JBM Electronics, Inc. The



new publication includes information on specifying and testing delay lines, as well as dimension data, circuit diagrams and specifications for approximately 200 standard DIP and SIPpackaged modules. Information on custom and military types is also included. JBM Electronics, Inc., Manchester, NH 03102, or please circle **INFO/CARD #147.**

Antenna Systems Catalog

Andrew Corporation, a supplier of antenna equipment to the telecommunications industry since 1937, recently published a new edition of its general catalog - Antenna Systems/Catalog 32. Andrew catalogs traditionally have been valued not only for their product listings, but also for the extensive technical information and system planning data that they provide. The new catalog includes many new features and products. The coaxial cable and power rating sections are reorganized to facilitate applications-oriented comparison. The book has been expanded to 208 pages with increased coverage of broadcast and earth



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- connector intermixing male BNC, and Type N available
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- flat coupling, ±1.0 dB

ZFDC 20-5 SPECIFICATIONS

FREQUENCY (MHz) 0.1-2000 COUPLING, db 19.5		
INSERTION LOSS, dB	TYP.	MAX
one octave band edge	0.8	1.4
total range	1.5	2.3
DIRECTIVITY dB	TYP.	MIN
low range	30	20
mid range	27	20
upper range	22	10
IMPEDANCE	50 ohr	ns

For complete specifications and performance curves refer to the 1980-1981 Microwaves Product Data Directory, the Goldbook or EEM



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INFO/CARD 54

station products. GRASIS[®] towers and equipment shelters appear in the catalog for the first time since Andrew Corporation acquired Grasis Corporation in 1983. Andrew Corporation, Orland Park, IL 60462, Please circle INFO/CARD #146.

Passive Components Catalog

A new 60-page two-color catalog on capacitors, resistors, diodes and potentiometers is available free from Baldwin Components Center, Inc. The comp-



onents described in the catalog are available in all standard values and are maintained in a computerized inventory for shipment in 24 hours. Components with non-standard values are available on special order. Many of the components are in currently-desired miniature and sub-miniature designs to assure optimum use of board space, and have high-precision, ultra-high precision and MIL ultra-high precision capabilities. Baldwin Components Center, Inc., Deer Park, N.Y. 11729, or please circle INFO/CARD #144.

Microwave Signal Sources Brochure

M/A-COM OSW, Inc., M • A • T • S Divison, San Jose, California, presents their all new Mrcrowave Signal Sources Brochure. Included in the attractive fourcolor brochure is a company profile highlighting Product Engineering by MOAOTOS's design oriented engineering team, a Quality Assurance team with the lowest return rate in the industry, and Guaranteed Reliability including computerized test data provided with each unit.Featured in the Standard Sources section are details on the Free Running Cavity Sources (FR Series), Phase-Locked Sources (PL Series), Automatic Phase-Locked Sources (FM Series), Mechanically





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Selection Guide on Consumer IC'S

A new 45-page selection guide outlining Siemens "consumer" integrated

products has recently been released. The "consumer" classification includes those integrated circuits for use in television receivers, satellite receivers, television cable converter systems, home and automobile radios, infrared remote control of television, CATV converters, radio and general applications. The color brochure contains a summary of IC types, block diagrams and package, function and electrical characteristics. Additional product literature and applications information are also available. Siemens Components, Inc., Iselin, N.J. 08830, or INFO/CARD #140.

RF Components Catalog

A new RF Components Catalog has just been released by KDI Pyrofilm. This 40 page catalog details KDI Pyrofilm's line of RF AND MICROWAVE **RESISTIVE COMPONENTS for military** and commercial applications in the frequency range of DC to 26.5 GHz. The KDI Pryofilm RF Components Catalog also includes sections on: Chip Resistor Applications; Installation/RF Matching-Power Terminations, and Temperature Calculations. KDI Pyrofilm Corporation, Whippany, New Jersey, 07981, or INFO/CARD #141.

Quartz Crystal Clock Oscillators

Frequency Control Products has released new, comprehensive literature describing its full line of Hi Reliability Quartz Crystal Clock Oscillators. The four page brochure gives complete details on their miniature low profile DIP types, available in both commercial and military versions including the TTL Series, covering a frequency range from 1kHz to 100MHz and the CMOS Series, covering a frequency range from 10kHz to 15MHz. Complete descriptions, features, environmental data, mechanical specifi-



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FREQUENC LO, RF IF	Y RANGE, (MHz) .05 - 2000 .05 - 500		
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One octave	from band edge	6.0	7.5
Total range		7.0	9.0
ISOLATION	, dB	TYP.	MIN.
.055	LO-RË LO-IF	25 25	20 20
.5-1000	LO-RF LO-IF	40 40	30 30
1000-2000	LO-RF LO-IF	30 25	20 15

Signal 1 dB Compression level +3dBm

For complete specifications and performance curves refer to the 1980-1981 Microwaves Product Data Directory, the Goldbook or EEM

"units are not QPL listed



INFO/CARD 59

cations, a screen test options chart. mechanical outlines, electrical specifications for both series, and ordering information are all detailed. Frequency Control Products, Inc., Woodside, N.Y. 11377, or INFO/CARD #145.

Capacitor Catalog

Republic Electronics Corp., announces availability of its new 1983 Catalog U-1 (12 pages), describing its complete line of MUCON Subminiature Ceramic capacitors. A complete line of Microwave capacitors CDR11 thru CDR14 and CDR21 thru CDR25 QPL to MIL-C-55681 are included; CY81 thru CY87 QPL to MIL-C-11272. NPO capacitors in styles CCR05 thru CCR09, CCR13 thru CCR19 and CCR75 thru CCR79 QPL to MIL-C-20. Also available is a complete line of temperature compensating capacitors with coefficients from NPO thru N5600. Republic Electronics, Paterson, N.J. 07524, or INFO/CARD #139

Booklet on Solving Coil Design Problems

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