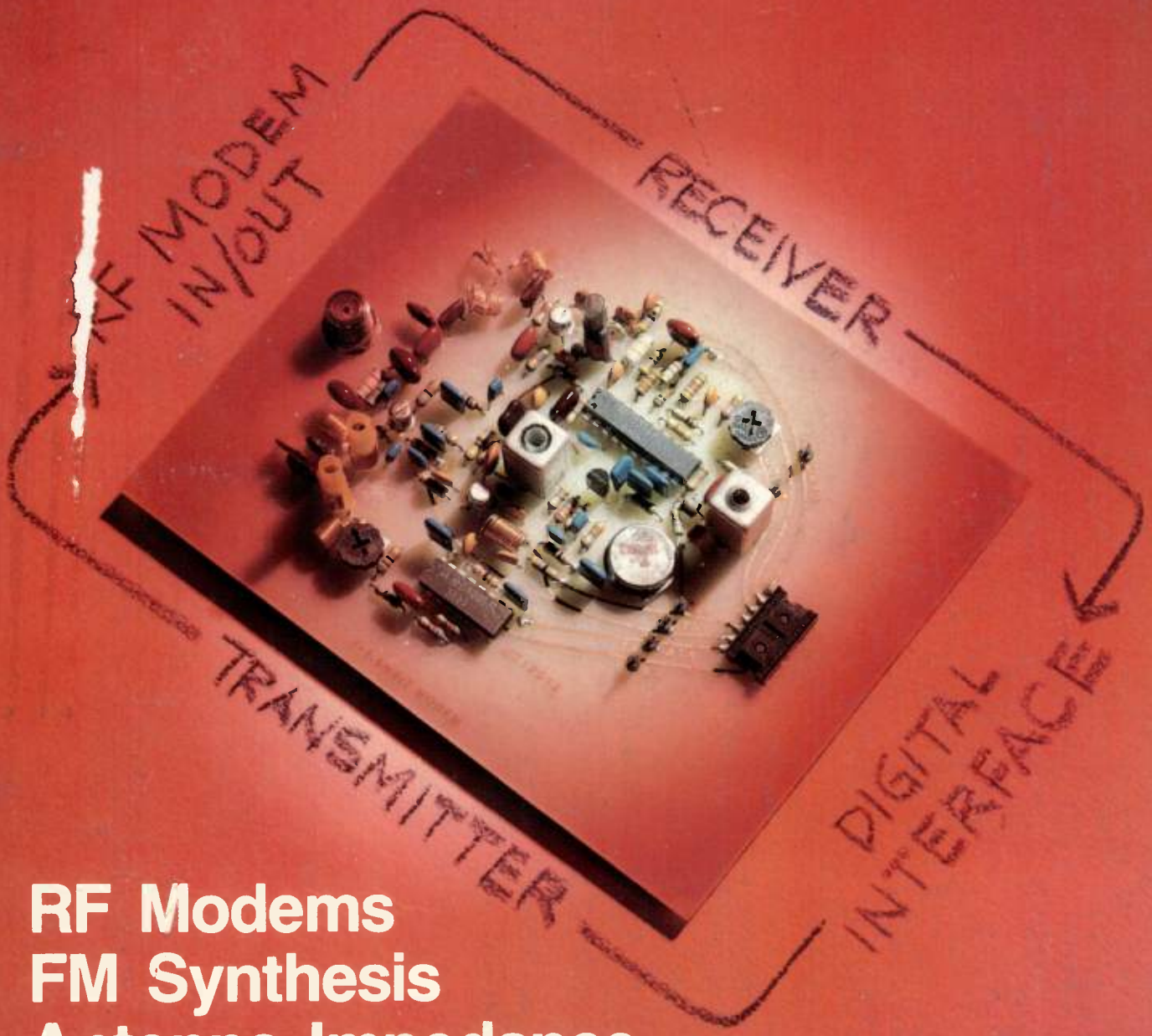
September/October, 1984

A Cardiff Publication

rf design

Communications



RF Modems
FM Synthesis
Antenna Impedance
Snyder Antenna

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Now—reliable RF Transistors from 900 MHz down to 1 MHz for Mobile Communications.

900 MHz	MOBILE APPLICATIONS				
Type	Power (W)	Freq. (MHz)	Gain (db) min.	VCC (V)	Package
BLU98	0.5	900	9.0	12.5	SOT-103/E1
BLV90	1	900	7.5	12.5	SOT-172
BLV91	2	900	6.5	12.5	SOT-172
BLU99	4	900	7.3	12.5	SOT-122
BLV92	4	900	8.0	12.5	SOT-171
BLV93	8	900	6.0	12.5	SOT-171
BLV94	15	900	6.0	12.5	SOT-171

400 to 512 MHz	MOBILE APPLICATIONS				
BLU60/12	60	470	4.8	12.5	SOT-119
BLU45/12	45	470	5.1	12.5	SOT-119
BLU30/12	30	470	6.0	12.5	SOT-119
BLU20/12	20	470	6.5	12.5	SOT-119
BLW82	30	470	5.0	12.5	SOT-119
BLW81	10	470	6.0	12.5	SOT-122
BLU99	5	470	10.5	12.5	SOT-122
BLW80	4	470	8.0	12.5	SOT-122
BLW79	2	470	9.0	12.5	SOT-122
BLX65	2	470	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

30 to 900 MHz	BASE STATIONS				
Type	Power (W)	Freq. (MHz)	Gain (db) min.	VCC (V)	Package
BLW96	200	30	13.5	50	SOT-121
BLV25	175	108	10.5	28	SOT-119
BLV80/28	80	175	6.5	28	SOT-119
BLV33F	85	225	10.5	28	SOT-119
BLV36	120	225	10.0	28	SOT-161
BLU53	100	400	6.5	28	SOT-161
BLV97	30	860	6.5	24	SOT-171
BLV57	38	860	6.5	25	SOT-161

66 to 870 MHz	AMPLIFIER MODULES FOR LAND MOBILE				
Type	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	2.2	9.6	SOT-26NC
BGY22	380-512	50	2.9	12.5	SOT-75A
BGY23	380-480	2.5 WATTS	7	12.5	SOT-75A

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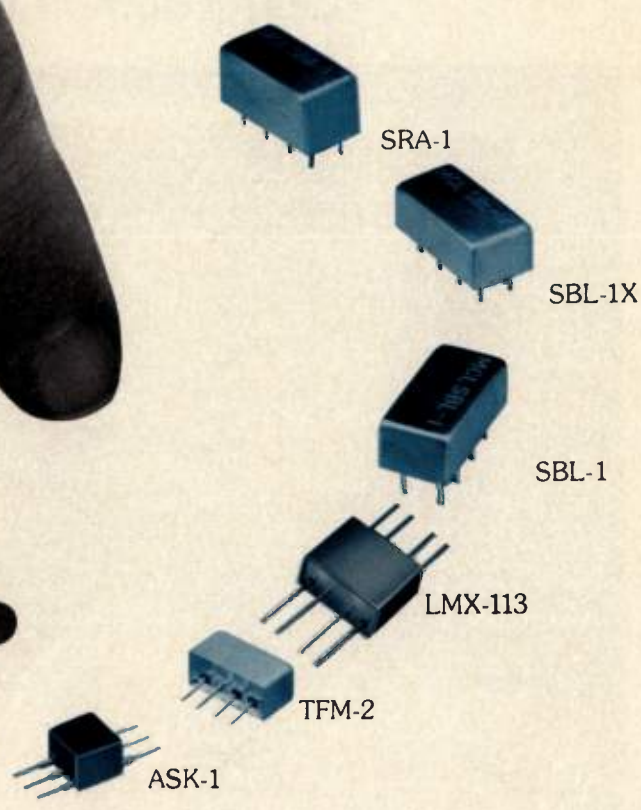
INFO/CARD 2

pick a mixer



500 KHz to 1 GHz from $3.95 hi-rel and industrial miniature, flatpack, and low profile

MODEL	FEATURES	Freq. (MHz)		†Conversion Loss (dB)		L-R Isolation (dB)			Price/Qty.
		LO-RF	IF	one octave bandedge	total range	lower bandedge	mid range	upper bandedge	
SRA-1*	the world's standard . . . HTRB tested hi-rel 3 year guarantee	.5-500	DC-500	5.5 typ.	6.5 typ.	50 typ.	45 typ.	35 typ.	11.95 (1-49)
TFM-2*	world's tiniest hi-rel mixer only 4 pins for plug-in/flatpack mouting,	1-1000	DC-1000	6.0 typ.	7.0 typ.	50 typ.	40 typ.	30 typ.	11.95 (6-49)
SBL-1	world's lowest cost industrial mixer, only $4.50, metal case	1-500	DC-500	5.5 typ.	6.5 typ.	50 typ.	45 typ.	35 typ.	3.95 (100) 4.50 (10-49)
SBL-1X	industrial grade, rugged all-metal construction	10-1000	5-1000	6.0 typ.	7.0 typ.	50 typ.	40 typ.	30 typ.	11.95 (1-9)
ASK-1	world's smallest DBM flatpack mounting, plastic case	1-600	DC-600	5.5 typ.	6.0 typ.	50 typ.	35 typ.	30 typ.	5.95 (10-49)
LMX-113*	rugged flatpack, hermeticity tested thermal shocked to MIL-STD-202	5-1000	DC-1000	6.5 typ.	7.0 typ.	50 typ.	40 typ.	35 typ.	14.95 (6-24)

***meets MIL-M-28837/1A performance**
units are not QPL listed

†LO = +7 dBm

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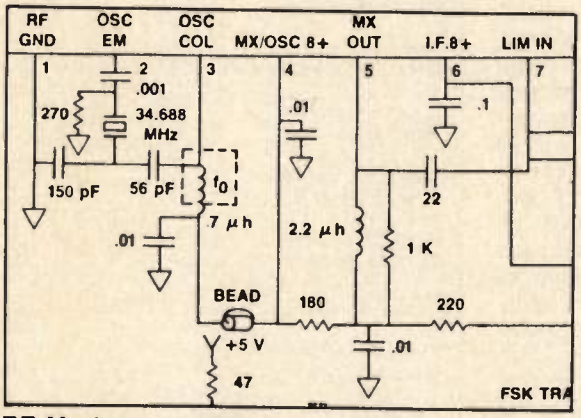
INFO/CARD 3

C74 REV. E

September/October 1984



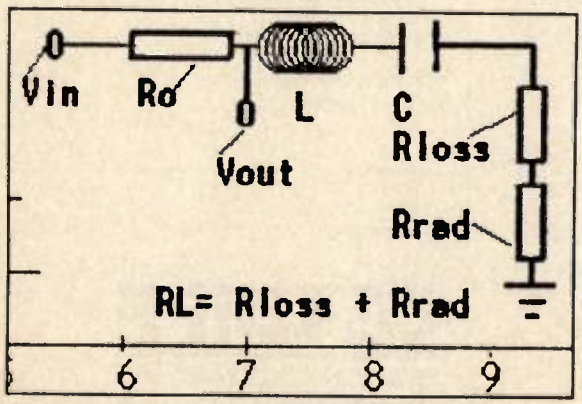
RF Modems, p. 12.

$$\phi(t) = \int 2\pi\, f(t)\, dt \quad ,$$

$$\phi(t) = \frac{2\pi\, \Delta f_{pk} \sin \omega_m t}{\omega_m} \quad , \text{and}$$

$$\phi(t) = \frac{\Delta f_{pk} \sin \omega_m t = \beta \sin \omega_m t}{f_m} \quad ,$$

Synthesis of FM Signals, p. 29.



Antenna Impedance Matching, p. 40.

Cover

September/October Cover — This issue's front cover, courtesy of Motorola Semiconductor Products Sector, shows the circuitry for an RF modem. A two-part series discussing designs for various types of RF modems begins with this issue.

Features

12 **RF Modems** — The first part of this two-part series provides an introduction to the subject of RF modems and covers designs for single channel units. John Hatchett and Bill Howell.

29 **Synthesis of FM Signals** — FM signals can be synthesized by controlling phase inside a variable-frequency phase-locked loop. This eliminates the need for a separate FM oscillator while providing unprecedented FM performance. Marcus da Silva.

40 **Antenna Impedance Matching Using a Sweep Generator** — This article describes an alternative method for matching a transmission line, through a coupling circuit, to an antenna requiring an impedance transformation. Riley H. Puckett.

49 **New Technology** — The Snyder Antenna

54 **r.f. designers notebook** — Complex Arithmetic on the HP-11C.

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R.F. DESIGN (ISSN: 0163-321X USPS: 453-490) is published bi-monthly plus one extra issue in June. September/October 1984, Volume 7, No. 6. 6530 S. Yosemite Street, Englewood, CO 80111 (303) 694-1522. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: 1 East First Street, Duluth, MN 55802, (1-800-346-0085). Subscriptions are sent free to qualified individuals responsible for the design and development of communications equipment. Other subscriptions are: $15 per year in the United States; $25 per year in Canada and Mexico; $25 per year for foreign countries. Additional cost for first class mailing. Payment must be made in U.S. funds and accompany request. If available, single copies and back issues are $5.00 each (in the U.S.). This publication is available on microfilm/fiche from University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106 USA (313) 761-4700.
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publisher notes

About That Shortage of RF Design Engineers . . .

As an RF engineer, you have an advantage over most people, when it comes to feeling needed. You actually *are* needed. The chances are pretty good you're being tracked right now by some headhunting firm, eager to flush you out of your present nest and herd you into a new one. If you are right out of college, your employer might have to pay you a starting salary of over $30,000, in order to stay competitive with other companies. (Forgive us old-timers if we seem shocked by that. You're worth every penny.)

The shortage of RF engineering talent is ironic, in that electronics *started* with radio: the present IEEE was originally named IRE . . . Institute of *Radio* Engineers. It was the advent of the digital computer, of course, that channeled so much of electrical engineering training down the paths of binary logic and on-off switching. The preoccupation with digital techniques has been so thorough that now a glut has begun to develop . . . with more digital engineers than there are jobs for them. Following the law of supply and demand, some of these wind up as RF engineers, floundering for fundamentals.

It is largely because of this situation that *r.f. design* magazine has conceived RF TECHNOLOGY EXPO . . . a three-day conference and exhibit intended exclusively for RF design engineers. It will be an annual event, with the first one being held next January 23-25 at the Disneyland Hotel in Anaheim, California. The technical conference will feature 100 papers, in 25 sessions, organized by Program Chairman "Andy" Przedpelski, V.P. of Development for ARF Products, Inc.

While many of the papers will deal with fundamentals of RF circuit and systems design, for the sake of those who need it, many others will follow a separate theme, to satisfy another need . . . the need to push forward the leading edge of RF technology. For, just as RF fundamentals have been neglected by engineering schools, RF "high technology" has been neglected by engineering forums. Where some are too digital or too general to be useful to the RF engineer, others are too microwave. There is certainly enough going on, in the lower reaches of high-frequency, to justify an RF TECHNOLOGY EXPO. In fact, we think it will fill a conspicuous communications gap, and do as much as any project in our society to help alleviate the shortage of RF engineering knowledge.

Whether we are right depends a lot on how you personally respond to the idea. If you agree with this analysis of the need, you ought to be there. Put it on your calendar now, and let us know you're coming. If you've been looking for a place to present a paper and haven't been able to find one, step forward now to volunteer it for RF TECHNOLOGY EXPO (call Andy Przedpelski, Program Chairman, at 303-443-4844.)

We believe that RF TECHNOLOGY EXPO will be a major event in the engineering world, beginning January 23-25, 1985 . . . and *the* major event to your own RF engineering community. We're sparing no effort or expense to test that proposition. Now all we need is your participation. See you in Anaheim.

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Publisher

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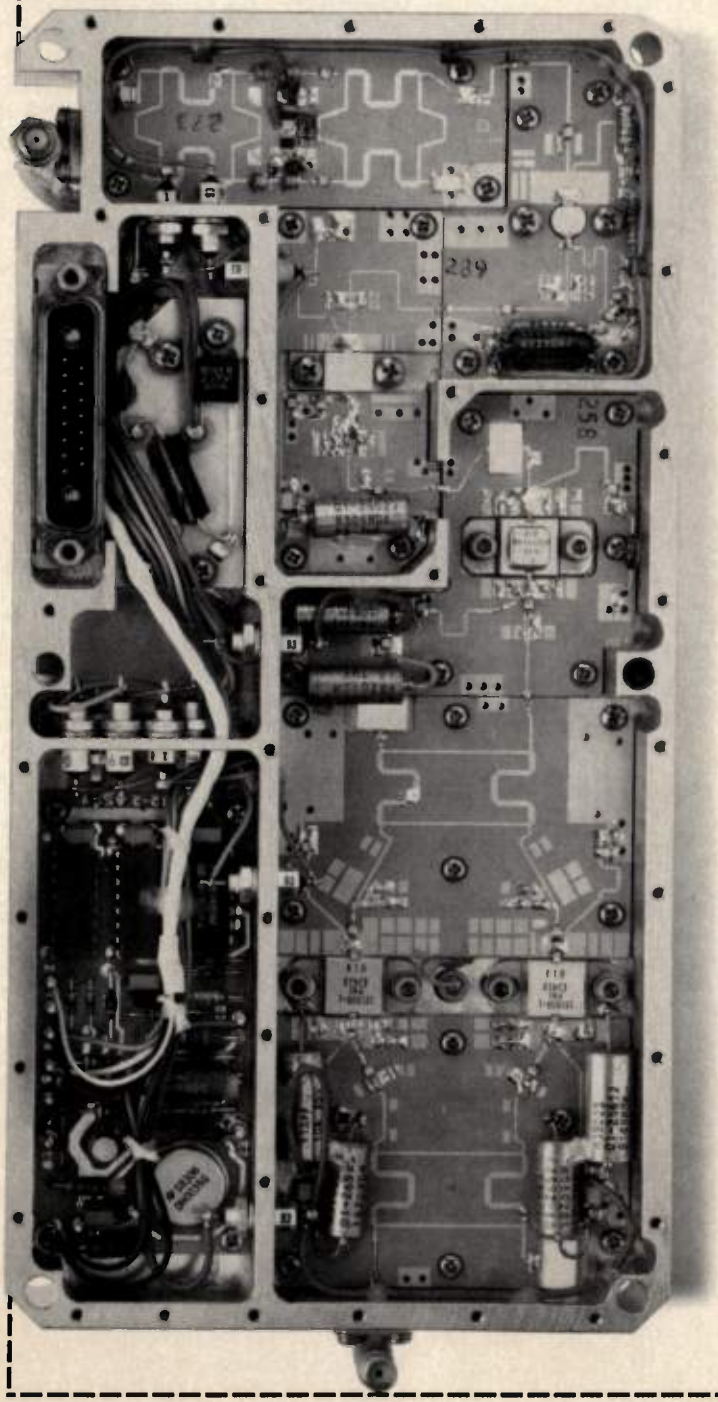

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INFO/CARD 4

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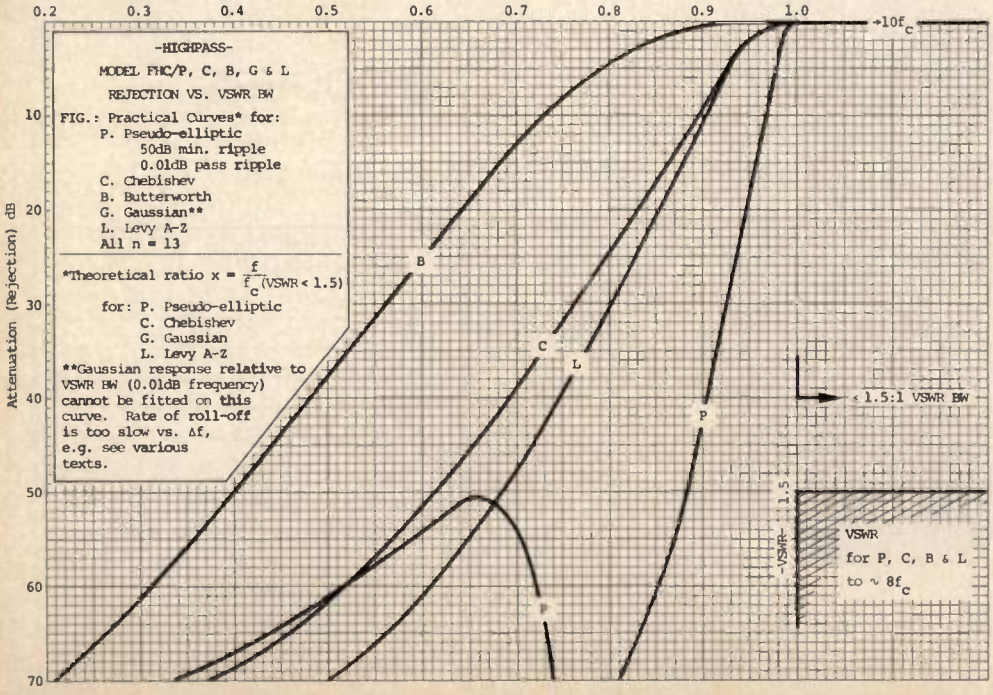
Cir-Q-Tel has again hit paydirt (gold) by introducing the low-cost, high-performance coaxially configured highpass filter models FHC/P, C, B, G, & L (Pseudo-Elliptic, Chebishev, Butterworth, Gaussian, and the NEW Levy A-Z).

THIS DESIGN HAS UNSURPASSED Q!
Without sufficient Q*, and enough of it, few filters perform well!

"Versatility" is the standard mode for design at Cir-Q-Tel:
1. Range: 100>2000 MHz at the time we go to press (→) Obsolete data!
2. Power: Up to 200 W CW; see (1↑).
3. Pseudo-Elliptic up to 15th order, Chebishev to 19th order, 21st-order Butterworth, Gaussian to 9th and, above all, the Levy A-Z up to 23 poles.
4. Passband: >4 GHz and above! WHAT'S NEXT? Give us a call, please.

At Cir-Q-Tel no filter problem is too great or too small for us to consider. We have more engineers per total employment (25%) than any other significant filter-producing company. Remember, we have over 30 years experience and 10X demonstrated innovative abilities all wrapped up in just one of our world class engineer/scientists.

*Without sufficient Q, designing filters is not a task, it's an impossible chore. The device configuration answer we've chosen is very nearly ideal!
Call Dr. Dick Wainwright--his flat passband width at present is 40 GHz!



Dear Sir:

There appears to be a minor typographical error in the article "Negative Feedback Amplifiers" (May/June) 1984, Page 49, Equation 4. The input impedance is stated to be:

$$Z_{in} = \frac{V_{in}}{I_{in}} = \frac{V_{in}}{V_{in}\,(1+BA)\,R_{in}}$$

whereas it should be inverted to read:

$$Z_{in} = \frac{V_{in}}{I_{in}} = \frac{V_{in}\,(1+BA)\,R_{in}}{V_{in}}$$

Thank you for an informative article and a fine magazine.

Joe Catalfamo
Lockheed Missles and Space Co.
Dept. 76-60 — Bldg. 579
Sunnyvale, CA 94086

Dear Sir:

"A Prompting HP67 . . . " [rf designer's notebook, July/August 1984] works great even though during transit between Siliconix and Englewood we got a couple of different programs!

Let me offer some corrections/improvements to the existing program offered in *rf design* that should help the reader understand the algorithm.

drop line	remarks/additions/etc.
048	We have the data in Register
058	Again, the data is in Register 2
060	Stupid! We never recall Register E!

change line

063	From RCL B to RCL 4 (34 04)
064	From RCL D to RCL 2 (34 02)
077	From RCL D to RCL 2 (34 02)
088	From gR→P to CHS (42)

The ultimate results are the same; now one can "read" the program and it (hopefully) makes more sense!

Sincerely,
Ed Oxner
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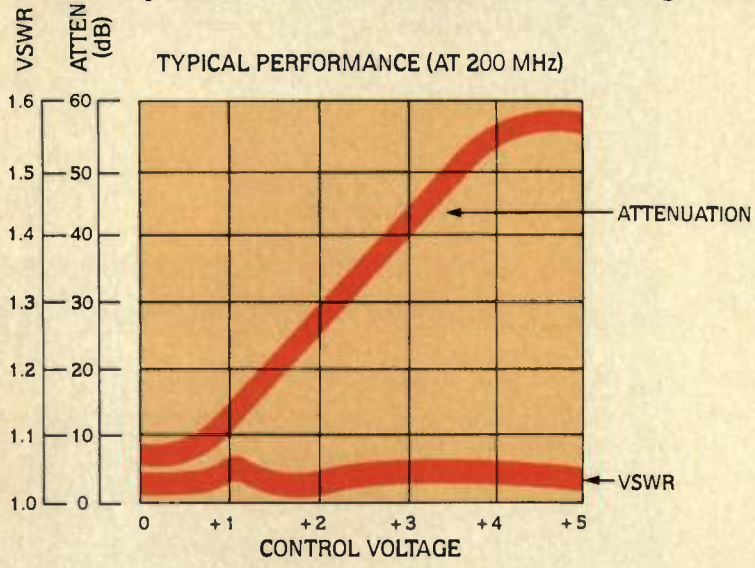

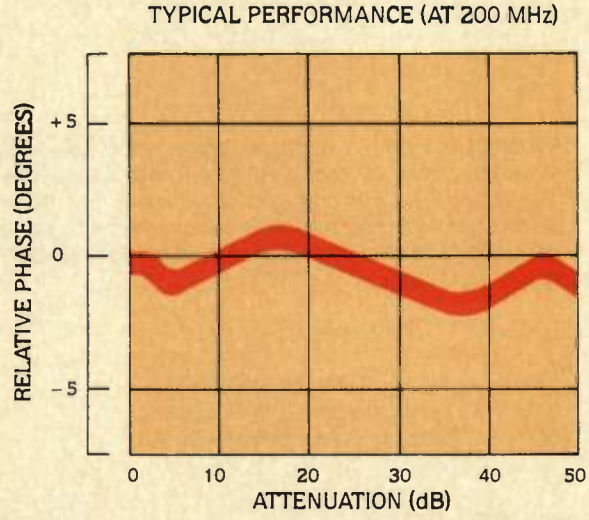

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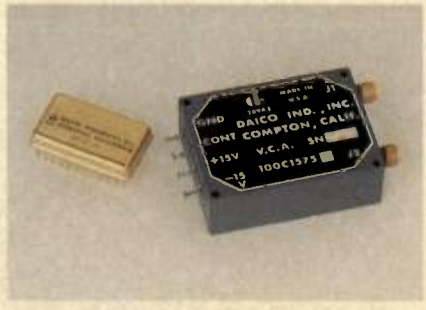

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frequency	150-250MHz
phase stability	10° max over specified attenuation
attenuation range	40 dB min
linearity	±2 dB
insertion loss	4 dB max
VSWR	1.25 max
control	0 to +5 volts
RF power	+15 dBm max
DC power	+15 volts @ 40 mA −15 volts @ 40 mA
impedance	50 ohms
size	1.5 × 2.0 × .6 in
connectors	SMA
part number	100C1575

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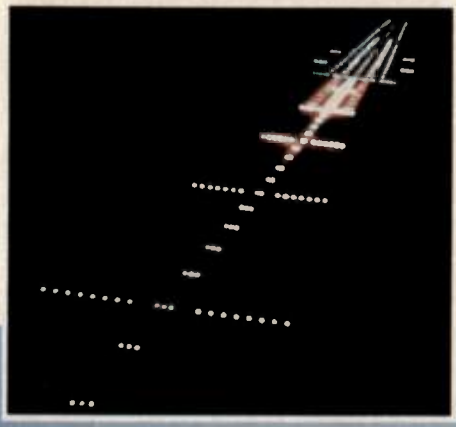
INFO CARD 7



New 2018/19 Signal Generator options test Radar and Avionics

The Marconi 2018 and 2019 Signal Generators now offer cost effective options for demanding applications. For test and maintenance of radar systems, the pulse option offers better than 65 dB carrier on/off ratio at 70 MHz. And the wideband circuits allow fast pulse edges to be handled.

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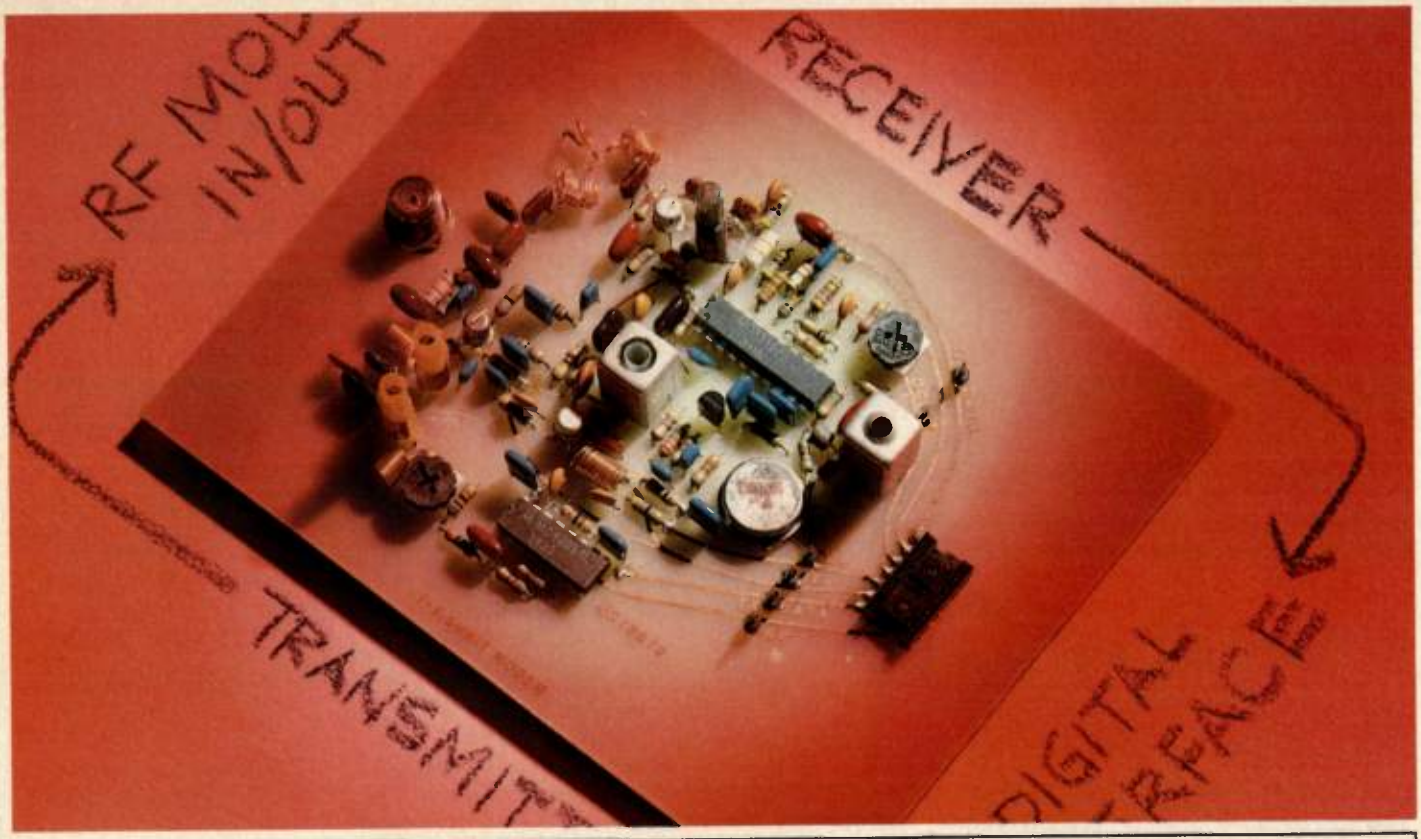
INFO/CARD 8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TRANSMIT

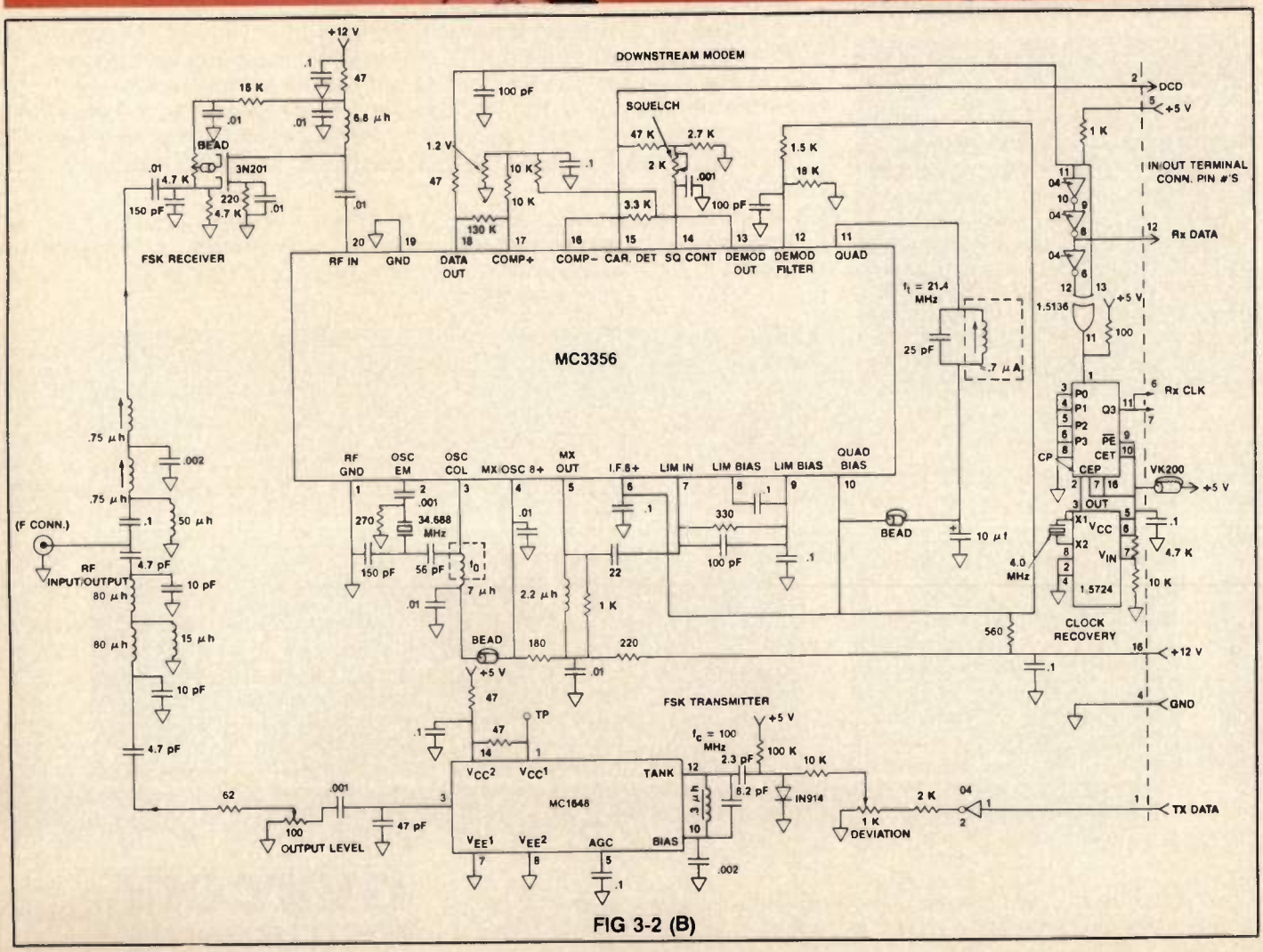
DOWNSTREAM MODEM
+12 V
SQUELCH
DCD
+5 V
IN/OUT TERMINAL CONN. PIN #'S
Rx DATA
Rx CLK
VK200
FSK RECEIVER
MC3356
RF IN
GND
DATA OUT
COMP+
COMP−
CAR. DET
SQ CONT
DEMOD OUT
DEMOD FILTER
QUAD
RF GND
OSC EM
OSC COL
MX/OSC 8+
MX OUT
I.F.8+
LIM IN
LIM BIAS
LIM BIAS
QUAD BIAS
BEAD
(F CONN.)
RF INPUT/OUTPUT
CLOCK RECOVERY
1.5724
FSK TRANSMITTER
MC1648
TANK
BIAS
AGC
IN914
OUTPUT LEVEL
DEVIATION
TX DATA
GND

FIG 3-2 (B)

RF Modems — Part I

Part I provides an introduction to the subject of RF modems and covers designs for single channel units.

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Motorola Semiconductor Products Sector
Phoenix, AZ

RF modems provide a means of relaying digital data between two locations by modulating/demodulating a carrier signal. In this sense they are like more common modems that interface to telephone networks. For telephone line modems, however, the carrier signal frequency lies within the audio range (<3 kHz) while for RF modems the carrier signal falls in the RF spectrum and is typically transmitted via the airways or a broadband coaxial cable similar to that used in CATV networks. RF modem carrier frequencies to over 400 MHz are practical for cable systems and operation to over 100 MHz is quite common. RF modems offer high data rates and the simultaneous use of many channels (one per RF carrier employed) and are frequently used in distribution systems and CATV networks.

The maximum data rate and number of operating channels required of an RF modem varies with the application. In some cases a single channel (or a transmit/receive channel pair) is sufficient. In other applications a multi-channel modem is required. The term "frequency agile" is used to describe modems that can be programmed to operate on various channels or carrier frequencies. In addition to being a key cost determining factor, the data rate also establishes bandwidth requirements for each RF channel and thus sets the maximum number of channels possible within a given system bandwidth. For example, 6 MHz of system bandwidth might be used to accommodate approximately 20 to 60 low data rate (64 Kbit) channels or two high data rate (approximately 1.5 to 2.5 Mbit) channels.

The Basics

The major functions of a frequency agile RF modem and its associated digital interface are given in Figure 1 along with ICs (also see Inset) useful for their implementation. The digital interface provides the necessary system control and data processing but is normally not considered as part of the RF modem itself.

The modem in Figure 1 can be programmed to operate on one of many RF channels via the channel code provided to the channel control function. This is accomplished by making the channel control function a phase-locked-loop (PLL) RF frequency synthesizer. A synthesizer controls both the transmitter's RF output signal frequency and the receiver's local oscillator or mixer injection signal frequency. The local oscillator signal dictates what RF channel the receiver will respond to. Depending on the degree of transmitter/receiver channel flexibility required, one or two PLL synthesizers may make up the channel control function. Also, in some design approaches, the data to be transmitted (T_X data) may also be applied to the program input of the PLL that is controlling the transmit channel frequency (dashed connection in Figure 1).

Non frequency agile modems are intended for operation on only one RF channel (or in some instances perhaps two or three channels at the most) and the frequency synthesizer channel control function is not required. Instead, crystal or ceramic resonator controlled oscillators are used to set up the operating channel frequency. A different resonating element/oscillator must be provided if one wishes to cause the modem to operate on another channel. This can be accomplished by physically changing the appropriate circuit elements or by electrically selecting between channel elements that are provided in a multiple fashion within the modem itself. A single channel modem can be produced for less cost than a frequency agile modem but this cost differential diminishes rapidly as the number of operating channels is increased.

System and Cost Trade-offs

The most important RF modem characteristics to be considered are:

- Number of channels.
- Maximum data rate.
- Channel frequency values/frequency range.
- Paired or independent transmit/receive channel frequencies.
- Transmit/receive frequency offset value.

All of the above must be traded-off against modem cost and suitability for a particular application.

The number of channels the modem is capable of being programmed to operate on dictates if a phase-locked-loop (PLL) frequency synthesizer must be incorporated in the design. No synthesizer is needed for single channel operation while greater than three channels will normally require a synthesized approach. Two and three channels units fall into the "gray" area. However, even if not required for channel generation, a PLL may sometimes still be incorporated as the method of generating an FSK modulated carrier for transmission. With the advent of economical LSI PLL ICs and low cost prescaler devices, the use of one or more PLLs does not necessarily mean the modem will be overly expensive.

Although system requirements may dictate a multi-channel modem, cost trade-offs still exsit since the transmitter and receiver can be designed so that channel control is available to each one independently (fully frequency agile) or so that the transmitter and receiver are controlled together with a fixed frequency offset between their respective channels (paired channel operation). For paired channel designs, the choice of transmit/receive offset will impact cost.

The *number* of operating channels alone does not, however, tell the whole story. One "X" channel modem may be significantly more complicated than another "X" channel modem — the actual frequency values involved and also the frequency spread or bandwidth over which the modem must perform can be of equal or greater importance is setting cost. Closely related to these issues is the modem's maximum data rate specification. Higher channel data rates require greater bandwidth per channel and thus a wider total frequency range for a given number of channels. It is worth noting that, for a given total system bandwidth, a small number of high data rate channels will give greater total data output than a large number of lower rate channels. This is because a portion of the system bandwidth must always be devoted to guardbands between adjacent channels. This portion of bandwidth becomes greater, of course, as the number of channels increases. In addition to increased bandwidth requirements per channel, higher data rate signals also tend to be more difficult and expensive to generate and to receive.

The wider bandwidth requirement imposed upon the modem's receiver by higher data rates can affect the choice of frequency for the receiver's IF. Relationships exist between the IF filter's passband and center frequency that must be adhered to. Also, the receiver's IF value and all signal frequencies present at the receiver's input (both desired and undesired) set the location and severity of receiver spurious responses and the

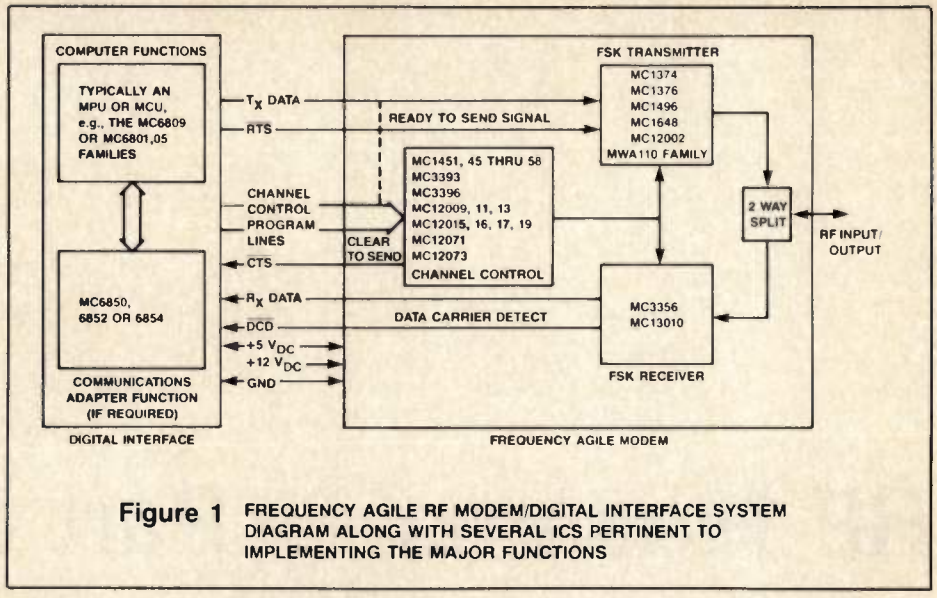


Figure 1 FREQUENCY AGILE RF MODEM/DIGITAL INTERFACE SYSTEM DIAGRAM ALONG WITH SEVERAL ICS PERTINENT TO IMPLEMENTING THE MAJOR FUNCTIONS

degree of receiver front end filtering that will be necessary for adequate performance.

Although the above trade-offs must be dealt with, the application will usually fix many of the key items such as maximum data rate, channel frequencies, and number of channels. This makes it easier to "zero in" on the remaining considerations.

In general, one may summarize as follows:

- Lowest cost units can support data rates up to approximately 200 Kbits per second. This breakpoint is set by the bandwidth limit if available low cost FM broadcast receiver IF filters.
- For lowest cost, receive channel frequencies should be less than approximately 150 MHz and receiver IF value less than approximately 30 MHz. These breakpoints allow economical data receiver ICs such as MC3356 to be used.
- Modem cost can be expected to rise as the bandwidth over which the modem's RF channels fall increases.
- Other things being equal, a lowest to highest cost progression can be expected for single channel, frequency agile paired channels and fully frequency agile modems, respectively.
- A substantial portion of the increased cost for wider bandwidth and higher frequency can be attributed to the filters and crystals required rather than the semiconductor content.

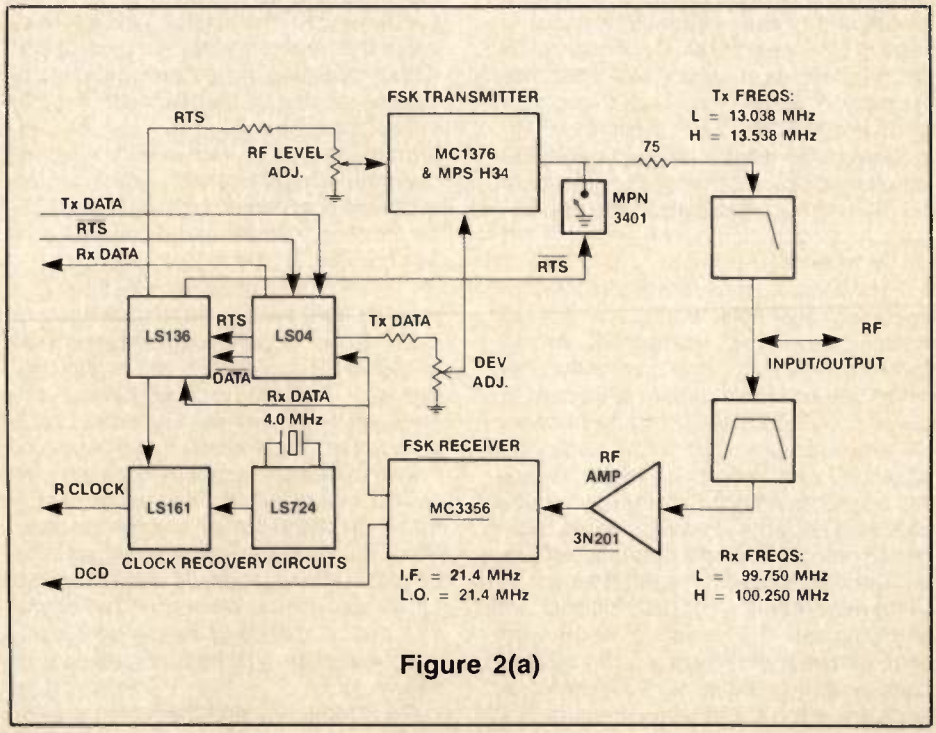


Figure 2(a)

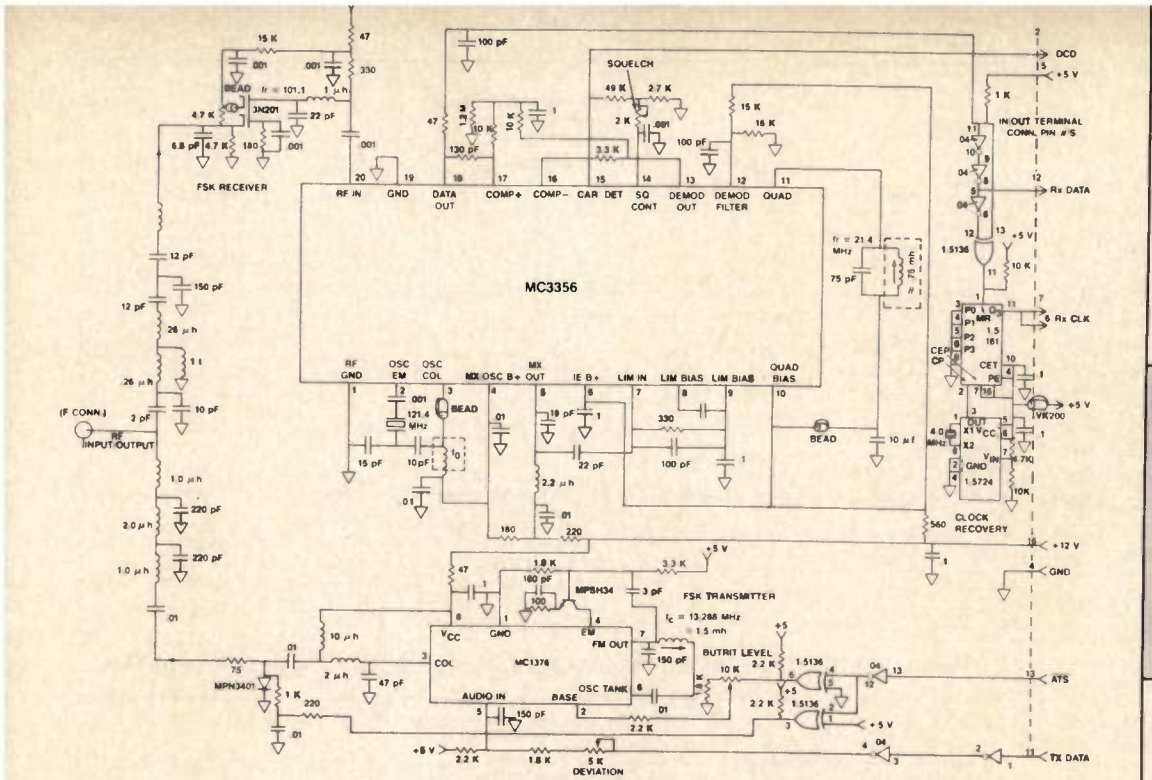
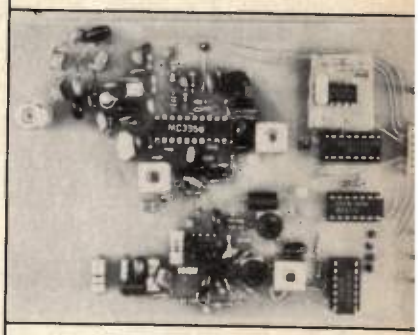


Figure 2(b)



As one would expect, cost of the digital interface functions is also substantially influenced by the data rate (T_X data and R_X data speeds). Other parameters being equal, some of the cost breakpoints for these functions can be estimated to be at about 10 Kbps (low cost MCUs such as the MC6852). Actually, the capability level and therefore cost of the digital interface circuitry is frequently dictated by system needs other than those of the RF modems. It is thus usually best not to include this cost factor as part of the modem's cost when arriving at modem performance/cost trade-offs.

Modulation Approaches

RF modem designs can employ any one (or variations thereof) of the three modulation methods: Amplitude Modulation (AM), Phase Modulation (PM), and Frequency Modulation (FM).

AM receivers or demodulators are susceptible to errors from impulse noise which is prevalent in digital systems. FM and PM are rather impulse noise immune once the receiver signal is great enough to cause IF limiting to occur. Phase modulation requires a somewhat complex receiver/demodulator to recover the data. Being complex, it is not as cost-effective as a frequency modulated system.

Even though FM may require slightly wider bandwidths than corresponding AM or PM system, it is employed in many applications because it is more effective than AM in combatting noise and interference and more cost-effective than a corresponding PM system.

A simple form of frequency modulation occurs when the modulating signal is a binary serial data stream. The frequency of the carrier is made to shift between two values, one occurring when the data is high and the other when the data is low. Such a binary FM system is referred to as a frequency-shift-keyed (FSK) system.

After considering cost, bandwidth requirements, impulse noise susceptibility, and the availability of proper transmitter and receiver parts, FSK modulation was selected for the RF modem designs described in the following sections.

FSK Transmitters

Four means of generating RF carrier signals for FSK transmission are:

- L/C Oscillator — The simplest but typically can be used only when a small number of channels are required and when the channel bandwidth allocation is great enough to allow the frequency deviation to be a large percentage of the carrier frequency. This allows for proper data recovery even though the carrier's center frequency is not extremely stable. The single channel modems described in Figures 2 and 3 employ this approach.
- Ceramic Resonator Stabilized Oscillator — Can be used for system requiring more frequency stability than is possible with the L/C oscillator method. A greater limit on the amount of frequency deviation than can be achieved is also imposed. An example of this approach will be presented in Part II.
- Crystal Oscillator Followed by a Digital Counter — The data to be transmitted causes the counter to divide the oscillator's frequency by one of two possible values when the data is a logic "high" and by the other value when the data is a logic "low." The single channel modem in Figure 5 uses this technique and employs a ÷10/÷11 dual-modulus prescaler for the counter function. This approach can provide a very accurate and stable FSK signal. However, it also has its limitations since the data rate, frequency deviation, counter divide values and the oscillator's frequency are all interrelated. This results in both upper *and lower* limits on maximum data rates and transmitter carrier frequencies that can be achieved with practical oscillator values.
- Novel Phase-Locked-Loop (PLL) approach — Provides a way of achieving a high degree of flexibility while still maintaining frequency stability. Both the loop's VCO and progammable counter in the feedback path are modified by the data to be transmitted, This technique allows frequency modulation of the loop VCO with non-symmetrical binary waveforms and is thus capable of processing NRZ data without and baseband encoding. This method will also be explored in Part II.

Non Frequency Agile Modems

The designation "non frequency agile" describes modems that operate on only a single RF channel (or a transmit/receive channel pair). To cause this type of modem to operate on a different RF channel usually requires physically changing certain frequency controlling elements, e.g. the crystal(s). However, it is sometimes economical to consider a "single channel" design for operation on two or poerhaps three channel pairs. This can be accomplished by adding the necessary frequency establishing elements for each channel to the modem and switching them in/out as appropriate by:

- Physically changing the appropriate circuit elements that control frequency.
- Electrically selecting between the frequency establishing circuit elements. This requires that all the appropriate elements be contained within the modem for each operating channel and that a means of selection be provided.

At a minimum, either of the above methods will require changing to one or more new crystals or other resonating elements for each additional channel of operation. In the case of switching electronically, switches exhibiting large on/off impedance ratios are required. With either approach, care must be taken during the modem design to use circuit techniques that are sufficiently broadband to allow operation over the intended RF range. This becomes difficult and impractical for wide frequency changes. However, for two or three channels (or transmit/receive channel pairs) that are closely spaced, either of the above approaches should be considered. For a greater number of operating channels or channels that are widely separated in frequency, a frequency synthesizer design approach should be employed.

Single Channel, 250 Kbps, CATV Modem Pairs

The terms "upstream" and "downstream" are frequently used in relation to CATV networks. They are also applied to modems used in these networks. An "upstream" modem resides at a subscriber's locations and a "downstream" modem is part of the headend equipment. CATV system requirements generally dictate that upstream modems transmit on frequencies below 30 MHz and receive on frequencies greater than 54 MHz. A typical receive channel frequency will fall in the vicinity of 100 to 120

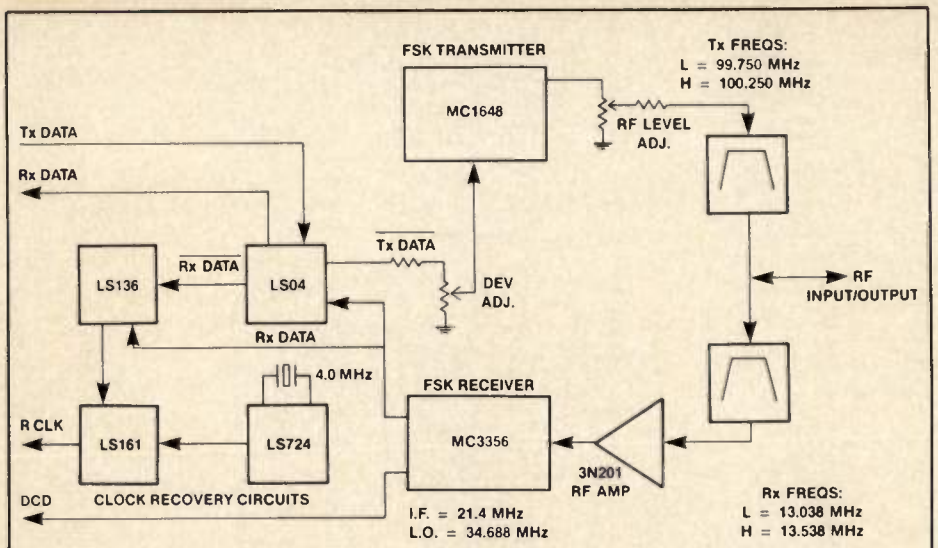


Figure 3(a) SINGLE CHANNEL, 250 KBPS DOWNSTREAM MODEM BLOCK DIAGRAM

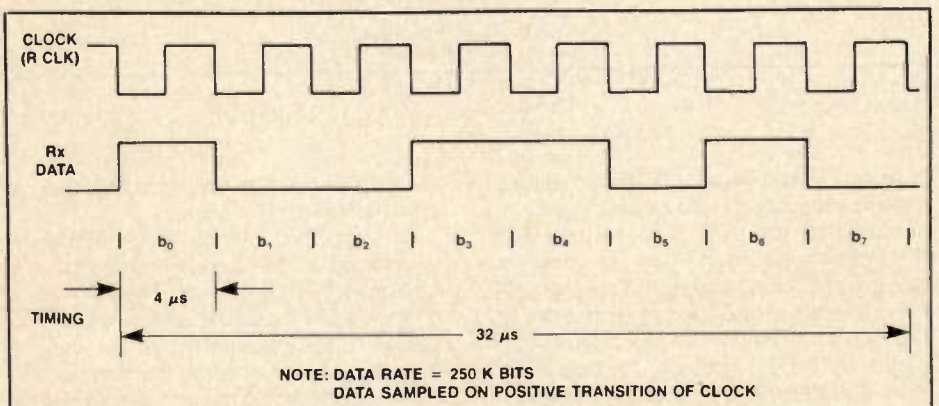


Figure 4 RECEIVED DATA AND GENERATED CLOCK WAVEFORMS

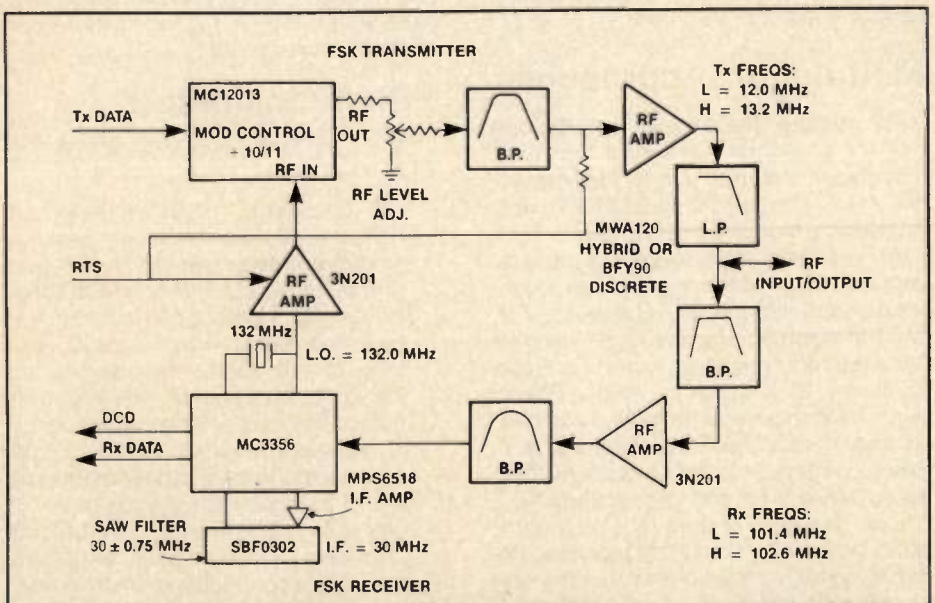


Figure 5(a) SINGLE CHANNEL, 1.5 MPBS, UPSTREAM MODEM BLOCK DIAGRAM

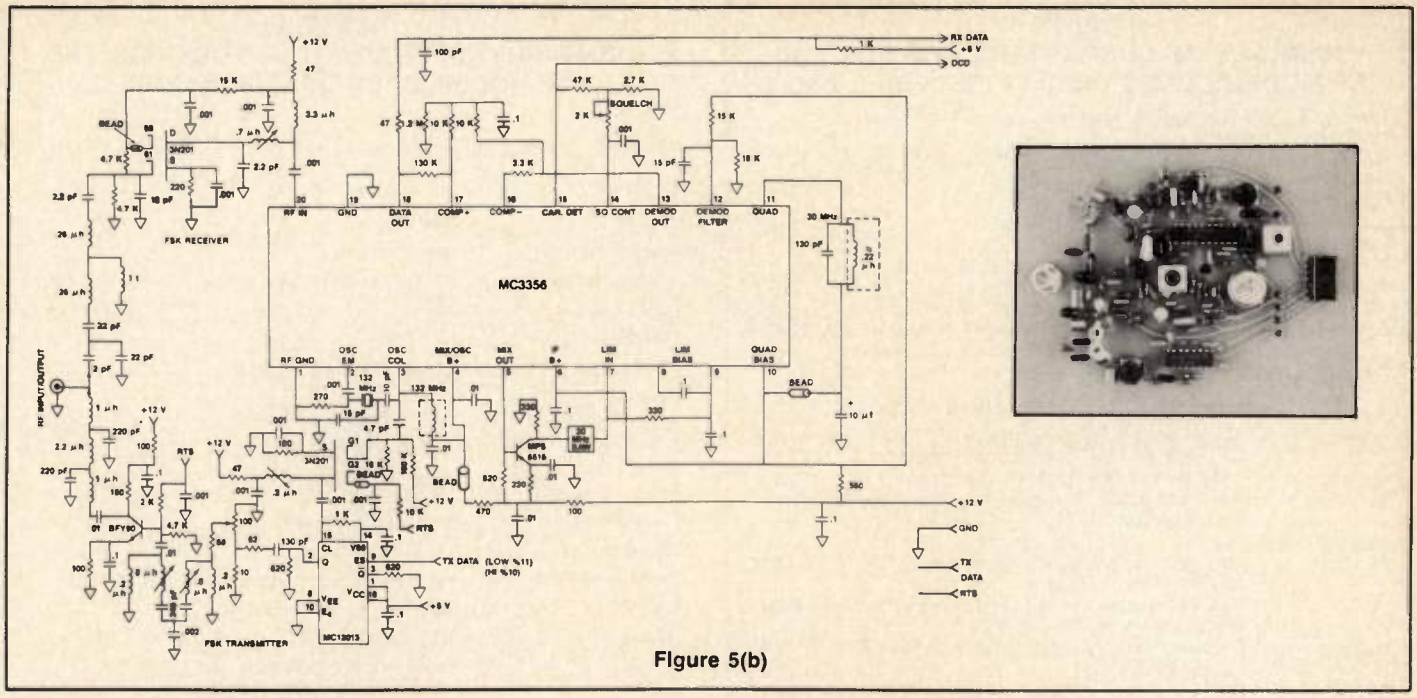


Figure 5(b)

MHz. The downstream modem transmits/receives on the exact opposite frequencies i.e. the receive/transmit frequencies of the upstream modem.

The modem described in Figure 2 can be considered an upstream modem and the design in Figure 3 a downstream modem. Their characteristics are summarized in Table 1. Both modems represent low cost designs capable of transmitting/receiving up to 250 Kbits per second of FSK data. Primarily, each of the modems requires only two ICs — the MC3356 data receiver and either the MC1376 (upstream modem) or the MC1648 (downstream modem) for use as the FSK transmitter. The LS devices indicated are essentially used for recovering a clock from the received data — a feature that can be considered separate from the RF modem itself. The upstream modem is described as having a transmit center frequency of 13.288 MHz and a receive center frequency of 100.000 MHz. The downstream modem operates on just the opposite frequency pair, Both modems employ 21.4 MHz for their receiver IF. Other frequency choices, within limits of the ICs, can also be employed using the same design approach.

Both the upstream and downstream modems employ similar sections using MC3356 with a discrete 3N201 RF front end gain stage tuned to the frequency of interest. The IF filters for the receivers (MC3356 pins 5, 7) are implemented using LC components. One may wish to use ceramic or SAW filters for these functions to improve band shaping and system signal to noise performance. Both receiver local oscillators (MC3356 pins 2, 3) are crystal controlled and require no adjustments. Neither transmitter, however, is crystal controlled. This is only ac-

IC'S USEFUL IN RF MODEM DESIGN

Receiver

- The MC3356 is a wideband FM receiver designed for use in digital data communications equipment. It includes an oscillator, mixer, limiting IF amplifier, quadrature detector, squelch, and data shaper comparator and is useful for RF inputs to over 150 MHz and IF value to approximately 30 MHz. Its -3 dB limiting sensitivity at 100 MHz is 30 μVrms (20 pin DIP).
- The MC13010 TV parallel sound IF includes a preamplifier, IF amplifier useful to over 80 MHz, quadrature AFT (automatic fine tuning) detector, and AGC outputs. The AFT output can be used to drive external data shaping circuits to provide the modem's received data output. The 13010 can be used when system requirements force the receiver's IF value to exceed the MC3356's capability (18 pin DIP).

Transmitter

- The MC1374 RF modulator includes an FM audio modulator, low and high frequency RF oscillators and a dual input RF modulator which can also serve as a doubly balanced mixer. The low frequency oscillator is useful to over 14 MHz and the high frequency oscillator and mixer to over 100 MHz.

In a typical RF modem application, the FM modulator and low frequency oscillator are used to form an FSK signal which is frequency converted in the mixer by adding/subtracting the two oscillator signals. The high frequency oscillator can serve as a VCO with the action of an external varactor diode (14 pin DIP).

- The MC1376 FM modulator includes the FM audio modulator and low frequency oscillator functions of the MC1374 described above (8 pin DIP).
- The MC1496 balanced modulator-demodulator can also serve as a doubly balanced mixer. Useful to over 100 MHz (14 pin DIP, 10 pin metal can).
- The MC1648 voltage controlled oscillator is a low noise design and includes an output buffer. Its frequency is determined by an external tank circuit which includes a varactor diode. The device is useful to over 200 MHz (14 pin DIP).
- The MC12002 double balanced mixer includes an input buffer amplifier and temperature compensated bias regulator. It is useful to over 400 MHz (14 pin DIP).

Channel Control

- The MC145145 thru 58 LSI CMOS PLL frequency synthesizer family consists of eight members. Each includes a crystal reference oscillator, reference frequency divider, digital phase detector and at least one programmable counter as well as other functions. Depending on the device, the reference divider is either fully programmable or provides eight preselected values.

All devices are specified for 15 MHz min. over -40°C to +85°C at 5 V_{DC}. Higher speeds are possible for higher supply voltages (to 10 volts maximum). Five of the devices are configured to control an external dual modulus prescaler which can extend their programmable counter capabilities to 1 GHz. The other five are intended for use without a prescaler or with a fixed value (single modulus) prescaler.

Three methods of programming are available: Four data bits combined with three address bits; a clocked, serial data stream; or fully parallel (14 or 16 bits). Package sizes range from 16 to 24 pins.

- Single modulus prescalers:

Device	Divide Values	Typical Max. Freq. (MHz)	Pkg. Pins
MC3396	20	200	8
MC12023	64	225	8
MC12071	64, 256	300, 950	14
MC12073	64	1100	8
MC12074	256	1100	8

- Dual modulus prescalers:

Device	Divide Values	Typical Max. Freq. (MHz)	Pkg. Pins
MC3393	15/16	140	8
MC12009	5/6	500	16
MC12011	8/9	550	16
MC12013	10/11	600	16
MC12015	32/33	225	8
MC12016	40/41	225	8
MC12017	64/65	225	8
MC12018	128/129	520	8
MC12019	20/21	225	8
MC12022	128/129	1000	8

TABLE 1
SUMMARY OF CHARACTERISTICS FOR THE RF MODEMS DESCRIBED IN FIGURES 2 AND 3

	General
Type:	Single channel
Maximum Data Rate:	250 Kbits/second (NRZ. other)
Modulation:	FSK
Frequency Deviation:	500 KHz (adjustable)
Transmitter RF Output:	0 to 35 dBmV (adjustable)
Input/Output Impedance:	75 ohms nominal (in band)
Clock:	250 KHz, synchronized on edges of received data. Positive going clock edges give timing for data sampling.
Receiver IF:	21.4 MHz
	Upstream Modem (Figure 2)
Inputs	
Power:	+5V_{DC} (terminal 5); +12V_{DC} (terminal 16); GND (terminal 4)
RTS:	Low enables, high disables transmitter (terminal 13)
T_x Data:	Serial data to FSK transmitter (terminal 11)
RF Input:	Receiver input (F connector); data high = 100.250 MHz, data low = 99.750 MHz
Outputs	
RF Output:	Transmitter output (F connector); data high = 13.538 MHz, data low = 13.038 MHz
DCD:	Data carrier detect — High in the presence of a received carrier (terminal 2)
R_x Data:	Received data — Demodulation of received FSK RF input signal (terminal 12)
R CLK:	250 KHz receive clock described above (terminals 6 and 7)
	Downstream Modem (Figure 3)
Inputs	
Power:	Same as above
RTS:	Now used — transmitter always enabled when power is supplied
T_x Data:	Same as above
RF Input:	Like above except data high = 13.538 MHz, data low = 13.038 MHz
Outputs	
RF Output:	Like above except data high = 100.250 MHz, data low = 99.750 MHz
DCD:	Same as above
R_x Data:	Same as above
R CLK:	Same as above

TABLE 2
SUMMARY OF CHARACTERISTICS FOR THE RF MODEM DESCRIBED IN FIGURE 5

	General
Type:	Single channel
Maximum Data Rate:	1.5 Kbits/second (NRZ, other)
Modulation:	FSK
Frequency Deviation:	1.2 MHz
Transmitter RF Output:	0 to 35 dBmV (adjustable)
Input/Output Impedance:	75 ohms nominal (in band)
	30.0 MHz center, -3 dB BW = 1.5 MHz — Bolth set by SAW filter (Toshiba SBF0302)
Receiver Mixer Injection:	High side, 132.0 MHz
Crystal:	Overtone, 132.0 MHz
Receiver Spurs:	Image = 162 MHz, Half IF = 117 and 147 MHz
	Inputs
Power:	+5V_{DC}, +12V_{DC}, GND
T_x Data:	Serial data to FSK transmitter
RTS:	Ready to send signal — High enables, low disables transmitter
RF Input:	Input for FSK receiver: data high =102.6 MHz, data low ³ 101.4 MHz
	Outputs
RF Output:	Transmitter output: data high = 13.2 MHz, data low = 12.0 MHz
DCD:	Data carrier detect — High in the presence of a received carrier
R_x data:	RF input signal

ceptable when proper shifts in carrier frequency are used in representing the digital data and when adequate system bandwidth and receiver IF bandwidth allowances are made to accommodate the potential frequency inaccuracies. In general, crystal or ceramic resonator controlled transmitter designs should be employed.

The clock circuitry generates a 250 kHz clock from the received data. It is synchronized on transitions of the incoming received data as shown by the waveforms in Figure 4. An appropriate data sample time is established by the clock's positive going edges.

Single Channel, 1.5 Mbps, Modem

The 1.5 Mbit RF modem illustrated in Figure 5 needs only two ICs and four discrete gain stages. The design receives and transmits on center frequencies of 102 MHz (CATV channel A-3) and 12.6 MHz respectively. Additional performance and operation characteristics are given in Table 2.

Both the modem's receiver and transmitter are crystal controlled by a single oscillator located in the MC3356 data receiver IC. The FSK transmit signal is achieved by dividing this oscillator's frequency by either ten (T_X data line high) or by eleven (T_X data line low). Proper division is accomplished by the MC12013 dual-modulus IC. The same oscillator provides the injection signal for the receiver's mixer which converts the incoming RF to the receiver's IF passband. The mixer and IF functions as well as the limiter, FSK demodulator and data shaping circuits are also contained in the MC3356.

The receiver 30 MHz IF frequency allows the use of a standard SAW filter which has reasonably optimum bandwidth to support a 1.5 Mbit data rate. However, 30 MHz is somewhat higher and the filter insertion loss greater than desired for the MC3356 and therefore additional IF gain is provided external to the IC by the MPS6518 stage (MC3356 pin 5).

The transmitter's RF output amplifier can be implemented using a discrete design as shown in Figure 5b or with a broadband hybrid amplifier gain block such as the MWA120 which is packaged in a three terminal metal can. RF transmission is inhibited by taking the RTS input line low. This renders both the transmitter's output amplifier and 3N201 input buffer amplifier inactive.

Part II to be included in the next issue (Nov/Dec 84) will cover multiple channel (frequency agile) RF modem designs.

About the Authors

John Hatchett, Member of Technical Staff with Motorola's Semiconductor Products Sector, is responsible for the systems engineering that leads to the definition, development and application of semiconductors in communication and home electronics equipment. A member of the Society of Professional Engineers, Hatchett received his BSEE degree from the University of Illinois and his MSEE from the Illinois Institute of Technology; he has been awarded two patents and has a third patent pending.

William J. Howell was born in Perry County, Indiana on June 27, 1933. He received an AAS Degree in Electrical Engineering Technology from Devry Technical Institute in Chicago in 1960. He worked for RCA in the RF Tuner Group at Indianapolis until 1973. In 1973, Howell joined The Motorola Semiconductor Group as an RF Application Engineer, where he is presently employed as a Sr. Staff Engineer in System Engineering Strategic Marketing. Howell has been awarded one patent and has two patents pending.

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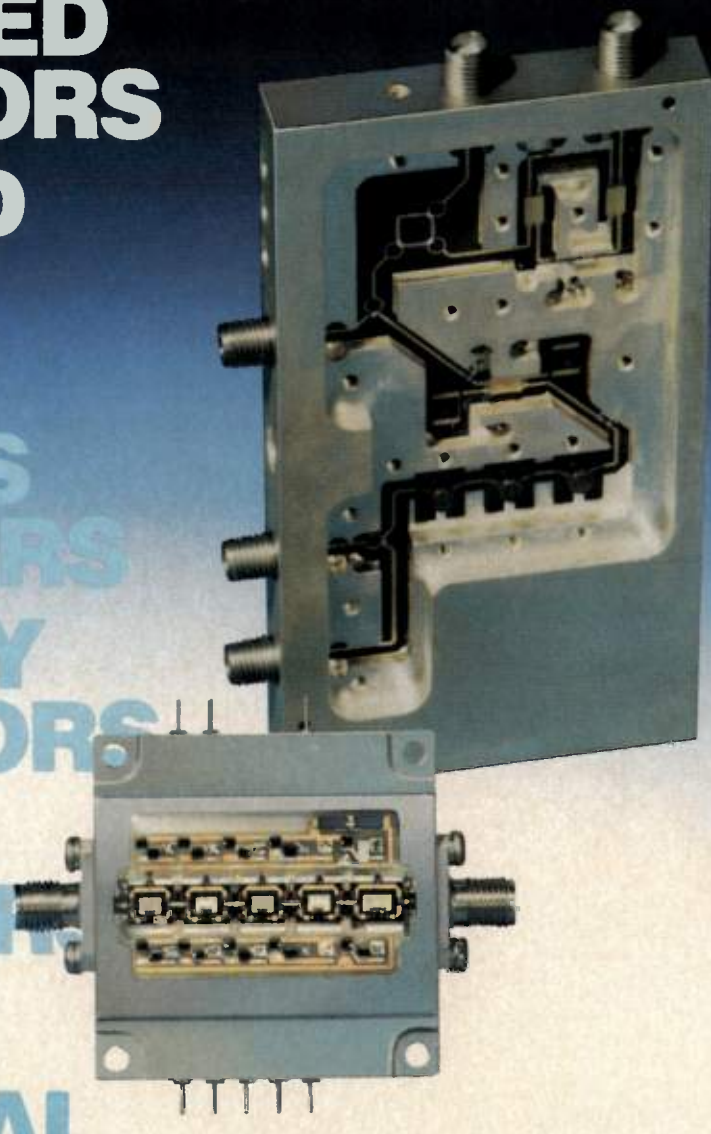

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MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200/510	300 - 1800 MHz	Log Periodic
SAS-200/511	1000 - 12000 MHz	Log Periodic
SAS-200/512	200 - 1800 MHz	Log Periodic
SAS-200/518	1000 - 18000 MHz	Log Periodic
SAS-200/530	150 - 550 MHz	Broadband Dipole
SAS-200/540	20 - 300 MHz	Biconical
SAS-200/541	20 - 300 MHz	Bicon'l, Collapsible

MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200/542	20 - 300 MHz	Biconical, Folding
SAS-200/550	001 - 66 MHz	Active Monopole
SAS-200/560	per MIL-STD-461	Loop - Emission
SAS-200/561	per MIL-STD-461	Loop - Radiating
BCP-200/510	20 Hz - 1 MHz	LF Current Probe
BCP-200/511	100 KHz-100 MHz	HF,VHF Cmt. Probe

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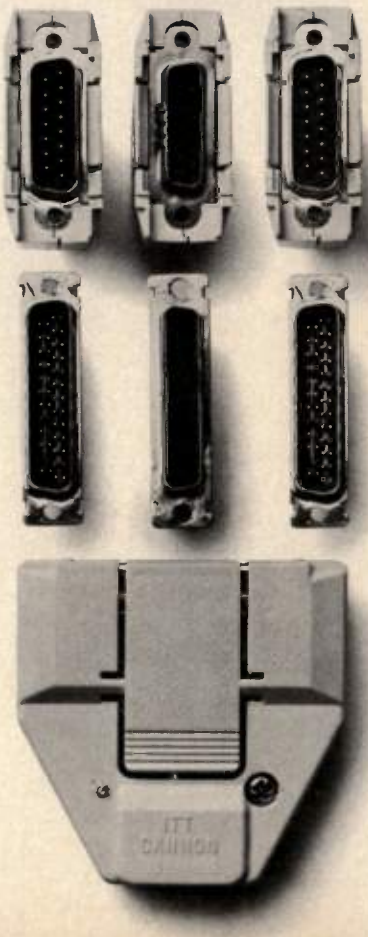

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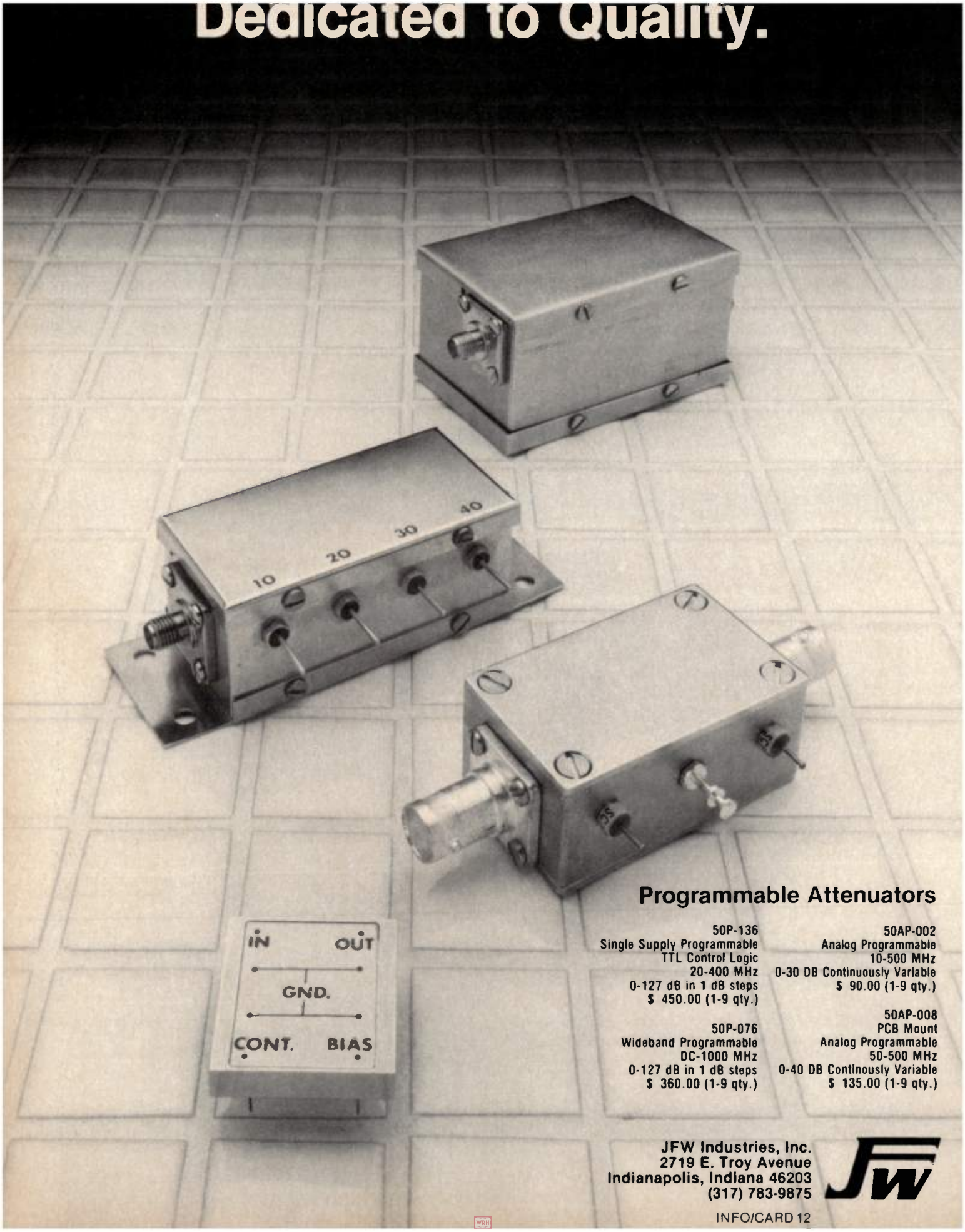

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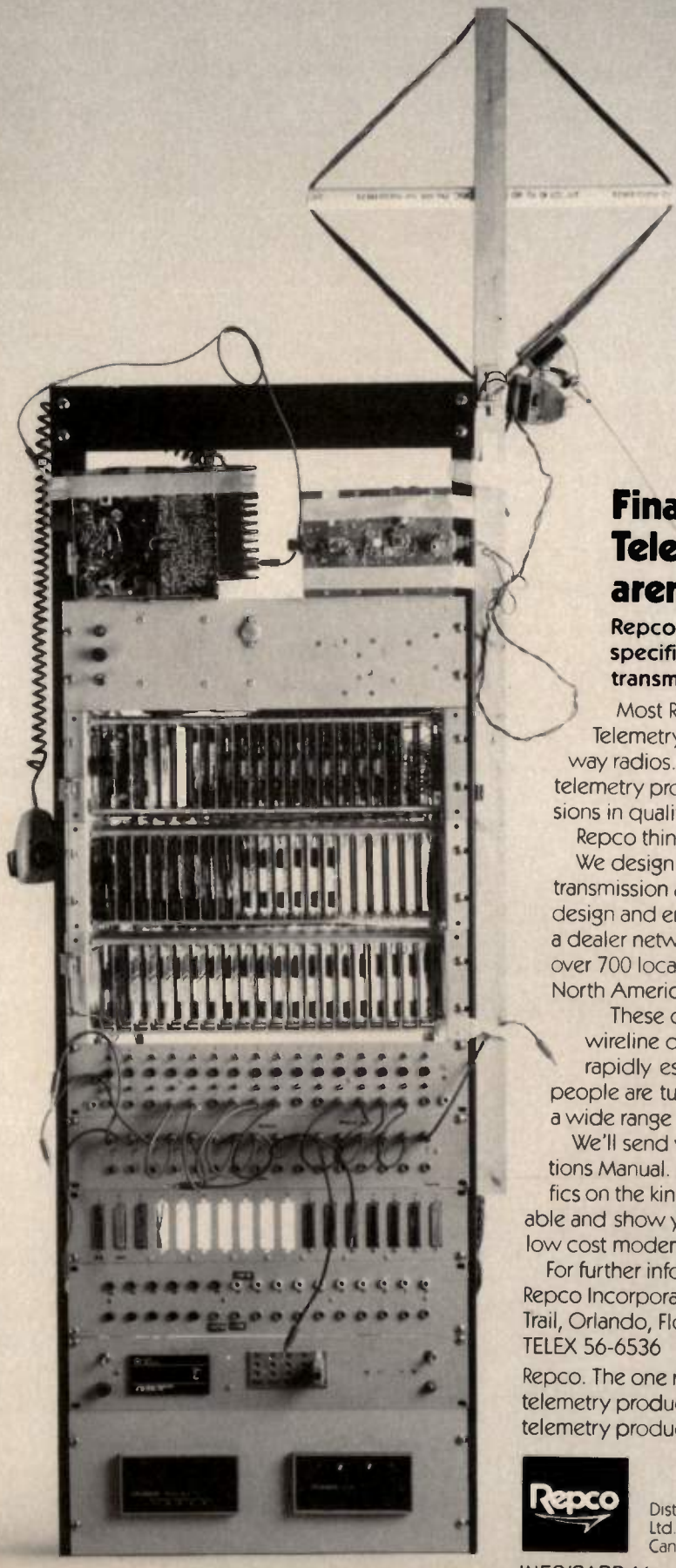

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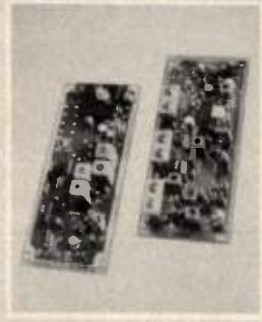

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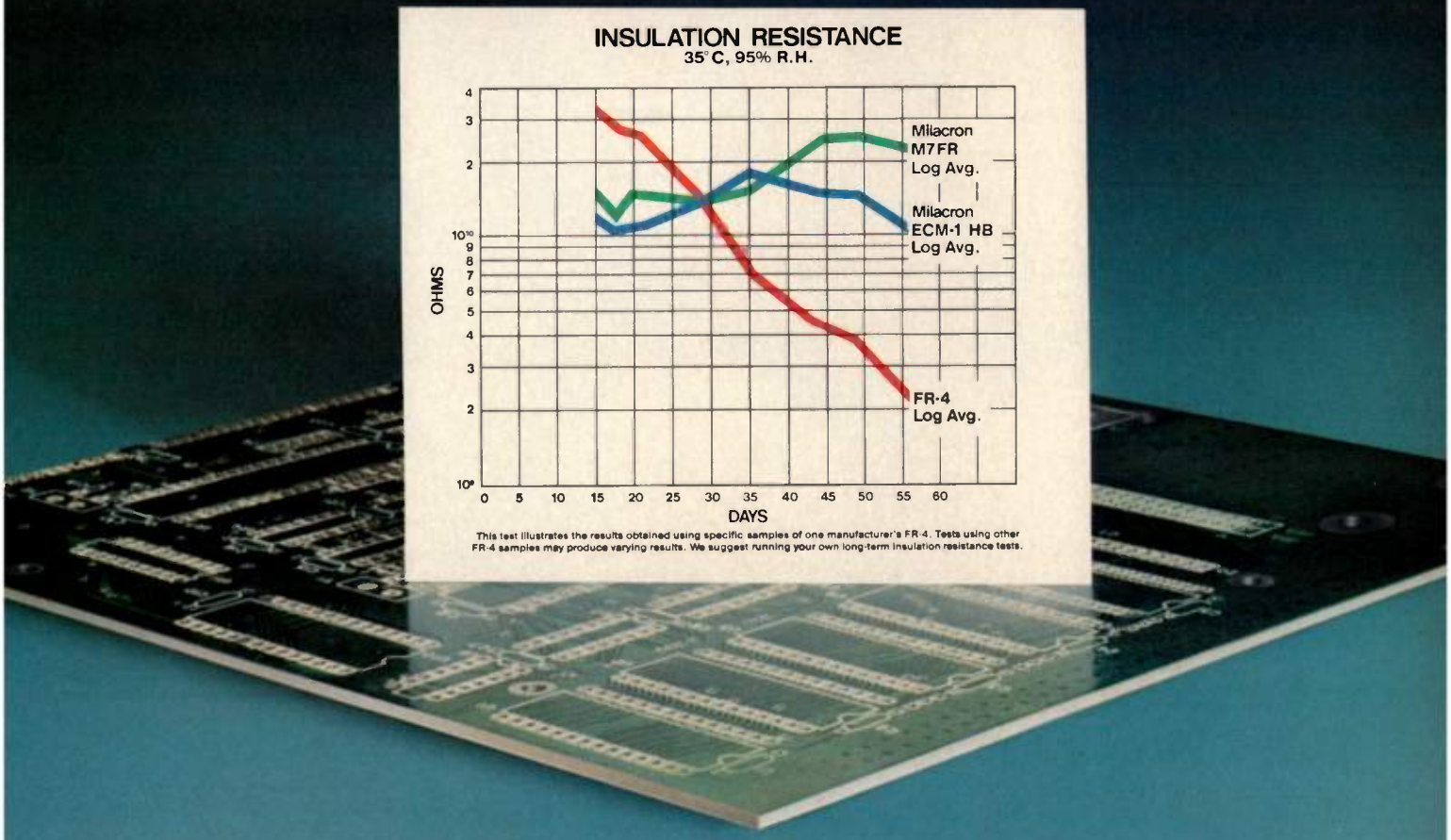

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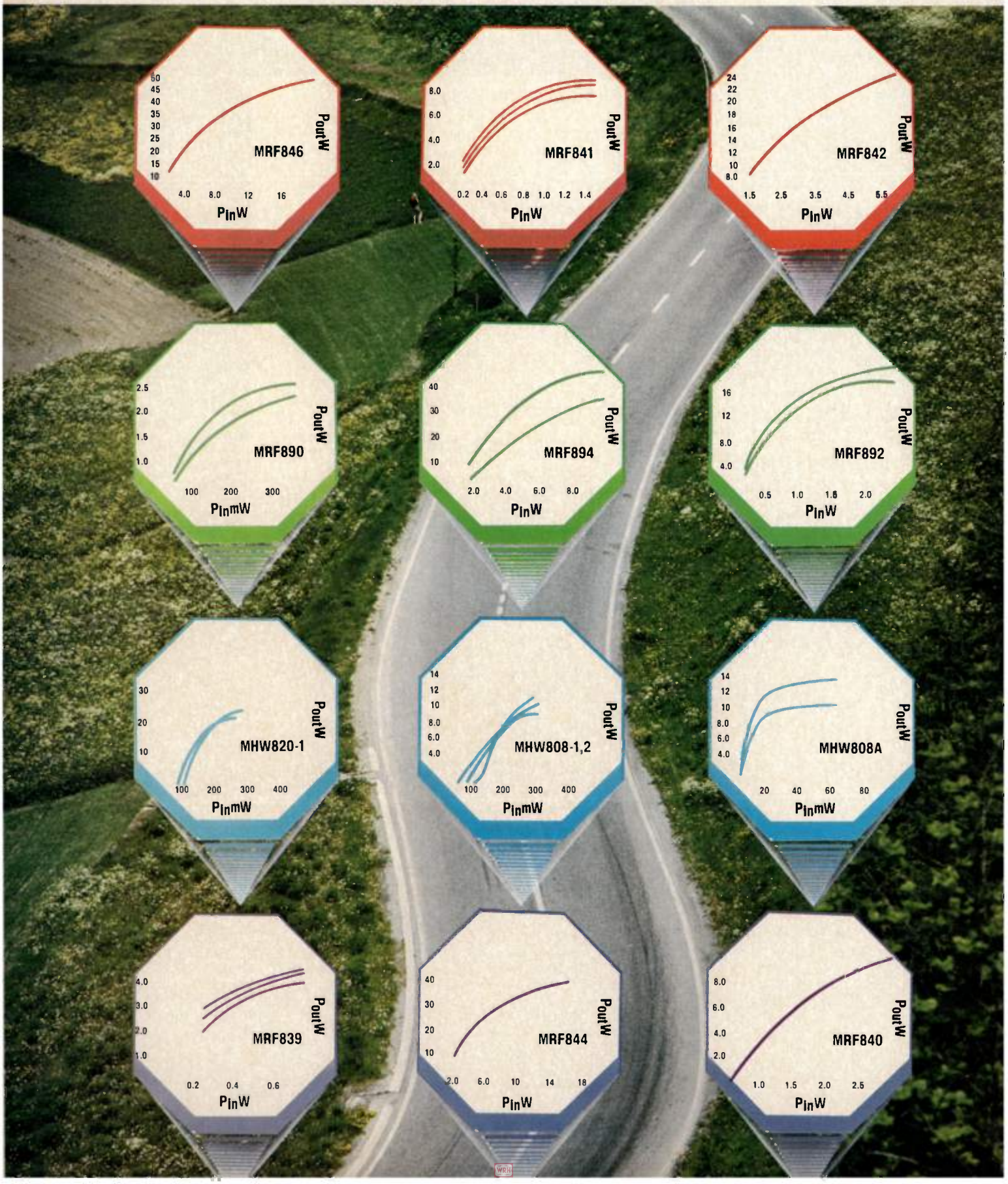

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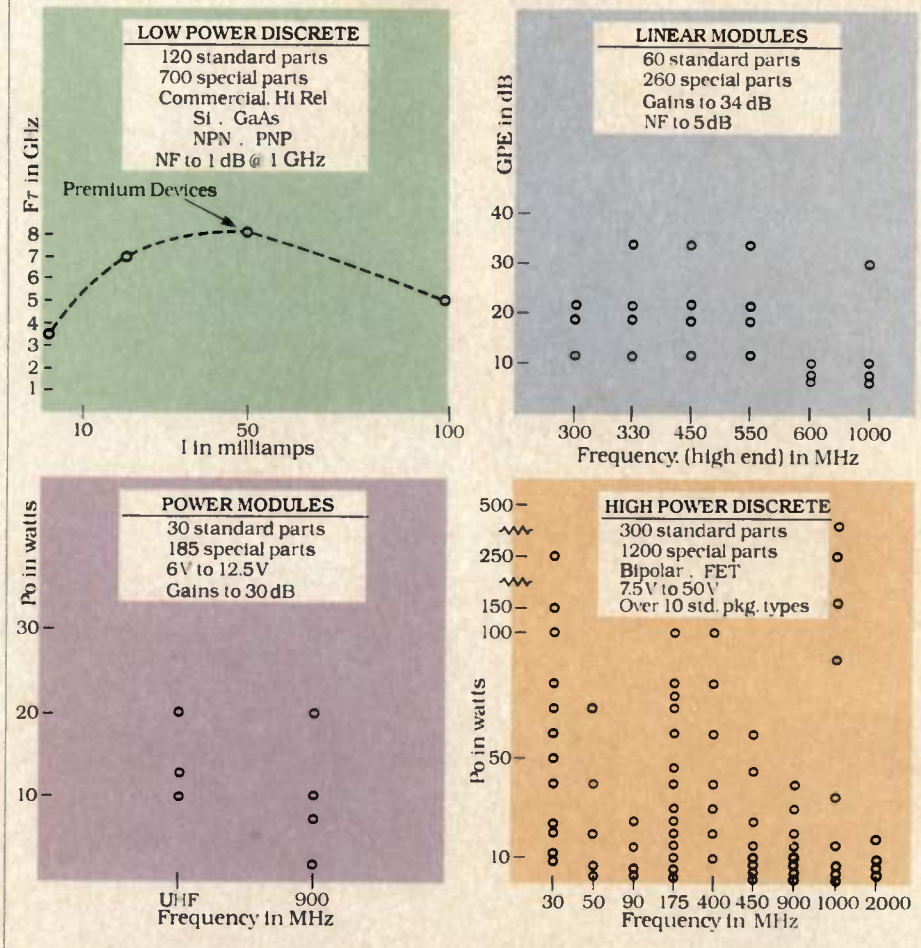

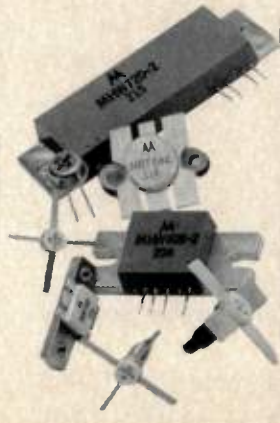

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INFO CARD 16

Synthesis of FM Signals

Signal generators are widely used to simulate communications signals. Use a variable-frequency phase-locked loop instead of a synthesis FM oscillator.

By Marcus da Silva
Hewlett-Packard Company
Spokane, Washington

The evolution in the uses for the RF frequency spectrum has so transformed test equipment requirements that the simple tunable oscillators of a few years ago have become the comlex synthesized signal generators of today. Among many other applications, signal generators are widely used to simulate communications signals. This requires them to have versatile and accurate modulation capabilities and wide frequency range along with ever increasing levels of frequency accuracy, stability and spectral purity.

Test equipment manufacturers have turned to frequency synthesis, typically using phase-locked loops, to achieve accuracy and stability in their RF signal generators. Phase-locked-loops, however, place some limitations on any type of angle modulation (phase or frequency). These limitations are normally overcome using a separate FM generator, usually a narrow-range voltage controlled oscillator (VCO) whose modulated signal is translated to the output frequency.

An alternate approach, used in the HP 8656B Signal Generator, synthesizes FM signals by controlling phase inside a variable-frequency phase-locked loop. This method eliminates the need for a separate FM oscillator while providing unprecedented FM performance. The synthesizer remains locked while in FM mode, retaining its inherent accuracy and stability.

The HP 8656B uses this scheme in a fractional-N phase-locked loop[1]. This implementation provides DC-coupled FM with drift rates of less than 10 Hz per hour and an initial offset of less than 500 Hz. It also allows AC coupled FM with a lower 3-dB frequency of less than one Hertz and a modulation index of 4000. Also, the loop bandwidth remains unchanged in FM mode, maintaining excellent phase noise and stability[2]. Low-drift DC FM is necessary for low-rate digital FM such as the unsquelching signals used in mobile radios or signaling codes used in modern pocket pagers. It can also be used as a general purpose VCO. AC coupled FM is needed in any application where the center frequency needs synthesized accuracy.

This article describes the theory and techniques used in implementing such an FM synthesis system. Some phase-locked loop basics are included as well as pertinent block diagrams.

Frequency (FM) and Phase (PM) Modulation

Frequency is the time derivative of phase. The same relationship holds for FM and PM[3]. For sinusoidal modulation,

$$f(t) = \Delta f_{pk} \cos \omega_m t \quad ,$$

where f(t) is the instantaneous frequency deviation and Δf_{pk} is the peak frequency deviation.

$$\phi(t) = \int 2\pi\, f(t)\, dt \quad ,$$

$$\frac{\phi(t) = 2\pi\, \Delta f_{pk} \sin \omega_m t}{\omega_m} \quad , \text{and}$$

$$\frac{\phi(t) = \Delta f_{pk} \sin \omega_m t = \beta \sin \omega_m t}{f_m} \quad ,$$

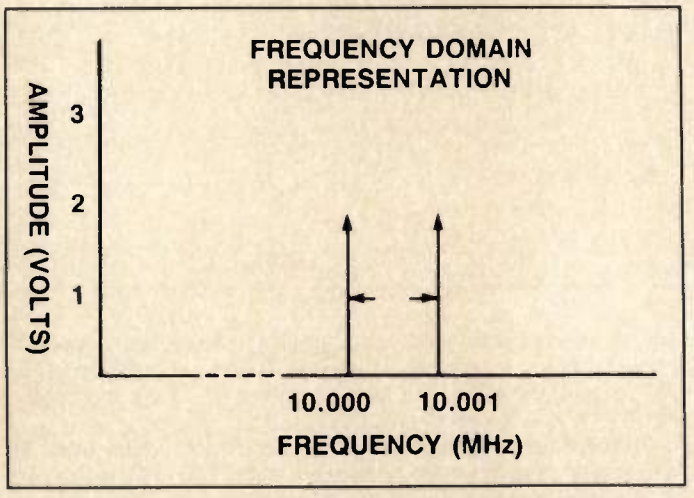
where $\phi(t)$ is the instantaneous phase deviation, and f_m is the modulation rate.

Eq. 1 desribes the instantaneous frequency deviation. When Eq.1 is integrated, it yields the instantaneous phase deviation shown in Eq. 2. the quantity β is called the modulation index. It is equivalent to the peak phase deviation and is measured in radians. If instead of a sinusoid the modulating signal is a DC level, the frequency is offest by a fixed amount. The phase deviation is then the integral of the frequency deviation and increases linearly with time. This point is illustrated by the following example:

Example

Consider two 10 MHz signals initially in phase. If one of the signals is DC frequency modulated with a deviation of 1 kHz, it will be a single tone at 10.001 MHz. Their frequency difference is 1 kHz as shown in Figure 1a. The phase difference between the two signals is a ramp that increases at a rate of 1000 cycles per second or 2000 π radian/sec. as shown in Figure 1b.

From Eq. 2 it follows that for sinusoidal FM with constant peak deviation the modulation index, β increases as the modulation frequency decreases. In the case of DC FM, β becomes infinite. These relationships between phase and frequency are crucial to the understanding of FM in a phase-locked loop.



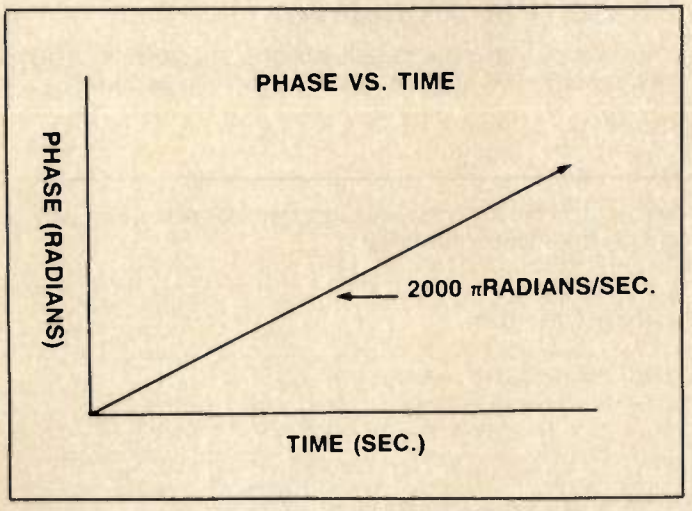


Figure 1b. Time-domain representation of phase deviation for a 10 MHz signal with kHz DC FM.

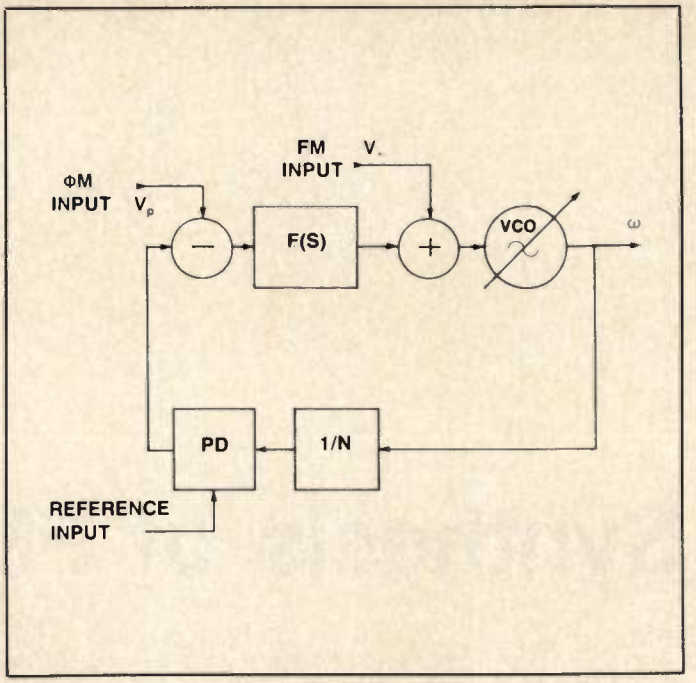


Figure 2. Basic Phase-locked loop

FM and ϕM in a Phase-Locked Loop

Fig. 2 shows a simplified block diagram for a phase-locked loop. It includes a phase detector (PD), an arbitrary loop filter (F(s)), a voltage controlled oscillator (VCO), and a frequency divider (I/N). Shown also are inputs for frequency and phase modulation of the output signal.

The general transfer function for such a phase-locked loop is given by:

$$\frac{\phi o(s)}{\phi ref\ (s)} = \frac{K_v K_D\ F(s)}{S + \frac{K_v K_D\ F(s)}{N}}$$

where $\phi o(s)/\phi ref(s)$ relates the phase of the output signal to the phase of the reference signal. K_v is the VCO gain constant (radian/sec. volt), K_D is the phase detector gain (volt/radian), N is the frequency divisor and F(s) is a transfer function that represents any circuitry such as filters and amplifiers[4].

The response to the ϕM input is given by the transfer function

$$\frac{\phi o(s)}{V_p(s)} = \frac{K_v F(s)}{S + \frac{K_v K_D\ F(s)}{N}}$$

which relates phase deviation of the output from its center value to the voltage at the ϕM input.

The response to the FM input is

$$\frac{\omega o(s)}{V_F(s)} = \frac{S\ K_v}{S + \frac{K_v K_D\ F(s)}{N}}$$

which relates deviation from center frequency of the output signal to the voltage at the FM output.

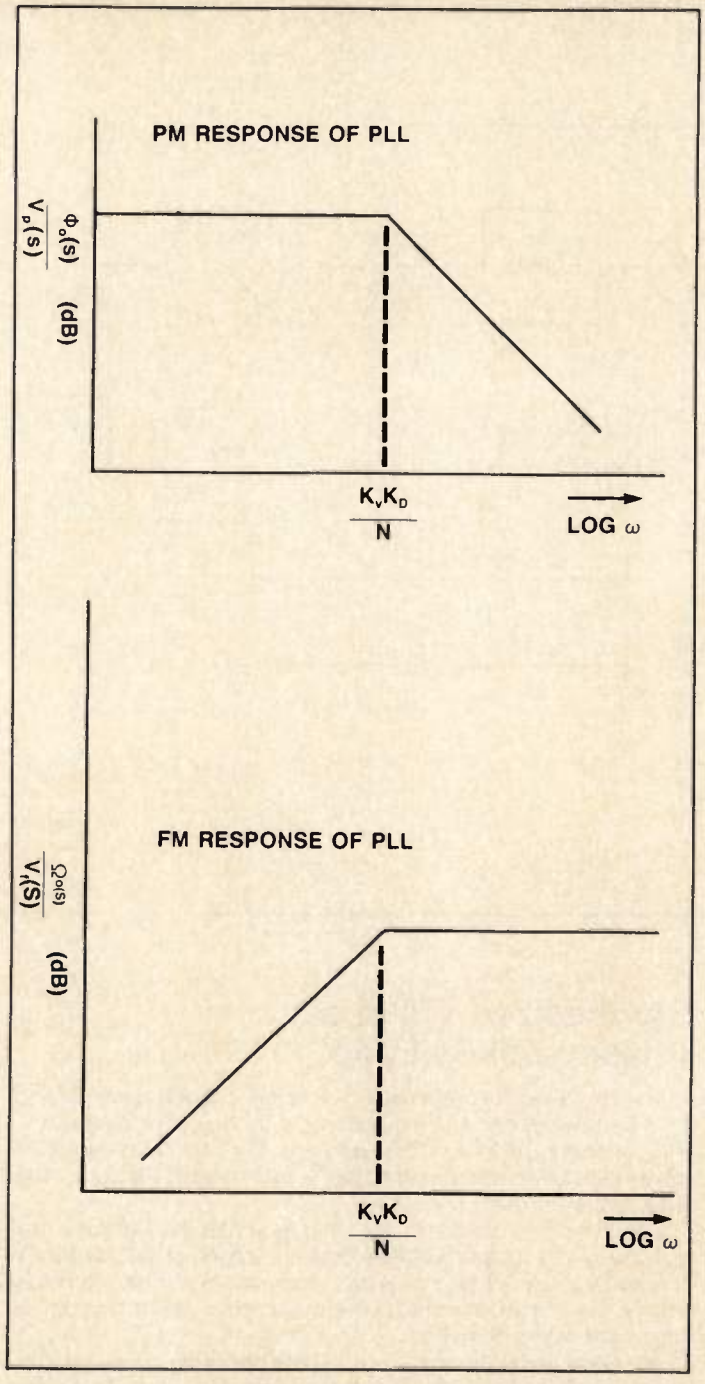


Figure 3. FM and ΦM response of a phase-locked loop

For the simple case where F(s)=1, the response to the ϕM input is a low-pass function and the response to the FM input is a high-pass function as shown in Fig. 3. The quantity K_vK_D/N deterines the loop 3dB bandwidth. It follows that a phase-locked loop can be phase modulated at rates that lie inside its loop bandwidth, and frequency modulated at rates that lie outside its loop bandwidth. These two properties are utilized in the method described here for obtaining flat FM response. The FM input signal is converted into an equivalent ϕM input signal via an integrator. Both the FM and ϕM inputs are then used in Fig. 4.

The transfer function of the integrator is given by

$$\frac{V_{o(s)}}{V_i(s)} = \frac{K_i}{S}$$

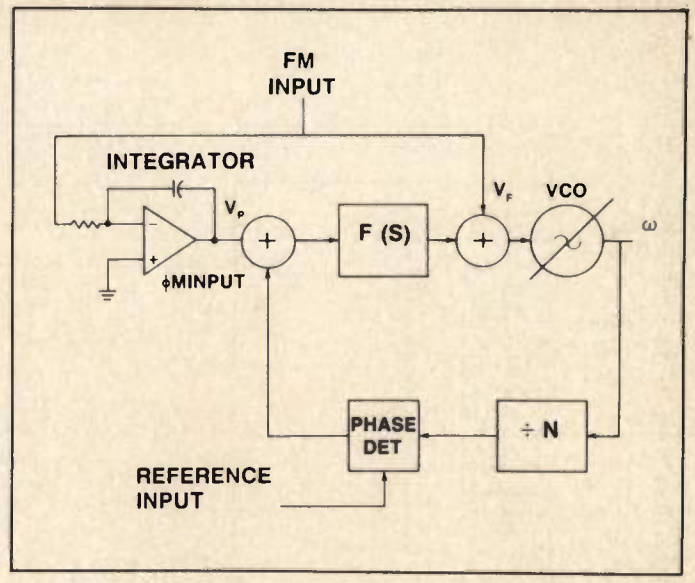


Figure 4. System for flat FM in a phase-locked loop.

The FM response due only to the integrated path is then

$$\frac{\omega o(s)}{V_f(s)} = \frac{K_iK_v\ F(s)}{S+K_vK_D\frac{F(s)}{N}}$$

If the responses to both paths are added, the result is

$$\frac{\omega o(s)}{V_f(s)} = \frac{S\ K_v}{S+K_vK_D\frac{F(s)}{N}} + \frac{K_iK_v\ F(s)}{S+K_vK_D\frac{F(s)}{N}}$$

Let $K_i=K_vK_D/N$, and

$$\frac{\omega o(s)}{V_f(s)} = K_v\ \frac{S+K_vK_D\frac{F(s)}{N}}{S+K_vK_D\frac{F(s)}{N}} = K_v$$

If the resulting gain of the integrator is chosen so that $K_i=K_vK_D/N$, the resulting FM response is only dependent on K_v as shown in Eq. 9. It does not vary with frequency and is completely independent of the loop filter F(s). This method allows the output of the phase-locked loop to be frequency modulated at rates that lie both inside and outside the loop bandwidth. Mathematically, the response of such a system can be extended to an arbitrarily low frequency, even to DC. Real phase-locked loops, however, have some limitations.

Limitations of Phase-Locked Loops

The ideal system for frequency modulation of a phase-locked loop consists of a wide-bandwidth loop with both a phase detector and an integrator that have infinite range. Realizable systems, however, cannot accommodate these requirements in a conventional manner.

Phase Detector Range

The peak phase deviation of the output signal is given by β. The greatest phase difference between the two signals at the phase detector is

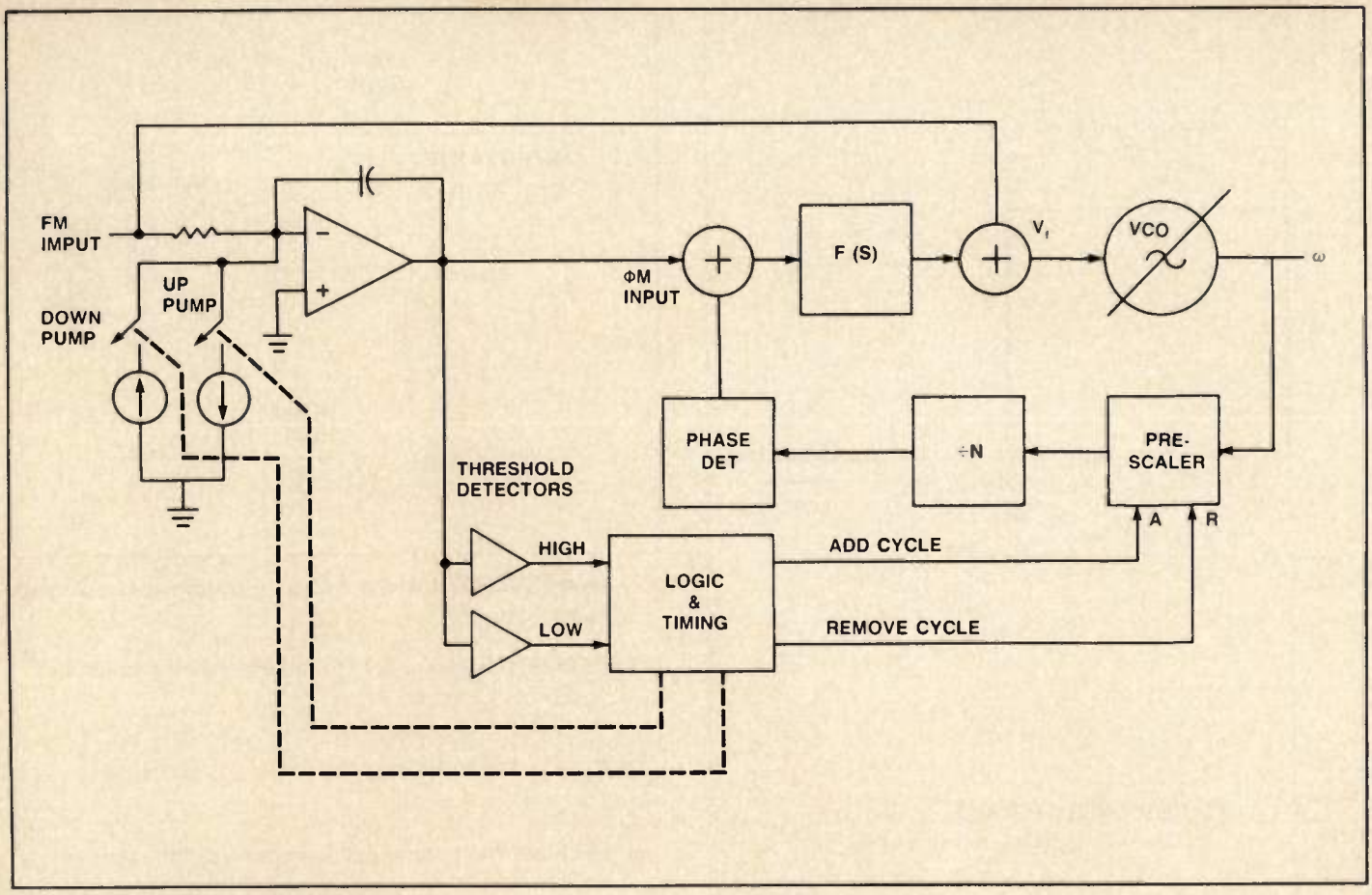


Fig. 5 Synthesized-FM System

$$\Delta\phi_{pk}=\frac{\beta}{N}$$

The phase detector must operate linearly over a range of β/N if the phase-locked loop is to faithfully reproduce the modulation signal. Double-balanced mixers have a linear phase measuring range of a few tenths of a radian. Digital phase detectors have ranges of up to 2π radians. The maximum possible phase deviation at the output of a phase-locked loop using a digital phase detector is 2π radians. This becomes a problem at low modulation rates and high FM deviations. DC FM is impossible since it requires an infinite modulation index.

Integrator Range

The integrator shown in Fig. 4 is typically implemented with op-amp. The output voltage swing is inherently limited by the power supply voltages. An ideal integrator's response to a DC input is a ramp that increases without bound. In a real integrator, the ramp stops at the op-amp swing limits.

Loop Bandwidth

In a typical signal generator application, the RF signal must be modulated at audio rates and relatively high frequency deviations. This requires high phase deviations at the lower modulation rates. the usual way to overcome the deviation limits is to build a phase-locked loop with a very narrow bandwidth, allowing most or all of the modulation signal to fall outside of the loop bandwidth.

The tradeoff of a low loop bandwidth is loss of the stability provided by a wide band loop. Phase-locked loops reduce phase noise at offsets from the carrier that are less than the loop bandwidth. Narrowing the loop bandwidth therefore reduces the noise improvement properties of the loop. Narrow-band loops are also more susceptible to noise and jitter caused by external sources such as powerlines and vibration.

Synthesized FM in a Phase-Locked Loop

The limitations of phase detector range, integrator range, and loop bandwidth can all be overcome with the scheme shown in Fig. 5. It consists of a system similar to Fig. 4 with the addition of a variable-modulus prescaler[5], threshold detectors, and switchable current sources.

The threshold detectors are used to sense the instant when the integrator output voltage crosses either of two arbitrary thresholds. One detector senses when the integrator output is above the higher threshold, the other when the integrator is below the lower threshold.

After one of the threshold is crossed, precision timing circuits momentarily activate the appropriate current source. This adds or removes a precise amount of charge from the integrator capacitor, effectively resetting the integrator and maintaining its output between two limits.

The prescaler is composed of a frequency divider with three moduli (9, 10, and 11) and some synchronization circuitry. The prescaler has three functions. Each time the REMOVE input is activated, one cycle is removed from the divider input by the prescaler. A current source is then turned on for a precisely controlled time interval. It pumps just enough charge into the integrator capacitor to compensate for the one cycle (2π radians) removed by the prescaler. When the output of the integrator crosses the lower threshold, a cycle is added to the divider input and charge is subtracted from the integrator. The net result is that even though the phase detector experiences a step change in phase, the integrator step compensates for it. The F(s) block contains a sampler so that at the time that each sample is taken, the effects of pulse removal or addition and those of resetting the integrator have all settled, the transients occurred

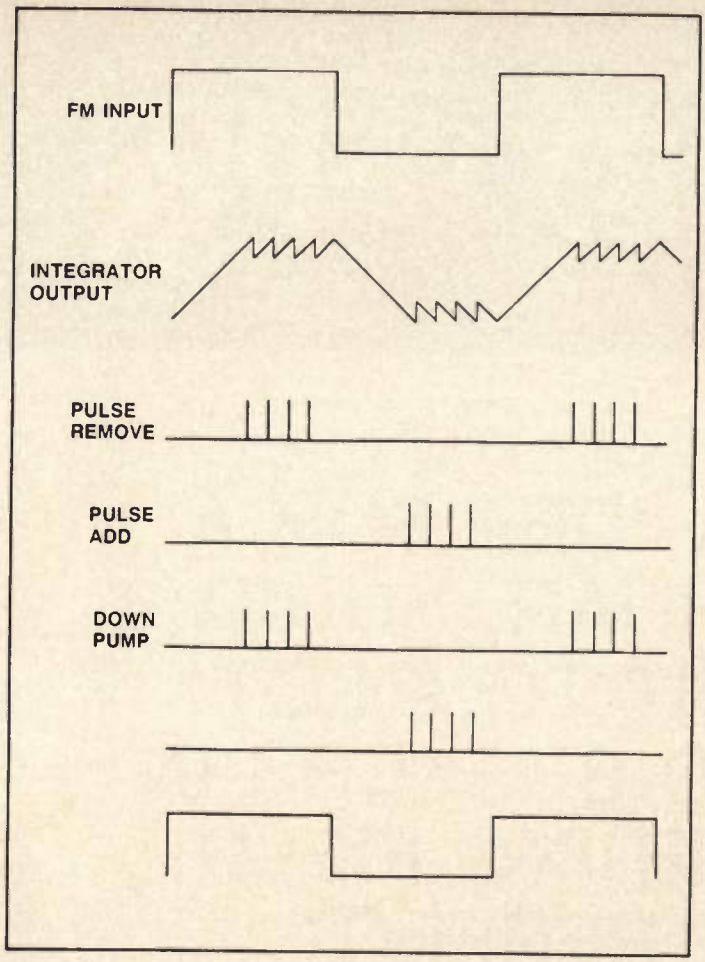


Figure 6.

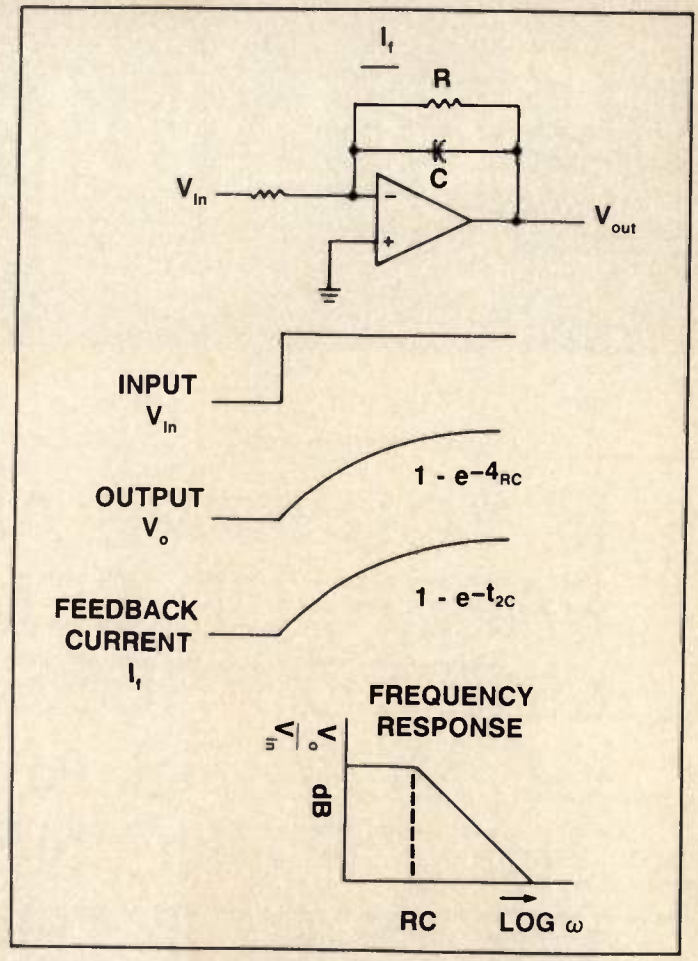


Figure 7. Time-domain and frequency-domain response of an integrator with resistive feedback.

between samples. The operation of the system is illustrated by the square-wave input example shown in Fig. 6.

The system oulined above provides DC-coupled FM. A DC input voltage will cause the output frequency to be offset by a proportional amount. Any offset currents in the integrator cause the integrator output voltage to drift, creating a shift in the output frequency. Since zero drift integrators are not available, this system will display an offset from center frequency even though no voltage is present at the input. The magnitude of this frequency offset can be made much smaller than that of a free-running VCO which is the usual technique for generation of DC FM. This offset is also relatively constant with time, unlike free-running VCOs.

AC-Coupled FM

It is often necessary to frequency modulate a signal while keeping its center frequency locked to a stable reference. The system shown above has a small frequency offset caused by integrator drift. Its center frequency, therefore, is not locked to the reference. To accomplish this, it is necessary to move the integrator pole away from 0 Hz by adding some DC feedback around the integrator. Fig. 7 shows a conventional integrator with DC feedback.

The resetting and pulse removal/addition action makes the integrator in Fig. 5 inherently non-linear. Some method is required to reconstruct linear operation from the circuitry. The signal fed back to the integrator input needs to be proportional to the instantaneous phase deviation of the VCO output signal. This can be done with the scheme shown in Fig. 8. Resistors R1, R2 and R3 provide feedback from the integrator output. The up/down counter keeps track of the total net number of pulses that have been deleted or added by the prescaler. The DAC converts the count into an equivalent voltage. Resistor R4 feeds that signal back to the integrator output. The resistor network is chosen so that the current fed back to the integrator input has the same gain through both paths. The Up/Down counter and DAC reconstruct a staircase approximation of the instantaneous phase deviation, each step corresponding to one cycle of phase (2π). Adding the feedback signal obtained from the output of the integrator fills in the space between steps as shown in Fig. 9. The overall operation of the system is that of an ideal integrator with a resistor in the feedback path that cancels out any offset currents in the integrator.

The amount of phase deviation that can be handled is determined by the number of bits in the counter and DAC. A 10 bit DAC and counter will allow a total phase deviation of ±512 cycles, or a β of 1024π. The DAC gain and the resistive divider network determine the effective integrator pole location.

This scheme of counting deviation cycles gives us true synchronized center frequency with no drift while allowing high deviations and arbitrary placement of the integrator pole. The HP 8656B implementation is capable of a peak phase deviation or β of 4000 radians and has an integrator pole location of 0.75 Hz. Disconnecting the counter and resistive feedback allows true DC-coupled FM with a center frequency offset that is determined only by the drift in the integrator. It is insensitive to VCO drifts and offsets.

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Here are some of the general subject areas that might be explored, just to spark your thinking. . .

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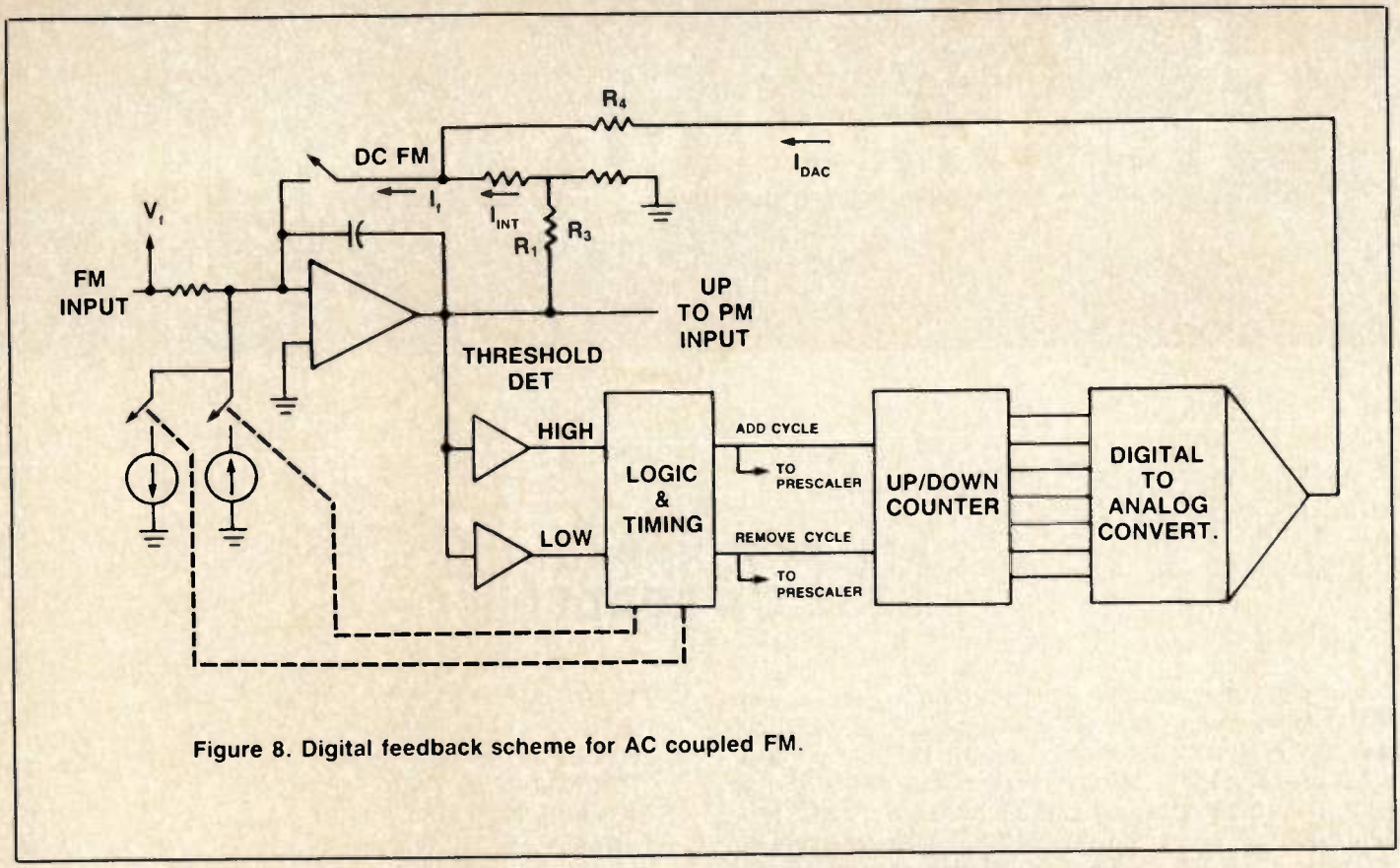

Figure 8. Digital feedback scheme for AC coupled FM.

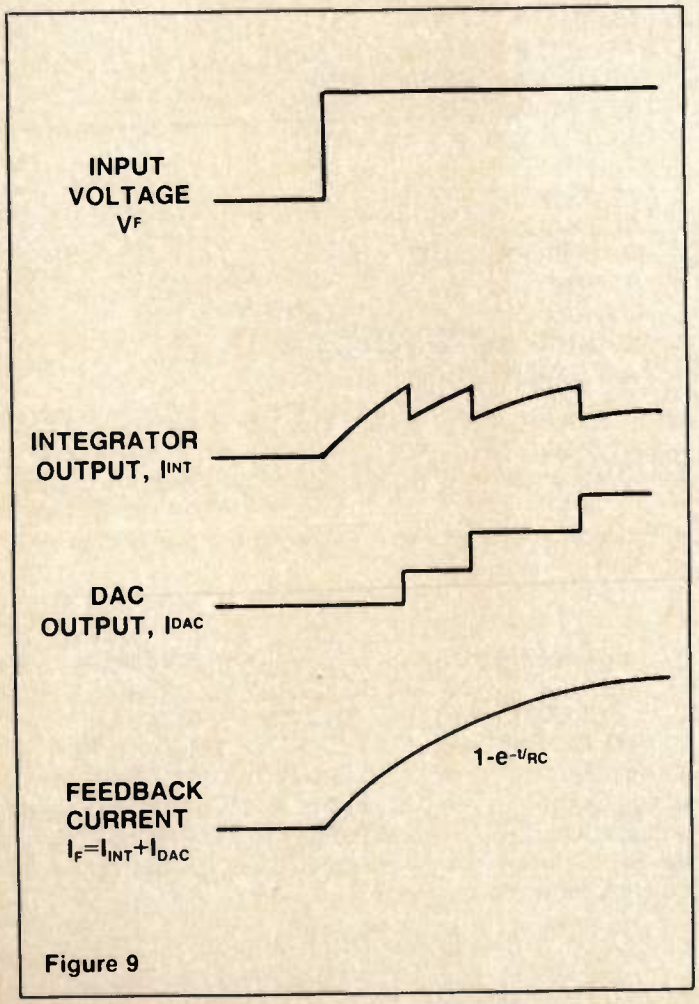

Figure 9

Design Limitations and Achieved Performance

The operation of this synthesized-FM system hinges on the digital removal or addition of VCO cycles. The phase transients caused by these abrupt phase steps must be cancelled by the integrator reset currents. If these currents are not accurate, the cancellation is not complete and the resulting errors show up as sawtooth-shaped phase modulation components on the output signal. These spurious modulation components have a repetition rate equal to the integrator reset rate and show up on a spectrum analyzer display as unwanted sidebands around the carrier. For good spurious cancellation, the resetting currents must be made to track any phase detector gain variations caused by aging, temperature, or component replacements.

The initial frequency offset and center frequency drift when in DC FM mode are determined by offset currents present at the input to the integrator. Good offset and drift performance requires audio circuitry with minimum offset voltages, currents and temperature effects.

The placement of the integrator pole determines the lower 3dB frequency in AC FM mode. The pole location is controlled by the ratio of feedback current to instantaneous phase deviation. This ratio is determined in two parts. The first is the DC feedback path from integrator output to input. The second is the gain of the counter/DAC system. There will be a certain amount of center frequency jitter if these two paths are not well matched.

The HP 8656B implementation of the phase reconstruction scheme provides spurious cancellation yielding sidebands typically better than –60 dBC at offsets greater than 5 kHz and –50 dBC of offsets less than 5 kHz. The initial frequency offset in DC FM mode is less than 500 Hz, and the center frequency drift rate is less than 10 Hz per hour including temperature effects. In AC FM the center frequency is synthesized (no offset) and the lower 3-dB frequency is less than 1 Hz. The peak frequency deviation is 99 kHz. The maximum modulation modulation index is 4000 in AC FM and unlimited in DC FM mode.

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REACTION INSTRUMENTS

Antenna Impedance Matching Using a Sweep Generator

A job that used to take all day can now be done during lunch.

By Riley Puckett
Burr-Brown Corp.
Tucson, AZ 85713

Reasons for the Method

The normal procedure for matching a transmission line, through a coupling circuit, to any antenna which requires an impedance transformation is usually specified by the manufacturer as follows (simplified):

1. Install an SWR meter between the coupler and the transmission line.

2. Key the transmitter (low power) and adjust the coupler matching components for the lowest SWR.

As anyone who has ever tried this method can verify, this is easier said than done. This is due to the fact that most SWR meters require switching between forward and reverse power indications while making the adjustments. If you have started from scratch and everything is in left field you may get fwd/rev power readings of almost anything. If you have a dual reading meter the degree of difficulty is decreased somewhat, yet the task is still less than ideal.

This method is also complicated due to interactions between channels while tuning, if a multi-channel coupler is used. Other factors to be considered are interference with other users while tuning and some solid state amplifiers become unstable at a high SWR further contributing to interference by spurious radiation.

A better way to accomplish this project was found using the maximum power transfer and voltage divider theorems in conjunction with a sweep generator and an RF detector. This method was devised using a 10 channel coupler which worked in the 2 to 3 MHz range. The normal time required to match all channels to less than 1.2:1 SWR was 8 hrs. After a brief familiarity period the tuning could be completed in about 1 hr., an 8:1 savings in time. The time decrease is due to being able to see immediately any effects the adjustments caused and the direction in which the next adjustment had to be made. Accuracy does not suffer because the point of exact match can be seen if the calibration was made correctly and the method is understood.

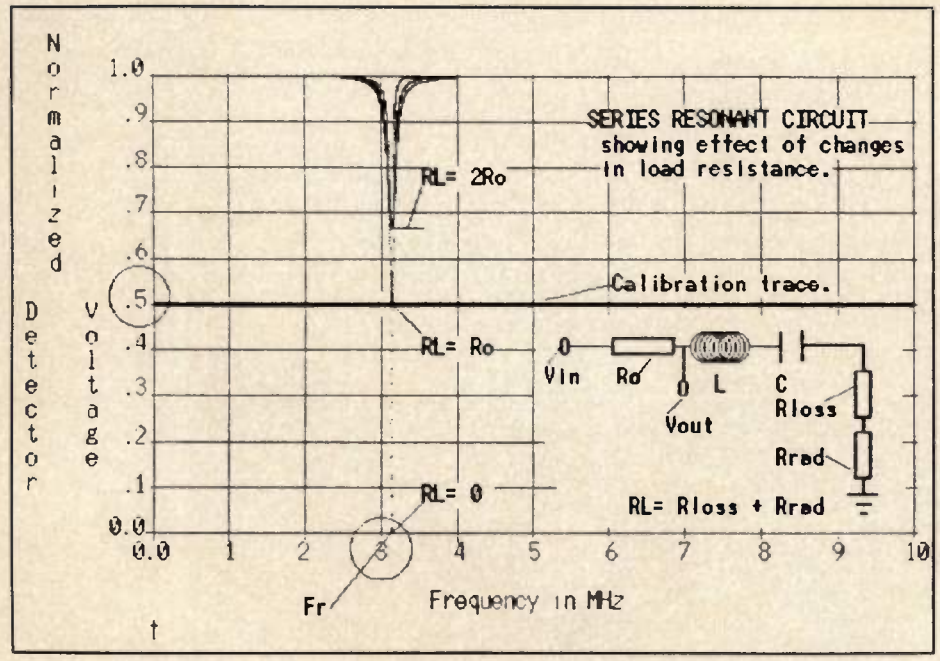


Figure One

Most modern laboratories have network analyzers and the use of this instrument can accomplish the same end results. However, they are expensive and I have never had the luxury of using one and it is felt that others out there may be in the same situation.

A Review of the Theory

A series LC circuit exhibits an impedance of zero at resonance (F_r) if it has negligible losses within its components. An amplitude vs frequency plot for this type circuit is show in figure 1. In figure 1A, a voltage detector will see V_{out} = zero at F_r as the sweep generator crosses this frequency if $R_{loss} + R_{rad} = 0$.

If a variable resistor is inserted in place of $R_{loss} + R_{rad}$ then the V_{out} at F_r will increase with an increase in resistance. This will allow the detector output voltage (V_{out}) scale to be calibrated in terms of resistance. This resistance will later be set to a value equal to the Z_o of the transmission line, to which the antenna will be matched. Note that bandwidth also changes due to a decrease in circuit Q which is analogous to antenna Q.

Any antenna will react in the same manner. However, there are some restrictions. If the connection cannot be made directly to the antenna or coupler circuit then an electrical half wavelength of low loss transmission line (or a multiple) must be used to get a true measurement of the antenna impedance. More on that later. Some deviation from the mathmatical model may occur when using a sweep generator if sweep width is too large or

sweep time is fast. The only area of interest is near F_r.

An antenna will exhibit an impedance which can be analyzed as a series circuit. This circuit will consist of a radiation resistance (R_{rad}), loss resistance (R_{loss}), inductance (L), and a capacitance (C) as shown in figure 1. Capacitive and inductive reactance cancels at F_r leaving only R_{rad} and R_{loss}. On either side of F_r the impedance changes from resistive (real) to complex and cannot be measured in this manner. However, it is only the resistive component that is of interest. Loss resistance will be included within R_L for all examples.

Equipment Setup

The equipment is set up as shown in figure 2. If an RF detector probe is not included with your sweep generator one can be fabricated or obtained commercially. Some generators may not furnish enough drive for this application. If this is the case then a broadband amplifier is needed. The Burr-Brown 3553 buffer amp is good up to 30 MHz, and will furnish more than enough drive. A stable frequency marker generator will be helpful if it is built into the sweep generator.

Use the following steps to calibrate the equipment:

1. Disconnect the coupler (or transmission line or antenna) on the R_L side of the R_o. Load the output with a carbon resistor which matches the value of R_o (which should match the transmission line characteristic impedance).

2. Set the sweep rate and width. A wide sweep setting should be used initially. It can be decreased later after gaining familiarity with the method. Set the marker(s), their amplitude and the harmonic spacing required.

3. Calibrate the scope scale with the retrace at the bottom and the detected signal level at mid scale. Midscale can be an arbitrary point and is not absolute. This point will not be changed after this setup since it is your Z_o reference point for all adjustments, DO NOT TOUCH. The scope trace is shown, after calibration, in figure 1. A value of 50 ohms, for R_o, will be used for all examples. However, this can be any value but it must match the Z_o of the transmission line used.

4. Disconnect the standard resistor and connect the coupler (or transmission line or antenna) back to the R_L side of R_o.

The trace must now be interpreted. It looks complicated. However, after a few minutes of adjusting L and C in the coupler it becomes very simple. Several examples will be given to give insight into the hows and whys of the trace. Note that distortion will occur at the point of "zero" frequency and also above F_r. Another deviation will occur at the point of interest due to the response of the detector probe. For the final steps of adjustment it is recommended that the sweep rate be set to below 10 Hz and increased until a change in any sharp transitions occur then back off a little. This caused considerable problems in the beginning because the SWR measurements did not relate to the scope trace (shifting occured).

In the following examples the analysis will not be as a series circuit. The transformer action of the matching circuits will cause R_L to be reflected as being equal to R_o when matched.

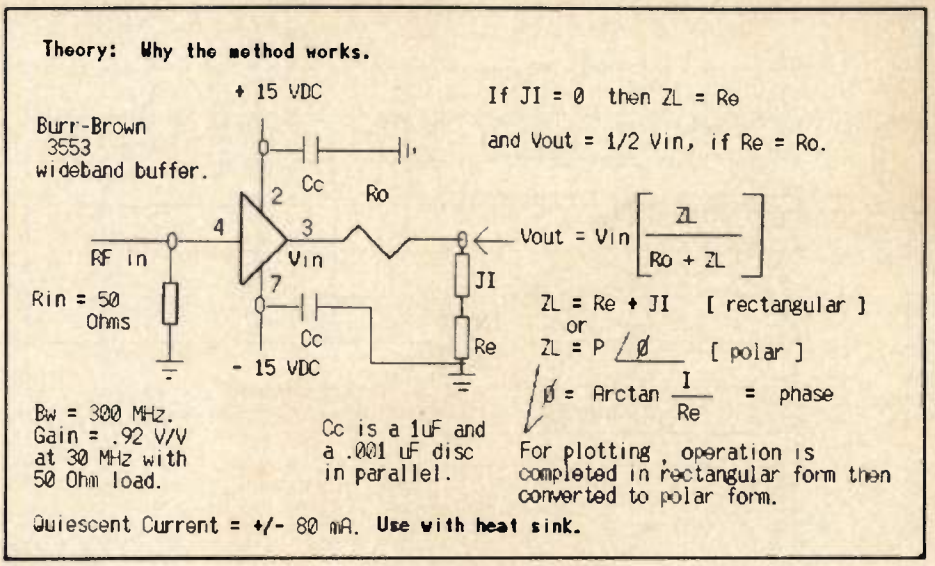


Figure 1a

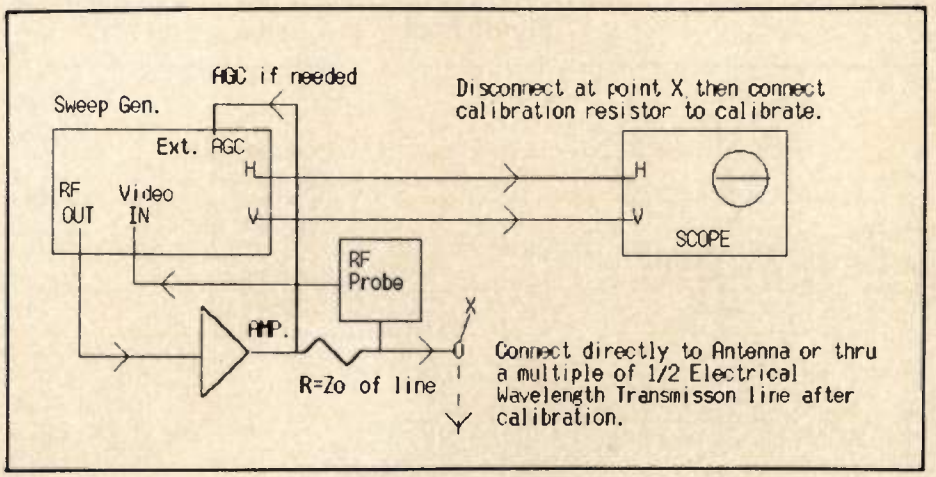


Figure 2 Equipment Set-up

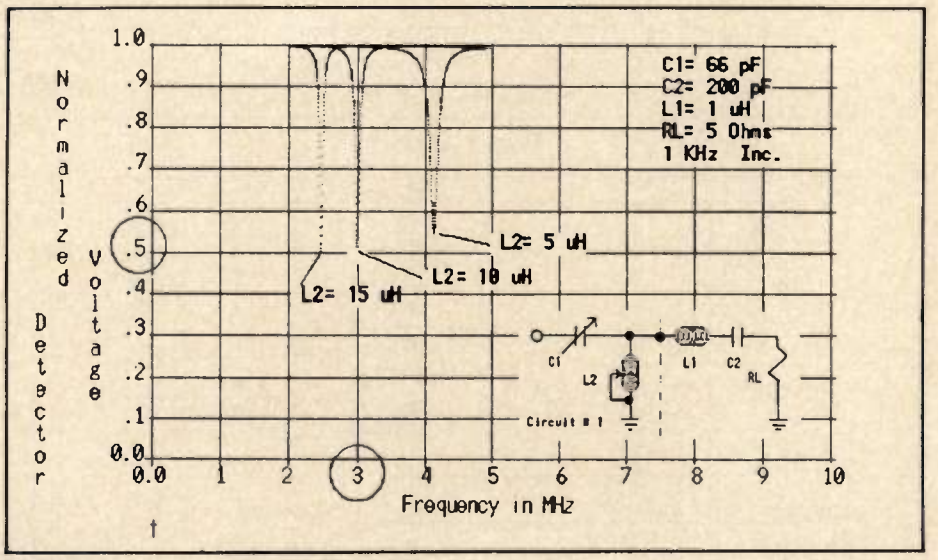


Figure 3

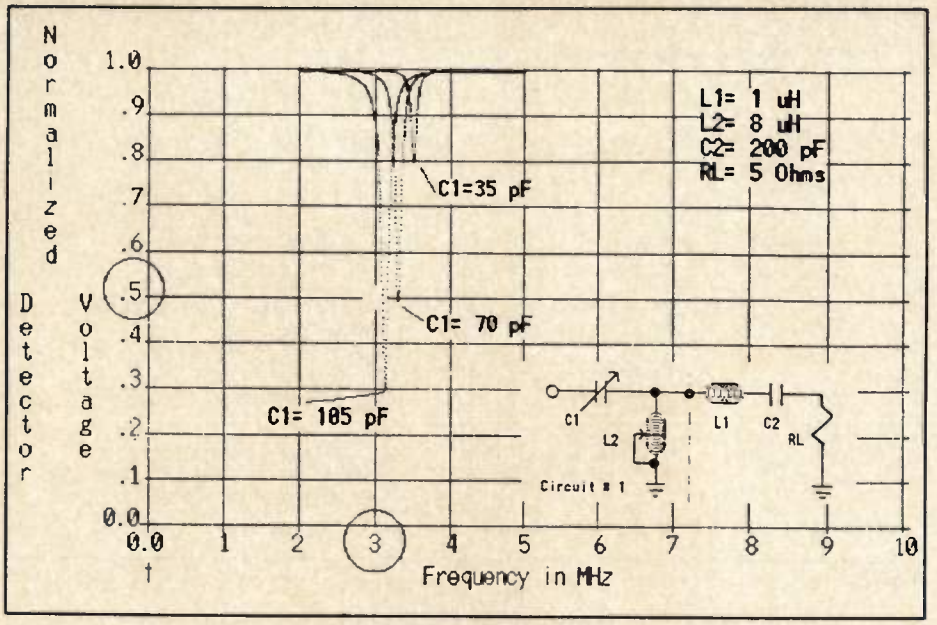


Figure Four

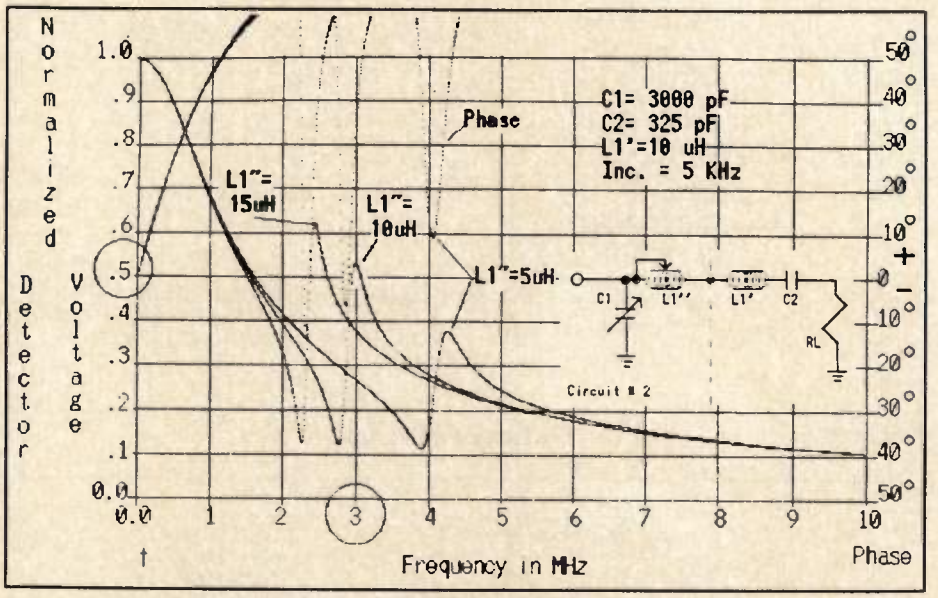


Figure Five

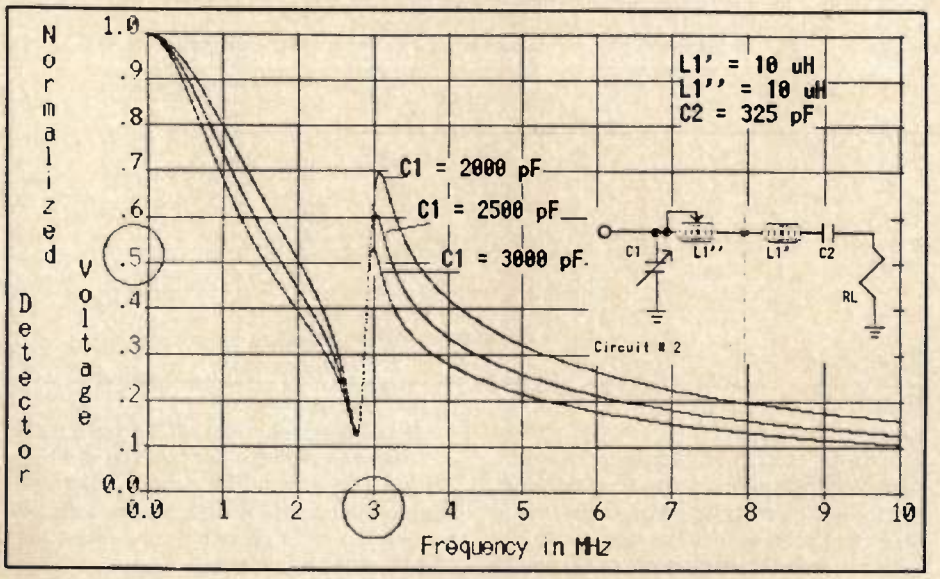


Figure Six

Example #1

Figure 3: This is almost exactly the same as the series resonant circuit and is the result of holding all parameters constant with the exception of L_2. The goal, a matched condition, is at 3 MHz and $V_{out} = ½ V_{in}$. This computer generated figure will almost exactly represent the actual trace on the scope. Again, it is the area around F_r which is of interest.

Figure 4: Here all parameters are held constant except C_1, which is adjusted to show the effect upon parameters near 3 MHz.

A study of the two figures reveals that C_1 has the greatest effect upon amplitude and L_2 changes F_r more than C_1. It appears that C_1 = load and L_2 = tune. What could be simpler? A graphic display of the two adjustments is now available and a SWR meter is unnecessary!

This process of repeatedly adjusting L and C to bring the dip toward the target will result in a 1:1 SWR — a perfectly matched condition ($R_o = R_L$).

Note that the tune and load adjustments will interact.

Example #2

Figure 5 and Figure 6: This display is completely different from example #1 in that it has a series and a parallel resonance very close together and will reflect two values of R_L. One will equal R_L, the other will transform R_L to equal R_o when the system is matched. The point of interest will be near the peak shown in figure 5 and figure 6. The "near" will be discussed in the topic of phase.

The tuning of this type circuit is almost the same, i.e. L is tune and C is definitely load. After adjusting L to retune, C will have to be increased (load) to lower the peak or decreased (unload) to raise the peak toward the target of 3 MHz.

Figure 5 shows the effect of adjusting L and figure 6 the effect of adjusting C with opposite parameters held constant.

Phase of the Reflected Load

This section was an afterthought in the interest of being thorough. I say this because, all the antennas with which this method was used to match, the SWR was always low and acceptable (less than 1.2:1). The delay in completing this article was worth the wait. In circuit 2 the phase does effect the SWR. This leads back the the "near" mentioned before.

Note that no physical measurements of phase have been made. The phase plot was computer generated during the plotting of V_{out}. The basic formulae used in the program are shown in figure 1A.

Figure 5: For any circuit to be resonant the phase angle of Z_L must be zero to

become a pure resistance. In figure 5 this becomes apparent. Notice that the phase never reaches zero for L = 5 uH and for L = 10 uH there are two solutions, one near the peak and the other farther to the left. The solution of interest is near the peak where the phase crosses zero again. This condition is not a true match. However, it will yield low SWR due to low reactive components. When L = 15 uH the amplitude and phase cross a unique frequency together. This is the condition of a true match. Notice that the amplitude is about 25% down the slope from the peak at ½ V_{in}. This is what we want. One problem, it is located about 2.3 MHz and should be at 3 MHz, the target. Therefore, readjustment is necessary to obtain the same condition at 3 MHz. From this it is concluded that the afterthought was worthwhile.

The plot of phase and amplitude in figure 7 shows a closely matched line and antenna at 3 MHz. The phase plot shows zero reactance at that point. For circuit 1 the reactance will always cross zero at the dip regardless of the amount of mismatch. The off resonance phase will decrease in amplitude as detector voltage (at the dip) increases toward unity as shown in figure 8.

Some special notes should be given here with regard to the exact condition of a good matched line to coupler. In all cases the amplitude will be at ½ V_{out} at whatever frequency is in question and the phase will cross 0 at this point. From the figures the frequencies of match are as follows:

Figure 1 — 3.15 MHz
Figure 3 — 3.0 MHz
Figure 4 — 3.3 MHz
Figure 5 — 2.4 MHz
Figure 6 — 2.9 MHz (C_1 = 2500 pF.)
Figure 7 — 2.95 MHz
Figure 8 — No match
Figure 9 — 3.0 MHz
Figure 10 — 6.0 MHz

CONCLUSIONS: After using this method for 12 years, with excellent results, from 2 MHz to 160 MHz I am convinced that anyone can use it. The method does not require any specialized equipment (none that the normal shop or lab should not have) and is very accurate in matching a system. If a sweep generator is not available, then an RF signal source can be substituted. However, some problems may arise in the interpretation of results. Radiation resistance measurements may be made if R_o is made variable, and direct SWR measurements by using an RC type SWR bridge with scope output taken at R_o. This will give SWR and $R_{rad} + R_{loss}$ simultaneously.

Example #3

Figure 9, Figure 10: Two more cases arise when it is desired to look at an an-

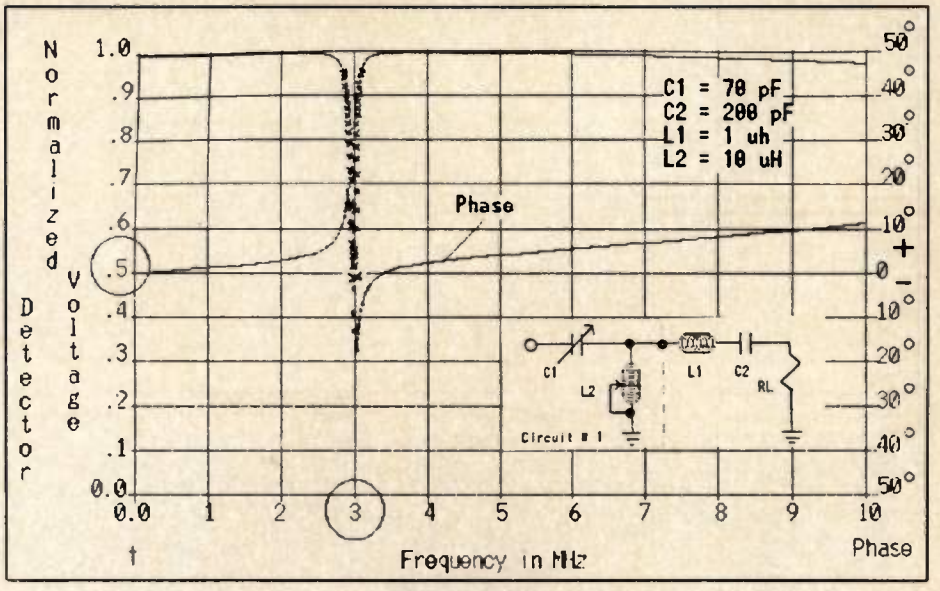


Figure Seven

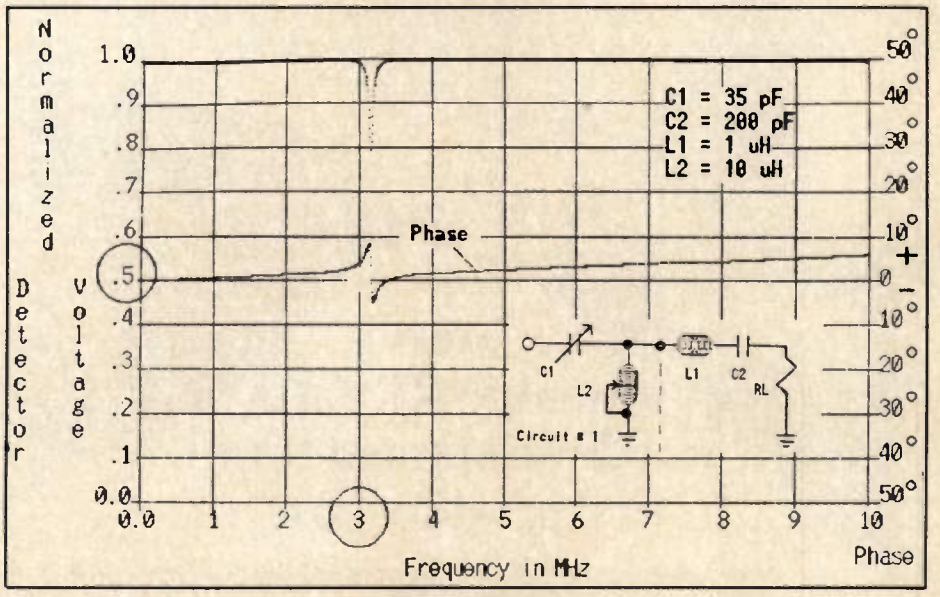


Figure Eight

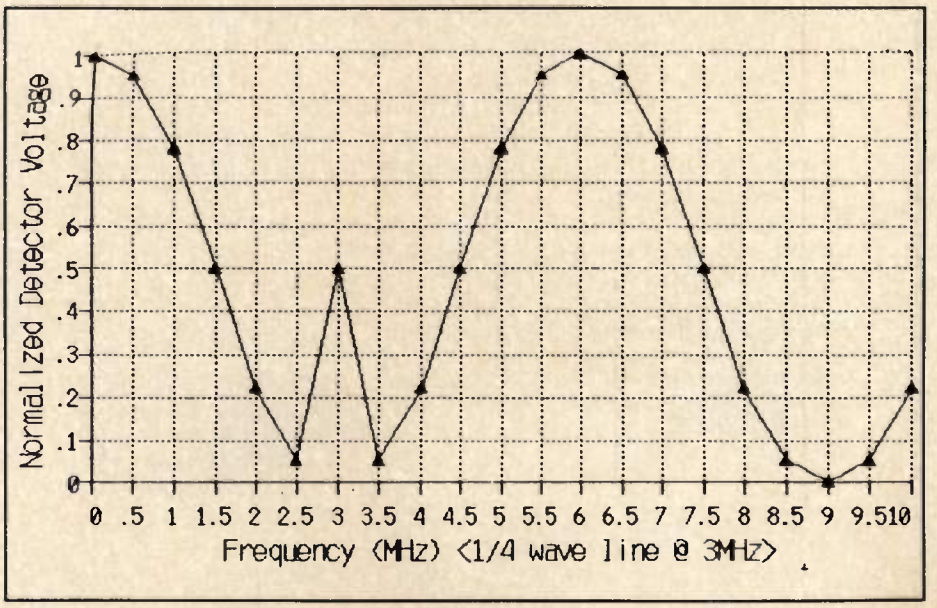
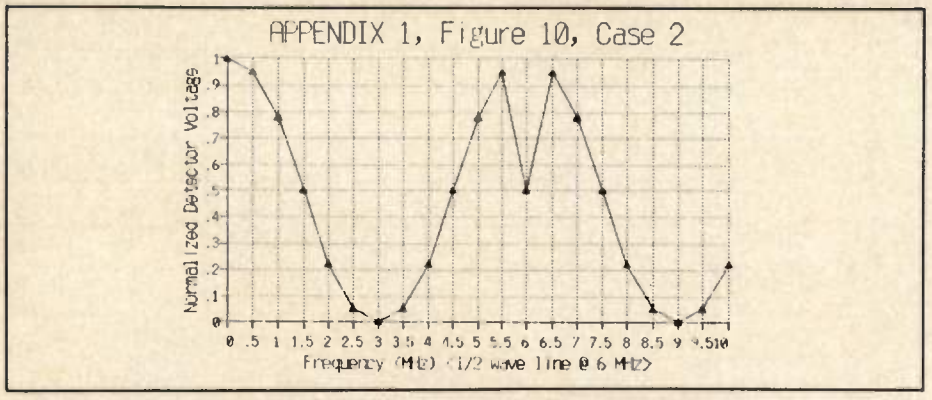
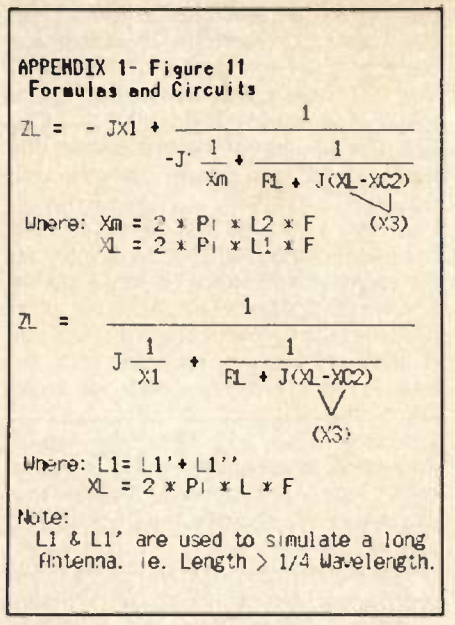
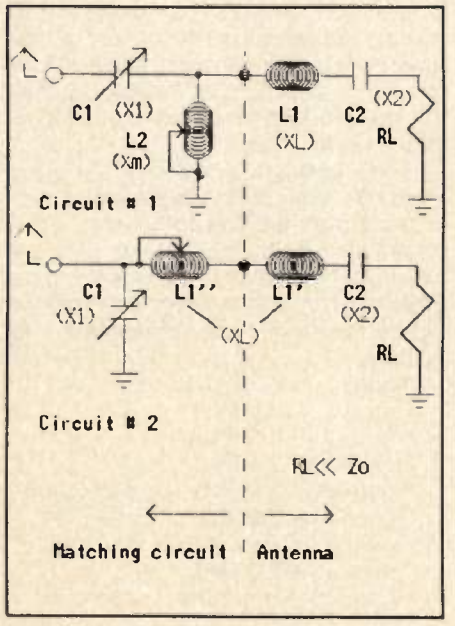


Figure Nine



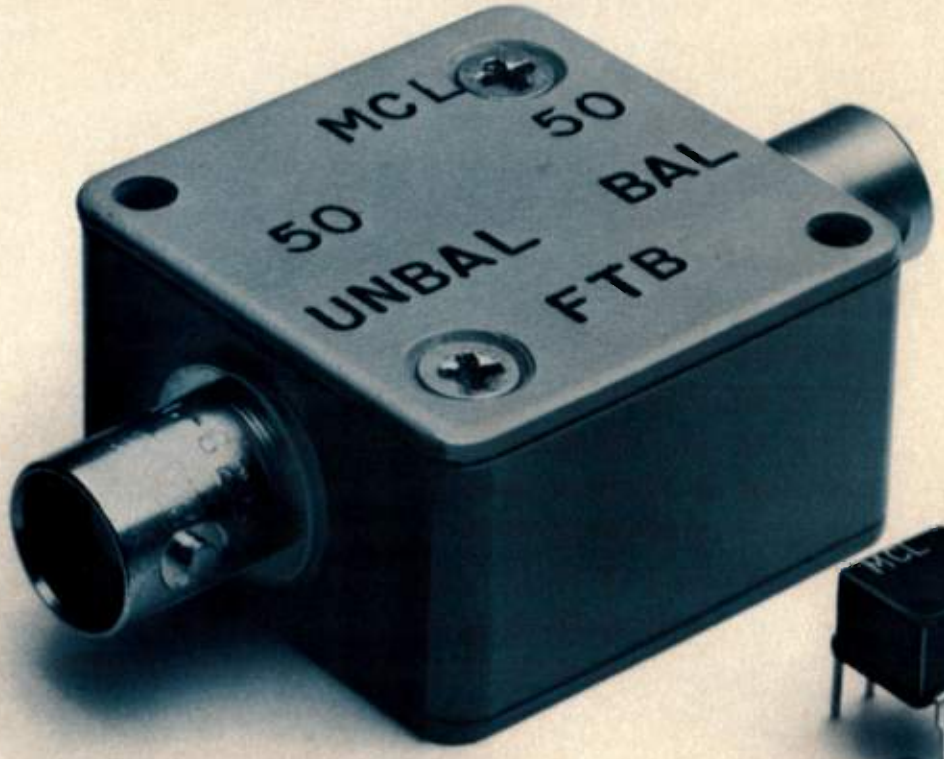


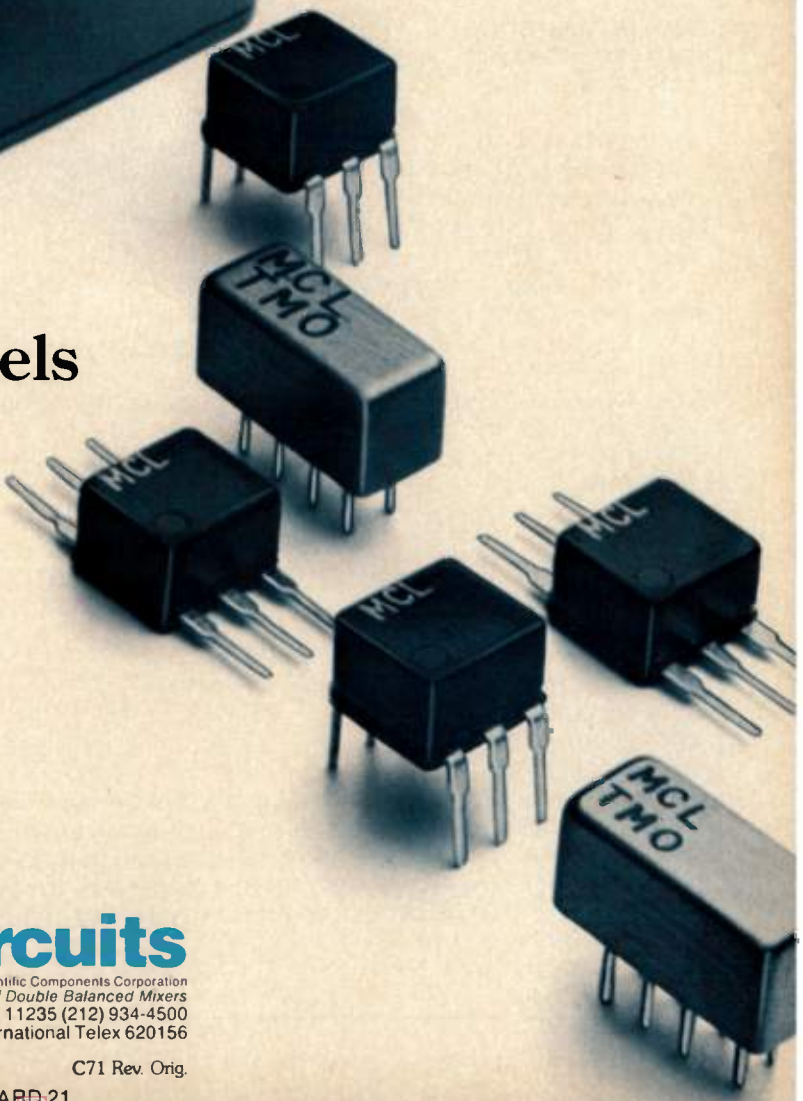


tenna through a transmission line. Both figures indicate a matched condition and the plots are not exact. However, they will give a general picture of what happens when the load resonant frequency is reached. In both cases the generator and detector see the same thing as they would if connected directly to the antenna or the coupler, with one exception, the impedance level will be different for the ¼ wave line case as explained below.

Case #1, Figure 9: 3 MHz, ¼ electrical wavelength (or odd multiples). This is not recommended since any small change in R_L is reflected as $Z_{in} = Z_o^2 / Z_L$. This case will work if the match is exact.

RF transformers





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Case #2, Figure 10: 6 MHz, ½ electrical wavelength (or any multiple). This is the case to always use since at ½ electrical wavelength the load is exactly reflected to the generator.

The Computer Program

Figure 11 shows the formulae used for the computer program. The resultant impedance was used (see figure 1A) to calculate ouptut voltage using the voltage divider theorem. The formulae are a form of the Cauer expansion for network realization except in a reverse manner. Meaning that in the program calculations were started at the bottom right in each case and then worked out toward the beginning. This appeared to be the simplest method to follow for this application.

All special program variables are shown in parentheses in figure 11. L_1 and $L_{1'}$ were used to simulate the case of a longer than ¼ wavelength antenna, which will not be covered here.

The plotting and graphics were implemented on an Epson QX10/MX80 system using a program utility called Qplotter, which is compiled BASIC called from BASIC.

```
5 REM ************* APPENDIX 1 *********************
10 GOSUB 10000
25 INPUT"name of store file":N$
28 N$="b:"+N$+"    "+""
30 F$="b:blank    "+"":RC=0
35 CALL QSTART:CALL QHOME
40 CALL QRETRV(RC,F$)
50 REM X=100:Y=70:V=50:W=30:L=5
60 REM  CALL QCURSOR(X,Y):CALL QAXIS(V,W,L)
70 IN!=1000
100 C1!=6.8E-11
101 C2!=2E-10
103 L1!=.000001
104 L2!=.000009
105 RS!=50:RL!=0
106 PI!=2*3.1415927#
108 F9!=2.5E+06
110 A9!=1/PI!:B9!=A9!*(1/C1!):C9!=A9!*(1/C2!):D9!=PI!*L1!:H9!=PI!*L2!
120 E9!=1/F9!:X1!=B9!*E9!:X2!=C9!*E9!:XL!=D9!*F9!:X3!=XL!-X2!:XM!=H9!*F9!:R9!=RL
!
130 GOSUB 300
140 R9!=G9!:X3!=(JB!+(-1/XM!))
150 GOSUB 300
165 R2!=G9!+RS!:X2!=JB!-X1!:R1!=G9!:X1!=JB!-X1!
166 GOSUB 400
170 Y=INT(70+P9!*300)
174 X=INT(100+(F9!/1E+06)*50)
180  CALL QPOINT(X,Y)
182 Y=INT(220+(3*W9!*57.2958))
184 REM CALL QPOINT(X,Y)
185 CH$=INKEY$:IF CH$<>"" THEN GOTO 200
187 IF F9!=4E+06 THEN RL!=RL!+5:GOTO 108
190 F9!=F9!+IN!:GOTO 120
200 CALL QSTORE(RC,N$):NQ=0:ST=0:CALL QPRINT(NQ,ST)
205 CALL QEND
207 LPRINT N$;C1!;C2!;L1!;L2!
210 END
300 T9!=R9!^2+X3!^2:G9!=R9!/T9!:JB!=-X3!/T9!:RETURN
400 A1!=R1!*R2!+X1!*X2!:A8!=R2!^2+X2!^2:G9!=A1!/A8!:JB!=(R1!*X2!-X1!*R2!)/A8!
500 P9!=SQR(G9!^2+JB!^2):W9!=ATN(JB!/G9!)
510 RETURN
600 LPRINT USING "####.###";P9!;
610 LPRINT USING "####.###";Y;
620 LPRINT USING "########.#";F9!
630 RETURN
10000 POKE 1,9:POKE 2,&HBB:Q=&HBB00:QSYSTEM=Q+3:QSTART=Q+6
10010 QEND=Q+9:QCLEAR=Q+15:QSTORE=Q+18:QRETRV=Q+21:QPRINT=Q+24:QSTRING=Q+27
10020 QPAT=Q+30:QOVER=Q+33:QZOOM=Q+36:QPAN=Q+39:QTRIANG=Q+42:QHOME=Q+45
10030 QCURSOR=Q+48:QMOVE=Q+51:QCHAR=Q+54:QDRAW=Q+57:QAXIS=Q+60:QARC=Q+63
10040 QLINE=Q+66:QPGRAM=Q+69:QDIAM=Q+72:QCIRCLE=Q+75:QWHERE=Q+78:QTIME=Q+81
10050 QDATE=Q+84:QPOINT=Q+87:QUAD1=Q+90:QUAD2=Q+93:QUAD3=Q+96
10060 QUAD4=Q+99:QRECT=Q+102:QPRINV=Q+105:QORG1=Q+108:QORG2=Q+111:QORG3=Q+114
10070 QORG4=Q+117
10072 DEFINT A-P,R-Z
10075 RETURN
```

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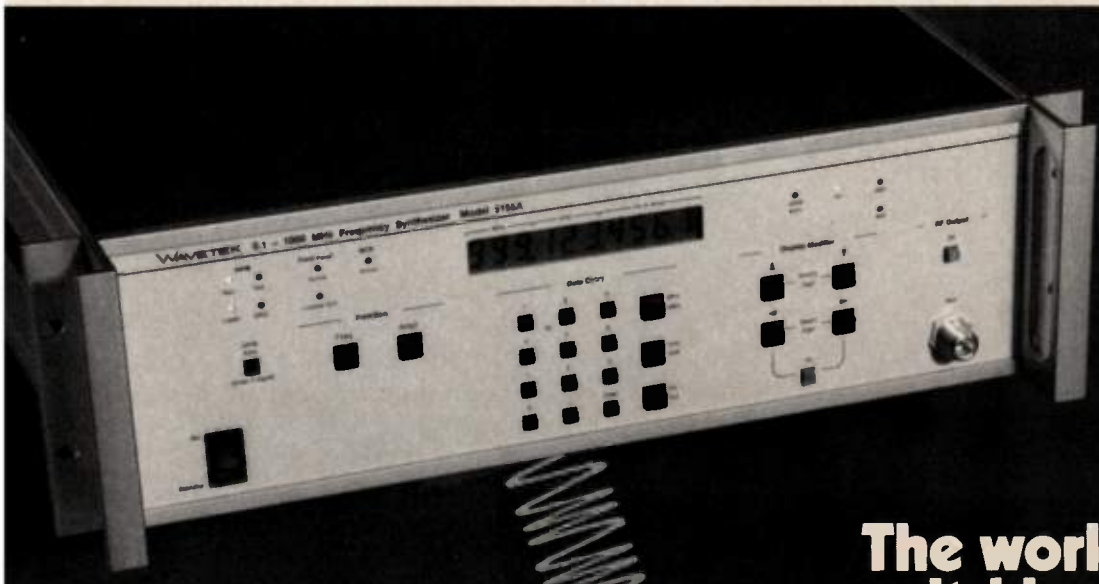

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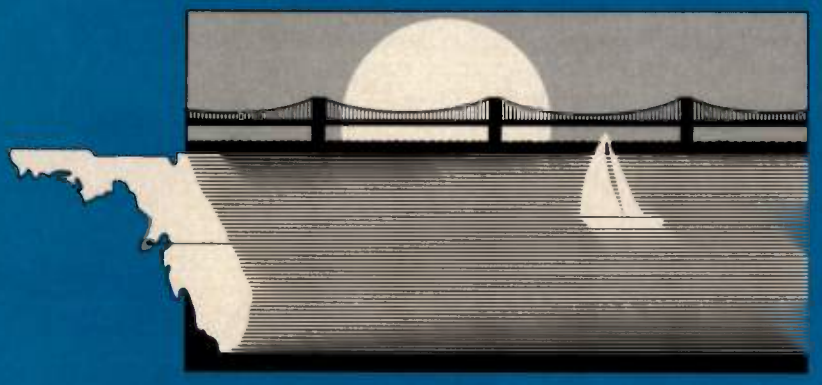

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INFO/CARD 24

The Snyder Antenna

The Snyder Antenna is a new form of antenna with greater tolerance to operating frequency shifts.

By Richard D. Snyder
Snyder Antenna Corporation
Costa Mesa, CA 92627

When in tune with the frequency of the RF energy it must process, and in balance with the system it serves, an antenna functions as a resistive, predictable load. Expressed as radiation resistance, the antenna load in a circuit continues to appear much like a fixed resistor so long as all the factors which affect its function remain the same. The two factors that most affect the circuit value of the antenna are: Operating frequency shifts, and the introduction of conductive or grounded objects into its immediate environment. Operating frequency shifts ask the antenna to operate at non-resonance. Nearby, interfering objects cause the antenna to change its natural, resonant response.

Non-resonant operation alters the antenna as a circuit component — the greater the shift from resonance, the greater the change in character. The change is from resistance toward reactance. When the applied frequency is higher than antenna resonance, the antenna appears as a combination of resistance and inductive reactance. When the applied frequency is lower than resonance, the antenna looks more like a combination of resistance and capacitive reactance. Resulting mismatches between the antenna and the system it serves are expressed in terms of impedance shift at the antenna input.

To illustrate a simple example of impedance shift all one need do is mount a half wave dipole at various levels above earth. The radiation resistance of the antenna, the main component of impedance seen by the system, rises steeply from under 30 ohms at 1/10 wavelength above earth to over 90 ohms between ¼ and ½ wavelength, and then falls to around 72 ohms when the height is stabilized at ½ wavelength above earth. In terms of circuit and system function, the results of such changes are obvious. Add to this the effects of reactance intrusion, and the results are even more dramatic.

Nothing can be done to correct the height-above-earth and other extra-system induced changes in antenna characteristics except to isolate the antenna. When using conventional antennas, whose tolerance to operating frequency shifts is extremely narrow, only limited options for correction exist. Hence, a logical first step in an attempt to stabilize the antenna as a circuit component would be to provide a new form of antenna with greater tolerance to operating frequency shifts. Working with this as a starting advantage, the designer can find new opportunities in communication system design.

The Synder Antenna

The Snyder design, which has been proven in transceiving and receiving antennas, produces antennas that are far less sensitive to shifts in operating frequency than are conventional units. The range of frequency response is from 5 to 6 times as wide as in ordinary, fundamental antennas. The most easily derived reading of antenna response is the Standing Wave Ratio plot. Increases of SWR in a 'clean' antenna system that occur as frequency is varied represent the antenna's intolerance of applied frequency. Figure 1 shows two SWR plots. The dashed line is the typical response of a conventional dipole; the solid line plot is typical of the response of a Snyder antenna. The frequency excursion is plus or minus 10 percent.

The dashed line plot shows the usual plus or minus 2 percent frequency shift tolerance as the conventional antenna presents a 2:1 SWR. The Snyder antenna tolerates a shift of plus or minus 10 percent before it presents the 2:1 SWR. The acceptance of such shifts, whether due to operating frequency or externally induced effects, enables this form of antenna to remain a more constant value circuit component as compared to narrow response antennas.

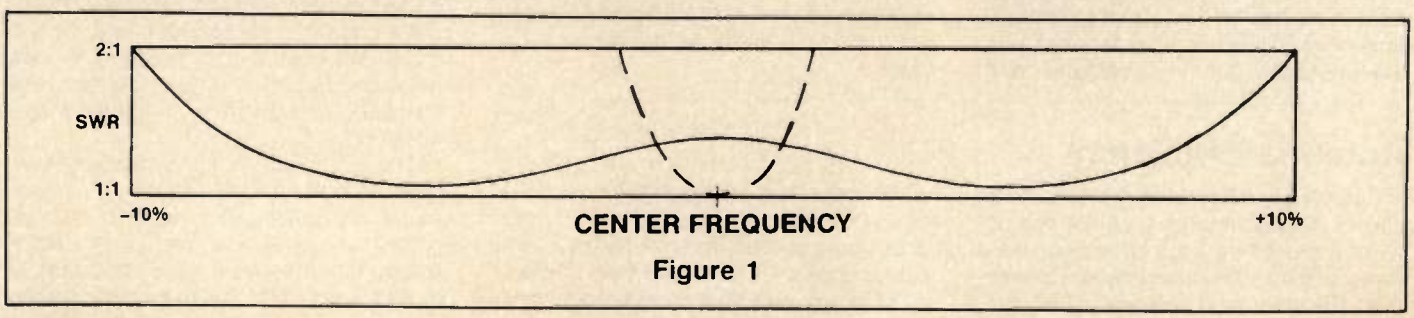
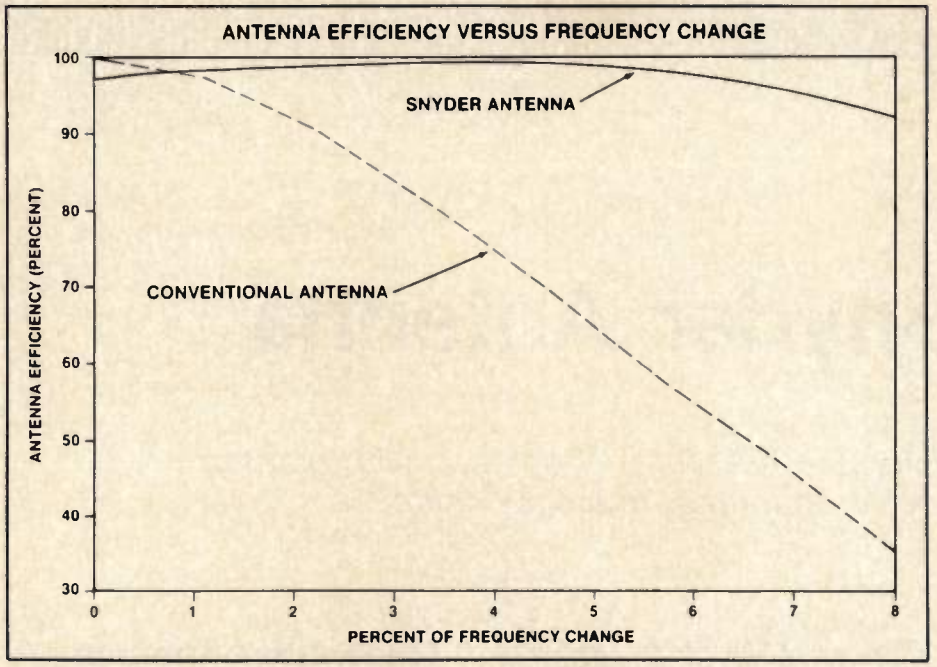


Figure 1



Efficiency versus frequency chart

The left side of the chart represents center frequency, or resonance, for any fundamental dipole or monopole. The top of the vertical coordinate is 100 percent efficiency. Readings across the chart reflect the change in efficiency through a frequency shift of plus or minus 8 percent (conventional antenna SWR = 9:1). At this extreme, the conventional antenna loses 64 percent of its ability to effectively process signals. In the receiving mode the rejected 64 percent of applied RF energy is simply lost; in the transmitting mode it is reflected back to the transmitter.

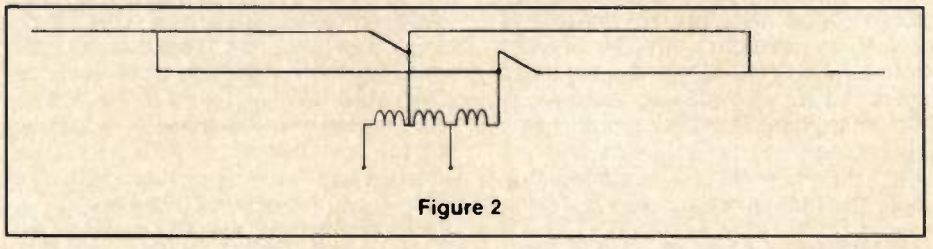


Figure 2

Figure 2

The two conductor elements appear to form a simple folded dipole with single conductor extensions. Further examination shows that the elements' two conductors are cross connected across the secondary of a trifilar transformer (balun). In this unique arrangement, the two-conductor portions of the elements become opposing stubs whose function cancels build up of reactance, allowing the antenna to appear much like a pure resistance over a relatively broad frequency range.

The effect of maintaining the antenna's radiation resistance at a relatively constant level has two important ramifications. First, as a circuit component, its characteristics remain acceptable with operating frequency shifts and externally induced resonance changes. Second, antenna efficiency remains high despite changes in either operation or environment.

The balun in the Snyder design is conventional in all regards except the way it is used. It may therefore be wound to accommodate a variety of feedline and system impedances. Its size is controlled by power handling requirements. Receive-only antennas, as in those for FM radios, use bead cores about .200" long. Transmitting antenna toroidal cores for powers up to 5 KW are 2" in diamter. As in conventional baluns, core configurations are not important; rods or toroids may be used.

Antenna Efficiency

Completely aside from the consideration of the antenna as a circuit component, it must also be looked upon as a free-standing system segment. Theoretically, the antenna is 100 percent efficient when operated at resonance and the SWR in the antenna system is 1:1. As the antenna is shifted from resonance, efficiency drops. Chart shows how efficiency changes with shift from resonance.

Inside The Snyder Antenna

A Snyder dipole looks very much like a conventional dipole. Its elements are one quarter wavelength long, and they may be installed in all the usual configurations: flat top, inverted "V," flat "V," loop, or whatever. The resemblance stops there. Electrically, the Snyder elements are made of two conductors in place of the conventional one. Figure 2 is a diagram of the design.

Mechanical Construction

As in any antenna, Snyder elements may be made from any suitable conductors, insulated or not. By far, the most convenient arrangement of the two-conductor portions of the elements is in coaxial relationship. This has led to the mistaken view that this design is related to older coaxial antenna designs like the "double bazooka" that aroused some controversy decades ago. An examination of the electrical diagram disproves this, and performance differences are vast.

Using The Snyder Antenna

In its simplest form, the dipole and the monopole, the Snyder design merely produces a new form of antenna that directly replaces conventional types whose center frequencies are the same. Using them is simpler because resonance shifts are not nearly as critical as in ordinary antennas. They are cut to basic quarter-wavelengths or multiples to suit frequency band requirements, they possess fundamental harmonic characteristics, and provide conventional radiation resistance values. Off-shoot designs, such as simple and complex beams, multi-antenna and multi-band arrays, as well as others, can use Snyder antennas as elements in much the same way ordinary elements are used.

Present development of the Snyder antenna has carried the design to the range of frequency response previously described. Commercial models are mostly for transceiver and receiver use in the range of requencies from 1 to 150 MHz. Most are used in communication systems in the Western Hemisphere; the remainder are used in Europe and Asia. Only a small amount of experimentation has been conducted in antenna arrays, but the subject is worthy of general discussion.

The vast majority of array designs have three popular requirements. They are: directivity, power gain and front-to-back ratio. It is not always overlooked, but a fourth dimension is just as important — that of bandwidth. The reason bandwidth

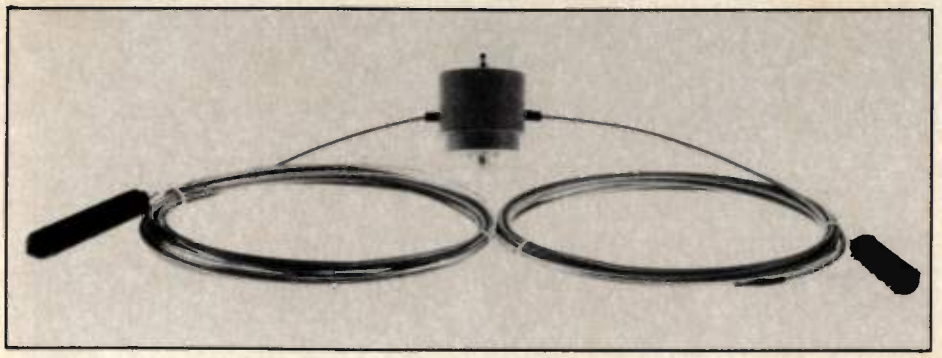


Figure 3

Figure 3 is a photograph of a 7 MHz Snyder dipole with elements coiled; it shows how conventional this design appears in physical form. When extended, the elements span 66 feet, with the two-conductor portions occupying about 45 feet of that length. The two-conductor portions are .180" in diameter, the size being dictated by power rating (5 KW) and the weight of the span they must support.

must be included is simple — if bandwidth is very narrow, the antenna is susceptible to resonance and operating frequency shifts which result in higher SWRs. As SWRs rise, directivity, power gain and front-to-back ratios degrade. Resonance shifts and non-resonant operation are not solely responsible for increased SWRs in array designs. Element lengths, element diameters and spacings between elements all change the interrelationships between driven and parasitic antenna components, individually and collectively, to increase reactance, diminish the values of desired characteristics and to elevate SWR. The use of elements with greater tolerance to frequency and resonance shifts will not erase all the fundamental problems in array designs, but can give the designer a basic component for new designs with far more forgiving characteristics than those available before.

Whether used in arrays or in their simple forms, the Snyder antenna designs are fundamental. Frequency limits are therefore closely matched to Hertzian dipoles and Marconi monopoles, and application ground rules are quite similar. Costs of Snyder dipoles and monopoles, in reasonable quantities, are only marginally higher than conventional units, the extra cost being in the use of a second conductor in each element. Arrays, on the other hand, particularly those designed for broad response and/or signal gain, can cost less because of the reduced requirement for the number of elements and size of the antenna structure.

Electrically, the balun is an integral part of the Snyder design and is therefore integral to its mechanical structure.

Product Availability

Snyder Antenna Corporation, the exclusive patent licensee, presently manufactures dipoles for a limited frequency range. Transceiver antennas are available for frequencies from 1.8 MHz to 31 MHz, and receive-only antennas to 150 MHz. These are wire antennas whose two-conductor sections are arranged in coaxial configuration, and they are 'ruggedized' for use in environments that might range from mild to extreme. Companies that may want to use the Snyder design for other antenna configurations and designs should contact the company in Costa Mesa, California.

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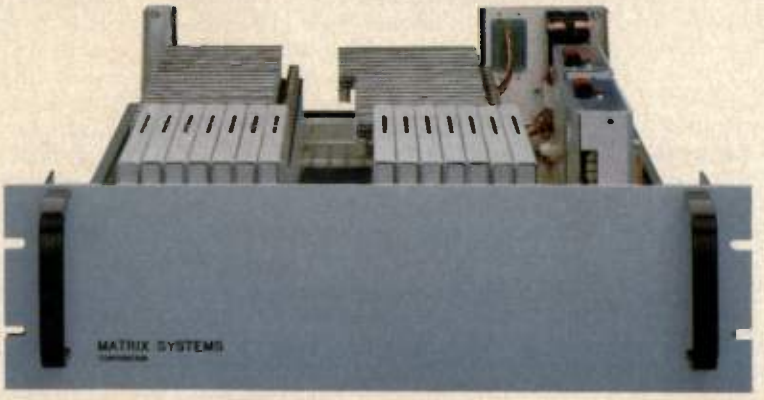

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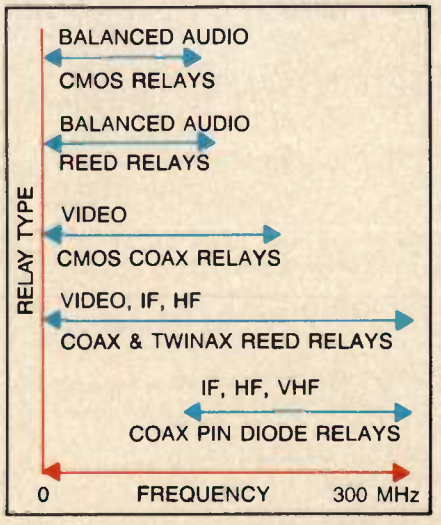

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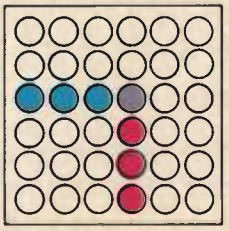

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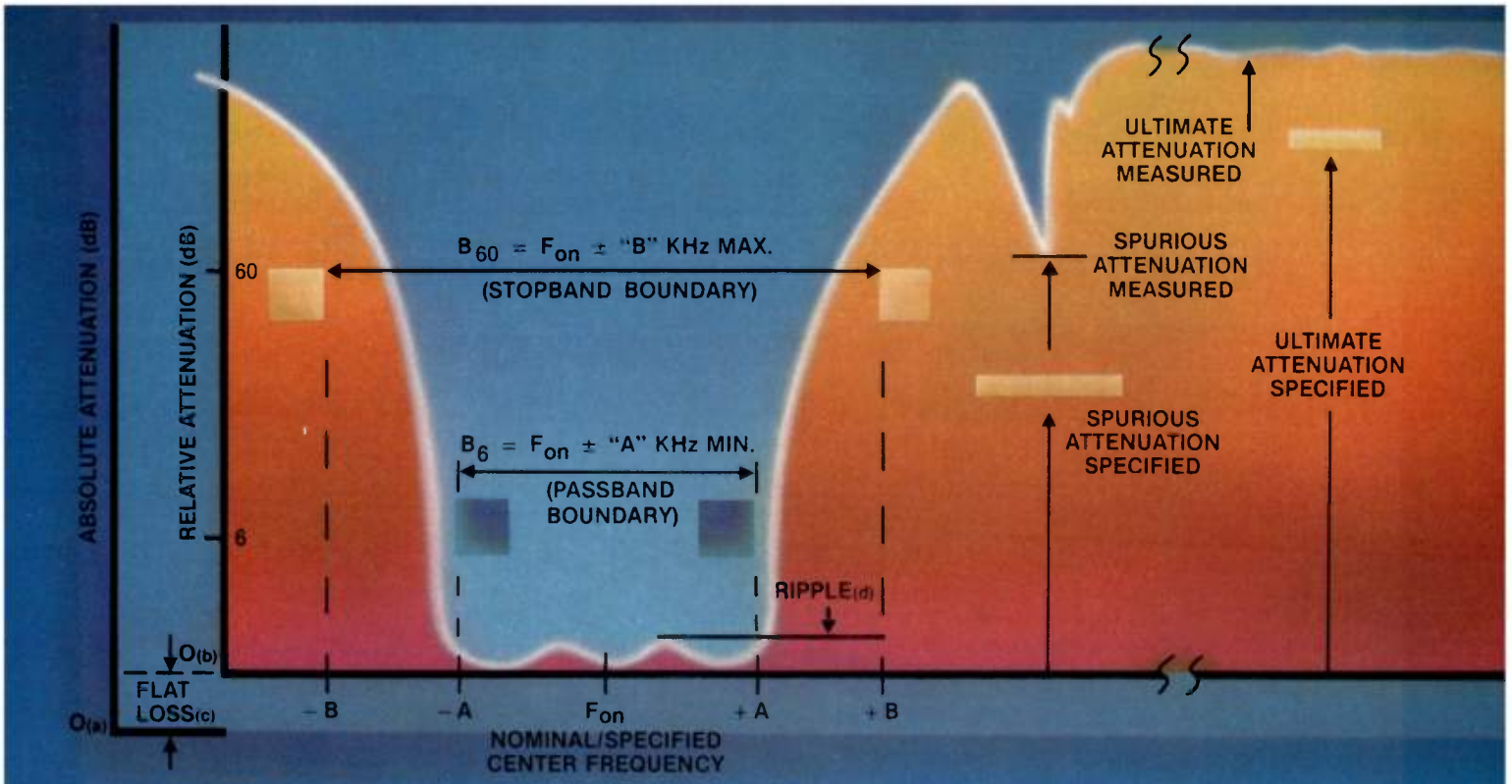
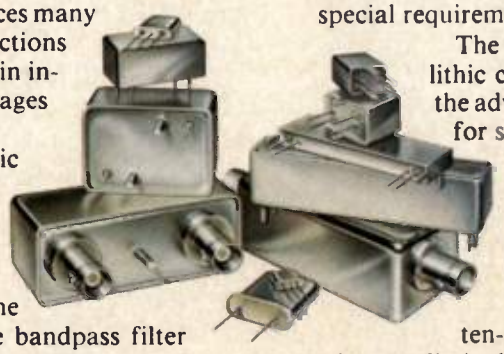


(a) ABSOLUTE ATTENUATION REFERENCE: SIGNAL LEVEL WITH SOURCE MATCHED TO LOAD.
(b) RELATIVE ATTENUATION REFERENCE: MINIMUM VALUE OF LOSS IN PASSBAND OR PEAK OF TRANSMISSION
(c) FLAT LOSS: POWER OUT AT PEAK OF TRANSMISSION DIVIDED BY POWER AVAILABLE
(d) MEASURED FROM PEAK TO VALLEY

A designer's guide to monolithic crystal filters.

Description. Monolithic crystal filters are today's choice for crystal filter applications — used everywhere from mobile radios to medical monitors to satellite communications equipment.

Their unique construction replaces many of the components and interconnections found in discrete filters, resulting in increased reliability, smaller packages and significantly lower costs.



In their simplest form, monolithic crystal filters consist of two, thin-film electrode pairs deposited on the faces of a quartz wafer to form input/output resonators.

Acoustical coupling between the electrode pairs creates a two-pole bandpass filter response. These "two-pole" filters are housed in single miniature (Type "F") or ultraminiature (Type "A") holders.

Four to ten-pole filters are available in miniature/ultraminiature, upright and flatpack designs, as well as in tandem sets — which are particularly suited for high-volume production applications.

Tandem monolithic construction connects, in cascade, two-pole monolithic filter sections using modern network theory. This combines the simplicity and size advantages of monolithic filters with added mode suppression and ultimate attenuation.

How to specify. To ensure getting the right filter to meet your needs, make sure to specify the nominal center frequency (F_{on}), bandwidth and attentuation (both passband and stopband), package specs and any special requirements.

The above illustration shows various monolithic crystal filter response parameters. Note the advantage of using single-sided boundaries for specifying bandwidths.

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INFO/CARD 27

Complex Arithmetic on the HP-11C

The program herein described performs addition, subtraction, multiplication, division, and reciprocation on complex numbers in either rectangular or polar form. Numbers are entered in the standard HP format; that is, imaginary part or polar angle first, then real part or magnitude next. Both numbers must be in the same form. If the numbers are rectangular in format, flag 0 must be cleared (CLF0). If the numbers are in polar format, flag 0 must be set (STF0) before calling the desired function. Answers come out in the same form (polar or rectangular) in which they were entered.

All five letter labels are used and labels 0 through 4. Storage registers 0 to 5, which are associated with the Σ function, are occupied, but only 1 and 3 are actually used.

Step	Command	Comment
1	*LBL A	Addition
2	F0?	rect. or polar format?
3	GSB 0	if polar format, go to subroutine
4	CLR REG	
5	Σ+	
6	R↓	
7	R↓	
8	Σ+	
9	RCL Σ	
10	CL REG	
11	F0?	rect. or polar format?
12	→P	
13	RTN	
14	*LBL B	subtraction
15	F0?	
16	GSB 0	
17	CL REG	
18	Σ−	
19	R↓	
20	R↓	
21	Σ+	
22	RCL Σ	
23	CL REG	
24	F0?	
25	→P	
26	RTN	
27	*LBL C	multiplication
28	F0?	
29	GTO 1	if polar, go to LBL 1
30	GSB 3	go to →P routine for two numbers
31	*LBL 1	multiplication for polar numbers
32	x ⇄ y	
33	R↓	
34	x	
35	R↓	
36	+	
37	R↑	
38	F0?	rect. or polar?
39	RTN	
40	→R	
41	RTN	
42	*LBL D	division
43	F0?	rect. or polar?
44	GTO 2	if polar go to label 2
45	GBS 3	go to →P routine for two numbers
46	*LBL 2	
47	x ⇄ y	
48	R↓	
49	÷	
50	R↓	
51	x ⇄ y	
52	−	
53	R↑	
54	F0?	rect. or polar?
55	RTN	
56	→R	
57	RTN	
58	*LBL E	reciprocation
59	F0?	rect. or polar?
60	GTO 4	
61	→P	
62	*LBL 4	
63	1/x	
64	x ⇄ y	
65	CHS	
66	x ⇄ y	
67	F0?	rect. or polar?
68	RTN	
69	→R	
70	RTN	
71	*LBL 0	converts two polar numbers to rect.
72	→R	
73	R↓	
74	R↓	
75	→R	
76	R↓	
77	R↓	
78	RTN	
79	*LBL 3	→P for two rect. numbers
80	→P	
81	R↓	
82	R↓	
83	→P	
84	R↓	
85	R↓	
86	RTN	

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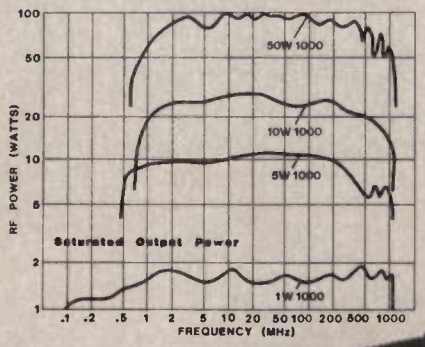

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Cellular-Radio Test System

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The price of the HP 8958A cellular-radio interface is $10,000. Delivery is estimated at 13 weeks ARO. The HP 8957S cellular-radio test system is available with many different configurations to match specific needs, and is priced accordingly. Prices and delivery are available at local HP sales office. **Hewlett-Packard Company, Palo Alto, CA 94304, INFO/CARD #176.**

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Any circuit element can be optimized within a user-specified frequency range, using SUGAR's fast-converging gradient search. Multiple frequency bands, with individually specified error factors and desired results, allow flexibility in optimization over a wide bandwidth.

Host equipment required for SUGAR is a Hewlett-Packard Series 200 Computer: either an HP 9836S, or an HP9816S (optional expanded keyboard recommended) with HP 9121D Disc Memory or equivalent; together with an HP 2225A Graphics Printer or equivalent.

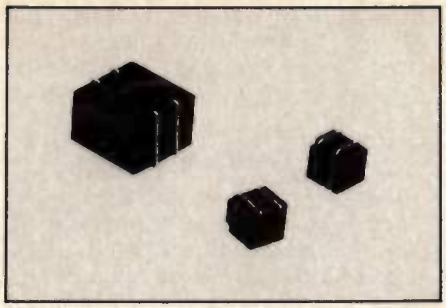
The SUGAR software is furnished on three floppy (5¼ inch) or microfloppy (3¼ inch) diskettes. A user manual is included. The price is $3,900, with immediate delivery. An over-the-telephone service for in-depth user support is available. **Systems for Automatic Test, Sunnyvale, CA 94089, INFO/CARD #175.**

Surface Mount Inductors

A new series of surface mount inductors has been introduced by West-Cap Arizona, a subsidiary of SFE Technologies.

Priced under $1.00, in quantities of 25,000, the SMI-200 series inductor features surfaces capable of vacuum pickup and handling by robotized pick-and-place machines. They are available in bulk pack or tape and reel — with an orientation to accommodate board placement.

The two package sizes of .215 and .400 square inch have a maximum height of .250 inches, and accommodate a wide



range of inductor values from a few microhenries to several hundred microhenries. The inductor is capable of withstanding solder reflow and detergent washes. Operating temperature range is -40°C to +70°C. The units are capable of enduring a humidity level of 80% RH at 85°C for 250 hours. They are rated to withstand thermal shocks between -40°C and -70°C for 20 cycles.

West-Cap Arizona should be contacted for information on available sizes for both power and RF applications. Custom designs are available on request. **SFE Technologies, San Fernando Electric Division, West-Cap AZ, please circle INFO/CARD #174.**

New Personal Computer

IBM introduced a new top-of-the-line Personal Computer with significant performance improvements.

The IBM Personal Computer AT uses advanced technology, including the high-speed Intel 80286 microprocessor, a high-capacity diskette drive and expanded fixed-disk drive options.

The new personal computer delivers almost five times the user memory and more than twice the information storage capacity previously available on IBM PCs. And, in most cases, system performance is two to three times faster.

The system is compatible with most existing IBM Personal Computer hardware and software. Starting at $3,995, the Personal Computer AT is available immediately at more than 1,500 Authorized IBM Personal Computer Dealers and through IBM's Product Centers and branch sales offices nationwide.

The Personal Computer AT can be used as a powerful single-user system or shared by up to three users. And because of its performance and storage capabilities, the new system is ideal for use with the new IBM PC Network that enables customers to easily link IBM PCs to share programs, information and peripheral devices.

The IBM Personal Computer AT comes in two easily expanded models:

- A $3,995 model that includes 256,000 characters of user memory and a new 1.2-million character high-capacity diskette drive; and
- A $5,795 model that includes 512,000 characters of user memory, the 1.2-million character diskette drive, and a new 20-million character fixed-disk drive.

Both models have an 84-key keyboard and eight expansion slots for additional features, devices and memory. Both also can be expanded with options to more than 3 million characters of user memory and up to 41.2 million characters of disk storage. A 12-month warranty is standard.

IBM also announced version 3.0 of its widely used Personal Computer Disk Operating System. This version has added function to support the new Personal Computer AT hardware and is compatible with all IBM PCs.

The IBM PC XENIX operating system, also announced for the Personal Computer AT, enables two additional terminals to share the computer's processing power. In either a multi- or single-user environment, IBM PC XENIX allows more than one task to be handled at a time. For example, a program can be compiled while another is being edited.

IMB also introduced new software development, text formatting and programming aids for use with XENIX and other programs. They include a professional "debug" facility and an application display management system.

Several application programs also were announced, including:

- IBM PC DisplayWrite Medical Support, used with the popular DisplayWrite 2 text processor to provide spelling assistance for frequently used medical terms; and
- IBM PC Office Correspondence Retrieval System, which enables users to retrieve documents by searching for individual words or phrases.

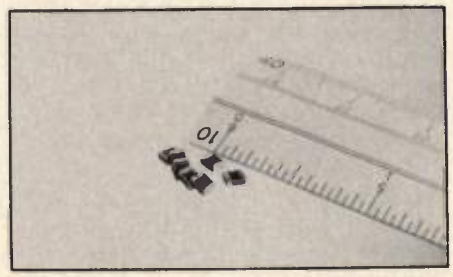
An IBM Personal Computer AT Technical Reference Manual, which details functional specifications, is available immediately.

The company also announced that IBM Credit Card applications are being accepted for use in connection with IBM PC-related purchases at Authorized IBM Per-

sonal Computer Dealers. Previously, the card was available for use in IBM Product Centers. **Entry Systems Division, Boca Raton, FL 33432. INFO/CARD #99.**

Multilayer Ceramic Capacitor Chip

Johanson Dielectrics, Inc. is producing what the company refers to as the "smallest multilayer ceramic capacitor in the world." Measuring .040" in length, .030" in width and .030" in thickness, the space saving capacitor chip is ideally suited for microminiature hybrid circuit applications. Designated the RO9 size, it is available in three families of dielectrics, covering a broad range of capacitance values.



NPO/COG — min. cap = 0.5 pf; max. cap = 100 pf.

BX/X7R — min. cap = 100 pf; max. cap = 2200 pf.

Z5U/Y5V — min. cap = 1000 pf; max. cap = .015 uf.

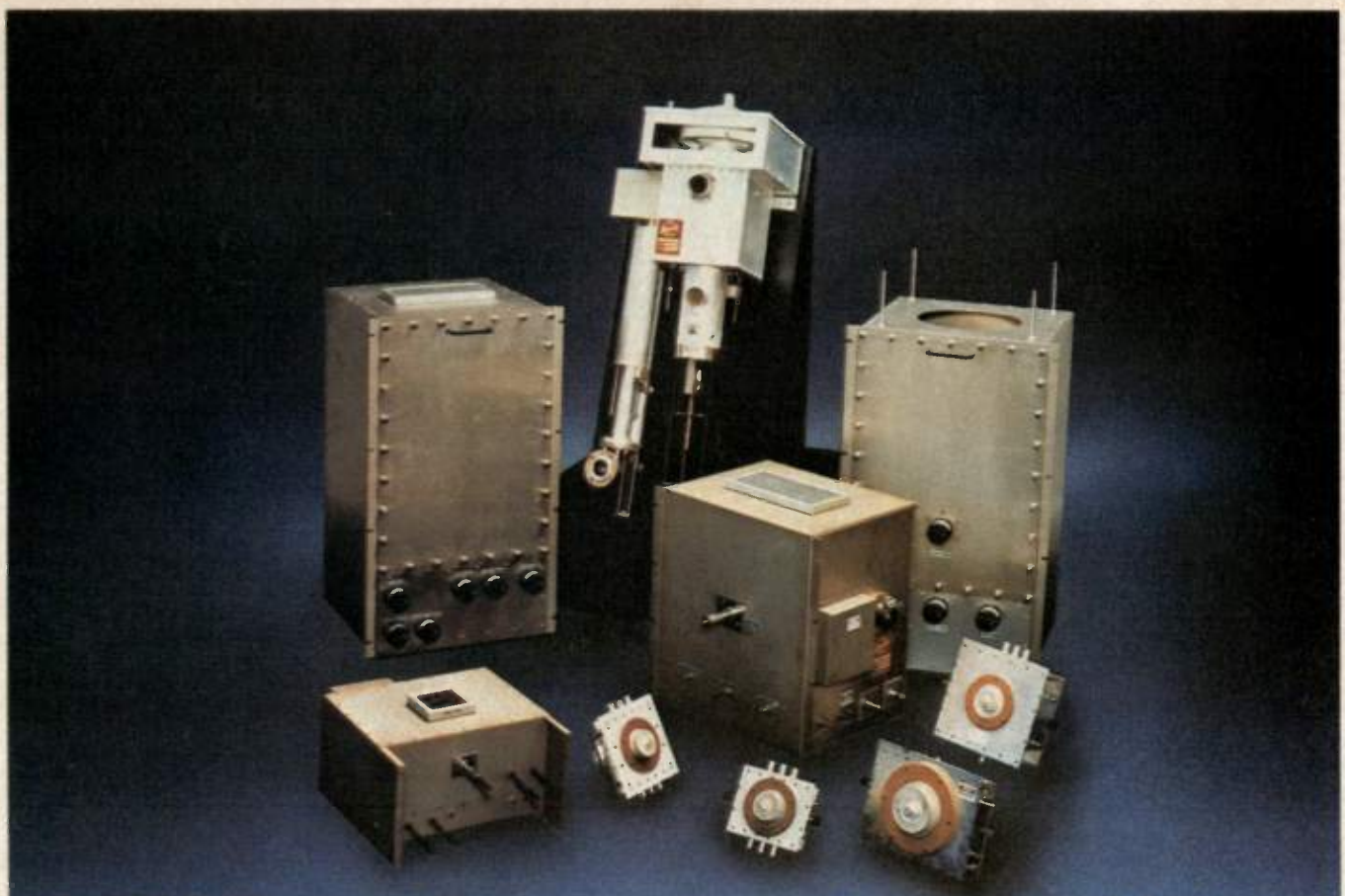
Prices range from $0.773 to $2.40 at the 1,000 quantity level with delivery being from stock to 10 weeks typical. **Johanson Dielectrics Inc., Burbank, CA 91505, INFO/CARD #173.**

VHF/UHF Receiver

Interad Ltd., an electronics R&D firm in Gaithersburgh, Maryland announces the availability of a frequency synthesized VHF/UHF receiver which tunes over the frequency range of 20-1000 MHz. The receiver is supplied in a leather case for

convenient portable operation. The 7520 receiver incorporates state-of-the-art technology and has the following major features:

- Frequency Range — 20-1000 MHz
- Frequency Resolution — 10 Hz
- Demodulation — AM, FM, CW/SB



EIMAC cavities cover 54 to 970 MHz at power levels to 30 kW —our design or yours

Varian EIMAC has complete cavity design and production capability. We make sure that tube and cavity are compatible. If it isn't an off-the-shelf-item, we have the designers and engineers for any specific job.

EIMAC has expertise in all disciplines including pulse, CW, FM, and TV. We match tube, power, bandwidth and operating mode to achieve optimum performance.

More information on EIMAC cavities and tubes is available in our Cavity Capability brochure from Varian EIMAC. Or for prompt consideration of your special design requirements, contact Product Manager, Varian EIMAC, or the nearest Varian Electron Device Group sales office. Call or write today.

EIMAC Cavity	Matching EIMAC Tube	Tuning Range (MHz)	Power Output
CV-2200	4CX20,000A	86–108	30 kW
CV-2220	3CX1500A7	86–108	1.5 kW
CV-2225	4CX3500A	86–108	5 kW
CV-2240	3CX10,000U7	54–88	10 kW†
CV-2250	3CX10,000U7	170–227	10 kW†
CV-2400	8874	420–450	300/1250 W*
CV-2800	3CX400U7	850–970	225 W
CV-2810	3CX400U7	910–970	190 W

*pulsed power
†peak sync, or 2.5 kW combined in translator service

Electron Device Group
Varian EIMAC
301 Industrial Way
San Carlos, California 94070
415-592-1221

Varian A.G.
Steinhauserstrasse
CH-6300 Zug, Switzerland
Tel: (042) 23 25 75
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- IF Bandwidths — 3 selectable (2.5 KHz to 5 MHz)
- Spectrum Display Unit — 3 MHz Sweep Width, 10 KHz Resolution
- RF Preselector — Optional Tracking 4 Pole Preselector of 5-10% Bandwidth
- Portable — In a 21" x 13" x 7" Briefcase
- Weight — Total Including Case, 45 lbs. **Interad Ltd., Gaithersburg, MD 20879, INFO/CARD #172.**

Custom Housings and Chassis

In-house software development for CNC-programming assures competitive prices with quick turnaround on both large and small runs. Close tolerance specificatioons are met. **Advanced Machining Techniques, Inc., Port Washington, NY 11050, please circle INFO/CARD #171.**

Broadband Doubler Covers 20-1500 MHz Output

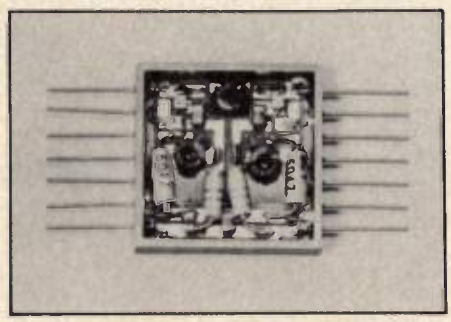
Anzac Division of Adams-Russell Company introduces a multioctave frequency doubler. The FM-105 has an input range of 10-750 MHz producing an output of 20-1500 MHz with converntion loss of typically 10 dB. (Harmonic products are

typically 30 dB down). The doubler is built in a .600 x .385 x .400 relay header.

The FM-105 is $35.00 in small quantities, and delivery is from stock. **Anzac Division of Adams-Russell, Burlington, MA 01803, INFO/CARD #170.**

Power Dividers

Typical specifications from Merrimac Industries' Hi-Rel Power Dividers provide: isolation (20 dB typ.); insertion loss (1.0 dB typ.); frequency range (700 to 1250 MHz); VSWR (input) (1.3 typ.; 1.5 max.), Z_{in}/Z_{out} (50 ohm nom.); power level (+30 dBm typ.); amplitude balance (+0.25 dB typ.); test in accordance with MIL-STD-202; hermetically sealed to 1 part x 10^{-10} ATM cc/sec; temperature -65 to +125°C operating; vibration 50g Sine; MTBF 300,000 hrs. min. Wired in accordance with MIL-S-45743; Q.C. system per MIL-Q-9858; inspection system per MIL-I-4208.



The 5-way power dividers are in stock for immediate delivery. **Merrimac Industries, Inc., West Caldwell, NJ 07007, INFO/CARD #169.**

Coaxial Protector

Protector units are now available for use in antenna systems, microprocessors, CAT scanners, local area networks and CATV installations. Other protection types may be used to prevent EMP damage.

Each offers a fast response, high energy handling capability and a connector body that has very low insertion loss and VSWR. A wide range of voltages and connector types may be inserted directly into a coaxial cable system.

Coaxial protection is a product of Reliable Electric. Since 1909, Reliable has designed and manufactured protection devices for the telecommunications in-

dustry. **Reliable Electric/Utitlity Products, Franklin Park, IL 60131, please circle INFO/CARD #168.**

13-Way Power Divider

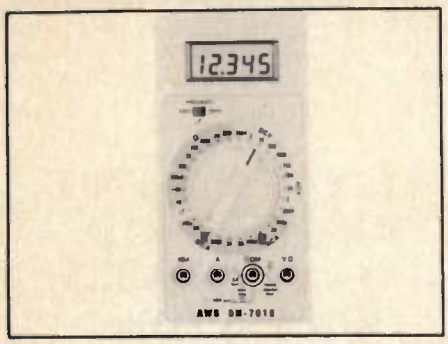
Sage Laboratories, Inc. now offers a 13-way power divider (Model FP3266) that will mate directly to a multi-element antenna thru precisely positioned outputs. Typical performance from 725 to 1275 MHz is 14 dB maximum insertion loss and 0.6 dB maximum insertion loss unbalance from the input to any output.

Input VSWR is 1.5/1 maximum and output VSWR is 1.25/1 maximum. Isolation between outputs is 25 dB minimum.

Price and delivery depend upon application. **Sage Laboratories, Inc., Natick, MA, 01760, INFO/CARD #167.**

DMM With Frequency Counter

The model DM-7010, a new DMM from A.W. Sperry Instrumental, Inc. boasts 9 functions on 33 ranges with basic DC accuracy of 0.05% of reading. Some of the DM-7010's features are: 4½ digits with a maximum display of 19999, AC and DC current functions, resistance and conduc-



tance capability, diode and continuity tests, frequency counter up to 200 KHz, overload protection on all ranges, safety designed input jacks and a built-in tilt stand.

The DM-7010 ranges are: DC Volts: 200mV/2V/20V/200V/1000V; AC Volts: 200mV/2V/20V/200V/750V; AC/DC current: 200mA/2mA/20mA/2A/10A; Resistance: 200Ω/2KΩ/20KΩ/2MΩ/20MΩ; Conductance: 200nS; Diode Check & Audible Continuity Check; Frequency Counter: 20 KHz/200 KHz.

A number of useful accessories are also available for the DM-7010. They are: Model C-36 carrying case, Model SJA-870 AC current jaw adaptor, Model

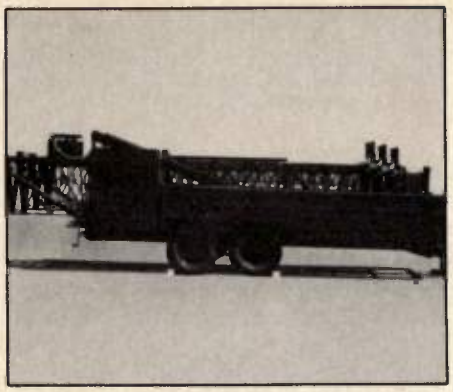
HVP-860 high voltage probe, Model HFE-840 transistor/diode test adaptor. **A.W. Sperry Instruments Inc., Hauppauge, NY 11788, INFO/CARD #165.**

Self-Contained, Transportable HF Antenna System

A self-contained, transportable log periodic HF antenna system was announced by Telex/Hy-Gain. The system, Model 5025, consists of the antenna, rotator, 60 foot (18.3 m) telescoping tower, generator, as well as installation tools and hardware, all stowed on one tandem axle trailer. The compact design permits all modes of transportation from towing with a pickup truck to airlifting on a C-130 aircraft.

The antenna covers the frequency range of 4-30 MHz and has a gain of 9 dBi from 4 to 6 MHz, and 12 dBi from 6 to 30 MHz. The electric antenna rotator can be controlled from the base of the tower or remotely with a two-wire remote control unit which is provided. The remote control features a digital display of the antenna azimuth in 10 degree increments.

Maximum use of color coding, captive



hardware, and modular construction makes the 5025 the fastest erectable rotating tower/antenna system in its class. The system can be assembled and erected by as few as two individuals' however, a team of four can complete this task in less than two hours. The self-contained 5 kW generator set provides all power necessary for erection and operation of the antenna. A hydraulic tilt-up trolley provides positive control during erection. According to Hy-Gain, this exclusive feature yields a high level of safety and eliminates the complexity and hazards associated with the manual erection of towers.

The company stated that the 5025 is a truly transportable HF antenna system with the same efficiencies and features previously available only in fixed station systems. **Telex Communications, Inc., Hy-Gain CIM Department, Lincoln, NE 68505, INFO/CARD #164.**

Microwave Chip Resistive Devices

KDI Electronics, Inc. has announced the availability of Microwave Chip Resistive Devices utilizing sputtered Tantalum Film Technology. An outstanding feature of this device is the method of adjustment. All values, for either attenuators, terminations or resistors are calibrated by an anodizing process. This electronic calibration technique creates a glass passivation layer over the undisturbed metal film and accounts for the excellent stability characteristics by providing hermetic type protection from harsh environments. These devices are manufactured using both alumina and beryllium oxide substrate materials. The high performance features include power capabilities to 200 watts CW and 8 KW peak. High frequency performance extends to 26.5 GHz and chip sizes range down to .040;; x .020". **KDI Electronics, Inc., Whippany, NJ, INFO/CARD #163.**

Programmable Attenuators

Telonic Berkeley Inc. has introduced a new series of programmable attenuators designed for precise controlling of signal attenuation in remote or automatic test systems.

The Telonic Berkeley Model 8300 programmable attenuators are available in three different ranges of attenuation: Model 8360 — 0-11 dB in 1 dB steps; Model 8367 —P 0-70 dB in 10 dB steps; and Model 8368 — 0-110 dB in 10 dB steps.

Each attenuator is composed of either three or four attenuation sections in series, with each section consisting of a precise thickflim microstrip attenuator, a 0 dB line, and a switched conductor pair. The conductors and 0 dB line comprise a TEM mode transmission line which maintains a constant impedance during switching.

The attenuator sections can be selected in any order desired to provide changes in attenuation from 0 dB to the maximum value, with the smallest change being the minimum selectable value. Each section is controlled by a latching relay with self-contained solenoid drive circuitry. Switching time is less than 20ms. Switching can be accomplished with either a mechanical switch closure to ground or a TTL-level signal. Command lines are pulled up to 5 volts.

The frequency range of the Model 8300 programmable attenuators is 0-4 GHz; impedance is 50 ohms; and RF power handling ability is 3 watts average, 200 watts peak. The attenuators are equipped with type SMA RF connectors per MIL-C-39012.

Model 8300 programmable attenuators are priced from $582, with 6-8 weeks delivery ARO. **Telonic Berkeley Inc., Laguna Beach, CA 92652, please circle INFO/CARD #160.**

Universal Bandpass Filter

Adjustable Range:
Time delay >14:1
Bandwidth >10:1
f_o adjustable over ±10%

A unique Cir-Q-Tel design, an adjustable capacitor that ranges from 1 > 20n pf, has been incorporated into this array of 2-pole adjustable-bandwidth filters. These devices:

- are available for any f_o from 1 > 6 GHz
- provide bandwidths (3 dB) continually adjustable from 0.1% > 1%.
- have Td (f_o), adjustable, from

70 > 500 nsec. (tyuical for 3-GHz model). Other models display similar performance.

• have a response shape that ranges from Pseudo-Butterworth to Gaussian over much of BW (3 dB) range.

At Cir-Q-Tel no filter design problem is too great or too small for us to consider. We have more engineers per total employment (25%) than any other significant filter-producing company.

Remember, we have over 30 years experience and 10X demonstrated innovative abilities all wrapped up in just one of our world class engineer/scientists. **Cir-Q-Tel Inc., Kensington, MO 20895, please circle INFO/CARD #159.**

Microwave Crystal Source

The model M4000 series source is a highly reliable, compact microwave oscillator, designed for military applications, operating over -54°C to +85°C.

Unit is produced at any set frequency in the range of 500 MHz to 3.0 GHz at output power levels up to 100 mw.

Output signal is extremely clean with harmonics, subharmonics and spurious down -60 dBc.

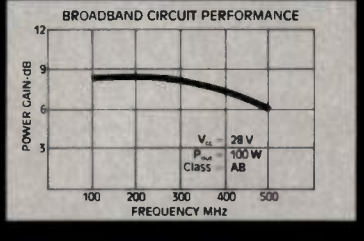
Unit offers low phase noise with a basic oscillator level of -135 dBc/Hz at 1 KHz removed.

Operation is from a standard +15 or

GOING THE DISTANCE

*The date: February 1, 1925—*Togo, *a 10-year-old Siberian husky, led his team in the desperate drive to carry diphtheria antitoxin to the children of Nome Alaska—going the distance for an incredible 340 miles, non-stop, in the face of 80 mph winds and 50-below-zero temperatures.*

ACRIAN GOES THE DISTANCE IN BROADBAND COMMUNICATIONS TECHNOLOGY



Acrian is a world leader in high power, high-reliability RF and microwave broadband power devices. We got there by going the distance—meeting a diversity of telecommunications needs with a non-stop commitment to engineering and manufacturing teamwork, no matter how tough the challenge, or how basic.

Take a hard look at the 0105-100, an internally input-matched balanced NPN power transistor, with 100 watts output for 100-500 MHz broadband applications.

Gold thin-film metalization and surface passivation deliver proven high MTTF, making the 0105-100 an outstanding example of the Acrian communication transistor series.

Call us for complete specifications on the 0105-100, or any of more than 500 Acrian products that go the distance in communications, radar, and avionics. Call or Telex: (408) 996-8522 TWX (910) 338-2172.

Acrian Inc. 10060 Bubb Road Cupertino, California 95014

ACRIAN

POWER WITH A PURPOSE

INFO/CARD 45

L-Band transistors 1200-1400 MHz 55 watts, 6.5 dB gain.

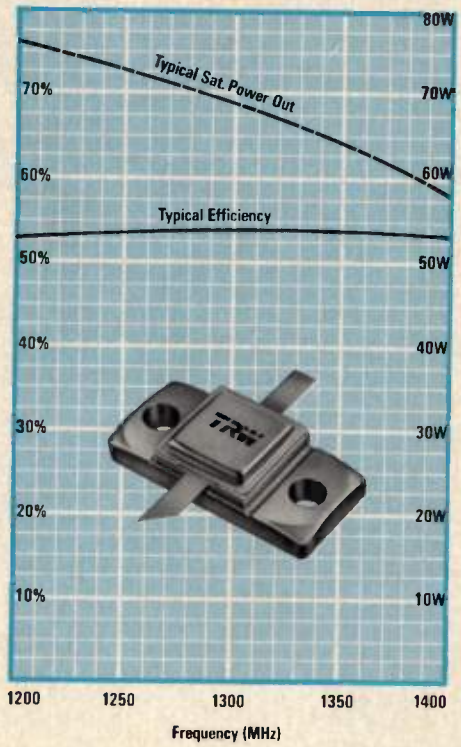
(Now available in production quantities)

Double your power output, cut circuit complexity 50%.

Get twice the power in a single package, and cut circuit complexity by 50%, with our latest L-Band transistor, the MRA1214-55H*—immediately available in the quantities you require through your local TRW distributor. This new microamp is a state-of-the-art device that incorporates special features pioneered by TRW such as PtSi—Ti-W-Au metallization and diffused silicon ballast resistors. It's the latest NPN silicon power microwave transistor for both military and industrial service in radar systems, ECM systems and other L-Band systems and its 100 unit U.S. price is in the $200 range.

Our new L-Band transistor provides a minimum of 55 watts output power at 28V collector potential—double the power output of other devices. In a pulsed mode (100μs modest duty) as much as 100 watts output power is available. And efficiency is 50%.

You can enormously simplify hybrid combining by using far fewer parts and ancillary components. You can cut circuit complexity in half to achieve a specific



power. The new MRA1214 is a tremendous technological advancement—the kind you'd expect from a company like TRW that's dedicated to advancing the state-of-the-art in RF Devices.

The MRA1214 is only the first of a whole new generation of RF Devices we'll be announcing during the next year. Keep your eye on TRW RF Devices.

For information and data sheets on the MRA1214-55H, contact your local TRW/ECG Field Sales Office or RF Devices Division, TRW Electronics Group, 14520 Aviation Blvd., Lawndale, California 90260, phone 213.536.0888.

 *U.S. Patent 3713006 (TRW)

INFO/CARD 46

TRW

RF Devices Division
TRW Electronic Components Group

ANNOUNCING THE END OF THE GaAs CRISIS.

Feel like you're waiting in line every time you order gallium arsenide devices?

Maybe it's bad enough when they're standard products you're after. And just plain intolerable when you need something made to your specs.

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Announcing a full line of high performance gallium arsenide diodes for C Band to millimeter applications, made the way you need them, available when you need them.

And they're all from Frequency Sources. So you know they've been measured, tested, retested and optimized in some of the most advanced microwave circuits anywhere.

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The ideal "chip form" Gunns for hybrid circuits. Feature power up to 500mW and 6% efficiency. Wide band widths up to 18 GHz.

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The rugged, reliable, MIL-SPEC standard for signal generation up to 24 GHz. Available to your exact specifications. Feature low noise and power to 500mW.

HIGH Q TUNING VARACTORS
The highest Q (up to 16,000) and lowest series resistance of any tuning varactor in the industry. Made to your specs in voltages from 15 to 60 volts. RF through millimeter tuning.

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INFO/CARD 47

LMI filters will solve your power and signal line RFI/EMI problems!

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Wall mounted Lectroline power line filter panels.

Floor mounted Lectroline high current power line filter panels.

Power factor correction networks, for filters with capacities of 20 to 200 mfd.

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Custom filters to your specs to comply with MIL-STD-461/2/3, FCC, VDE and other regs.

Common-mode filters.

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INFO/CARD 48

PSD-15A Electrostatic Discharge Simulator

Check your electronic equipment's ability to withstand electrostatic discharge from human or other objects. Standard discharge simulation circuit is 150 pF and 150 ohms. Other values are optional. Our PSD-15A is fully portable and comes in a compact transport case. Safe to operate, with adjustable voltage control and measuring of the charging voltage. Ergonomic, with light-weight, hand-held gun. DC or pulsed discharge circuits. ESD pulses can be triggered either as single or .1, 1, 10 or 100 impulses per second.

If you are concerned about your equipment's susceptability against electrostatic discharge, our PSD-15A testing unit will provide the answers you need.

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HV TEST SYSTEMS, INC.
Telephone (301) 826-8651 Telex 86223
Central Garrett Industrial Park, Accident, MD 21520

INFO/CARD 49

PIEZO's Finite Filter.

Our H-bar filters fill the gap between conventional crystal filters and SAW devices.

- ☐ Moderate loss, 7 dB typical
- ☐ Sharp selectivity
- ☐ No tuning or matching required
- ☐ Bandwidth from 50 to 500 KHz
- ☐ Less than 1 dB ripple
- ☐ SC cut crystals for high power applications
- ☐ High stopband attenuation greater than 60 dB typical
- ☐ Center frequencies from 40 to 150 MHz

PIEZO's new series of filters utilizing hi-frequency bulk acoustic resonators (H-bars) provide an attractive alternative network for system designers.

PIEZO H-bar filters can now be ordered with traditional crystal filter response characteristics designed to simply plug into your circuit. The H-bar filter eliminates the need to design a circuit to match existing devices for high frequency IF filter applications.

The costs associated with changes to circuit design, or tooling charges for SAW devices are often eliminated by ordering the proper PIEZO H-bar filter.

PIEZO Filters is an affiliate of PIEZO Crystal Company, a leader in the production of piezoelectric crystals since 1936. To discuss your applications call your nearby PIEZO representative, or write to PIEZO FILTERS, P.O. Box 619, Carlisle, PA 17013. Telephone (717) 249-2151.

TYPICAL PERFORMANCE (Actual Test Data)

Center Freq.:	100 MHz	Center Freq.:	70 MHz
3dB BW:	300 KHz	3 dB BW:	100 KHz
60 dB BW:	750 KHz	60 dB BW:	900 KHz
Insertion Loss:	7 dB	Insertion Loss:	7 dB
Ripple:	.75 dB	Ripple:	.75 dB
Impedance:	50 ohms	Impedance:	50 ohms

PIEZO FILTERS

INFO/CARD 50

+24 VDC supply and unit is packaged in a lightweight 4.38" x 1.75" x 1.05" high case. **Techtrol Cyclonetics, Inc., New Cumberland, PA 17070, please circle INFO/CARD #158.**

Microwave GaAs FET

Harris Microwave Semiconductor, a subsidiary of Harris Corporation, announced the availability of a new packaged GaAs FET, the HMF-0314, which features excellent gain and dynamic range characteristics for applications between 2 and 14 GHz.

Housed in a 70 mil square hermetic stripline package, the half-micron HMF-0314 provides maximum gain of 14 dB at 8 GHz (12 dB minimum guaranteed) and 10 dB typical at 12 GHz. Under power tuning and bias conditions, the HMF-0134 offers +18.5 dBm linear power.

Low noise performance of 0.9 dB typical at 4 GHz, 1.3 dB at 8 GHz and 2.3 dB at 12 GHz is achieved with a bias of 4 volts drain-to-source, and an I_{DS} of 20 percent of the saturated drain current.

The data sheet for the HMF-0314 includes characteristic S-parameters for high gain as well as for low noise bias conditions.

Priced at $23.75 (U.S.) each in 100 piece quantities, the HMF-0314 is available from stock. **Harris Microwave Semiconductor, Milpitas, CA 95035, please circle INFO/CARD #162.**

FiberOptic Interface Modems

An expanded series of fiberoptic RS-232-C modems are now available from Advanced FiberOptics Corp. AFI-232 modems are among the most versatile units of their kind. For example, all modems provide full-duplex asynchronous communication at rates in excess of 56 Kbaud, and half-duplex operation with handshaking capability. The units are configurable for either host supplied or external power, and have features not found in other units costs more. The units are DTE (Data Terminal Equipment) and DCE (Data Communications Equipment) compatible.

There are four models, two with SMA connectors and two with Optimate connectors; two are for short distance applications with plastic cable up to 100 meters long and two are for long distance with glass fiber up to several kilometers. AFC also provides cable termination service and termination kits. External power supply is also available. Prices for these modems start at $149.00. **AFC, Tempe, AZ 85281, INFO/CARD #161.**

Attenuator Chip Kit

A new Designers' Attenuator Chip Kit from EMC Technology, Inc. permits fast, convenient and accurate fine tuning of attenuation values for microwave circuits. The kit is comprised of 50 different EMC TSO-300 style attenuator chips, with five chips each of 10 different dB values ranging from 1 to 10. It is ideal for adjusting signal strengths in multiple channels as well as for many prototyping applications.

A company spokesman explained the main advantage of the new kit is the design flexibility and convenience it offers microwave engineers. By having a large quantity of attenuators on hand with different values, the engineer can readily experiment with various levels without purchasing individual attenuators or groups.

Attenuators in the kit are .050" sq., screen printed on Al_2O_3 substrates, and are available either pre-tinned or without tinning for wire bonding applications. In addition, unattached leads are also provided in the kits for bonding or soldering.

Complete attenuator chip kits cost $200, and are offered from stock. **EMC Technology, Inc., Cherry Hill, NJ 08034, INFO/CARD #124.**

Micro-Miniature Reed Relay

Standex Electronics has introduced one of the smallest reed relays in the industry, the Series SG Micro-Miniature. The relay occupies only .16 sq. in. of PC board space and is ideal for high-density packaging requirements.

The relay is available in Form 1A and Form 2A configurations. Options include electrostatic shielding and co-axial electrostatic shielding with termination at both ends of the relay. Magnetic shielding is also available.

The SG Series can use any one of several Standard Standex Reed switches, including the GHG560 reed switch which features an amalgam contact material designed specifically for ATE applications requiring long life with low and stable contact resistance.

Pricing for SG relay in a Form 1A, with 5 volt version is $1.05 at 1K.

Standex Electronics Reed Relays are manufactured using advanced highly automated manufacturing techniques and unparalleled quality control methods resulting in highly competitive prices. The products are internationally known for

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SOLUTIONS TO YOUR RFI/PACKAGING PROBLEMS

— 420 standard configurations off — the shelf
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— Capable of performing all — secondary operations to our standard enclosures from your specs
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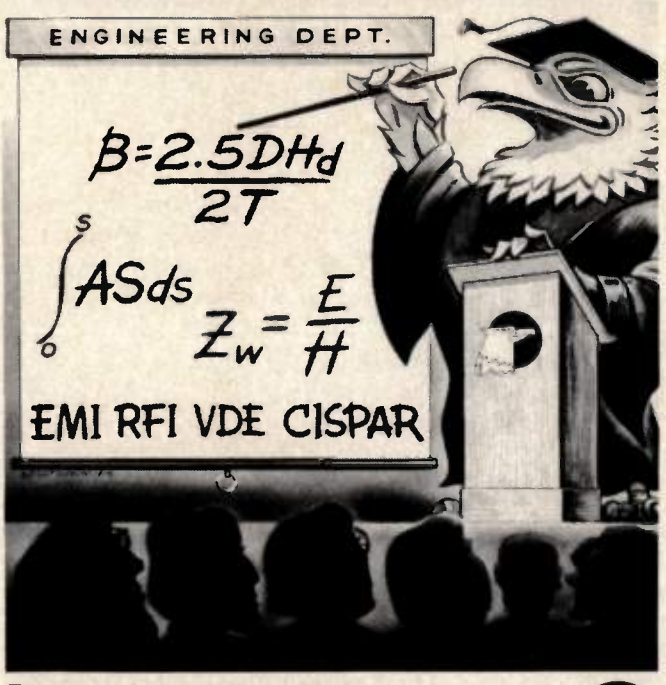
INFO/CARD 56

EMI PROBLEMS?

Let Eagle Magnetic solve your magnetic shielding problems!

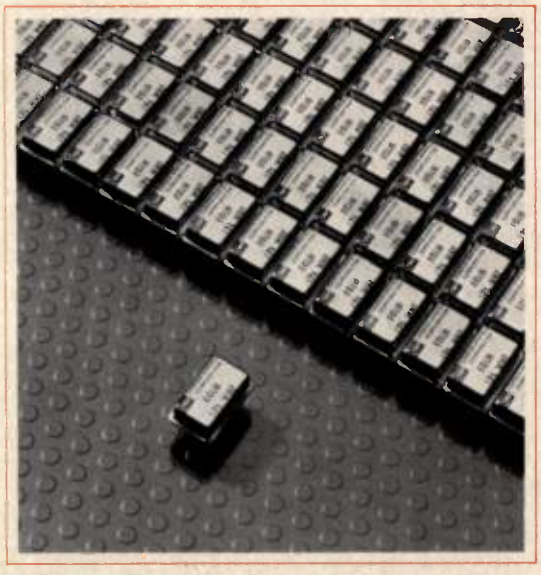


For more information write or call:
P.O. Box 24283 • Indianapolis, Ind. 46224
Phone (317) 297-1030

INFO/CARD 57

CONNOR-WINFIELD OSCILLATORS

SHORT-ORDER SPECIALISTS



But we can cook up a big batch, too!

Connor-Winfield is ready to serve. Whether the oscillators you need are in stock or custom designed or whether you need 1 or 10,000, our special of the day—everyday—is meeting your needs with the right combination of quality and low cost. Are you ready to order? Call or write us today for more information.

ECL DIP High Frequency	Models:	ECLA, ECLB		
	Frequency:	8MHz—200MHz, ±.01%		
	Supply:	−5.2Vdc ±5% or −4.5Vdc ±5%		
	Output:	10K ECL or 100K ECL		
	Package:	All metal, hermetically sealed		
DIP SINEWAVE Low Freqency	Models:	DPS1	DPS2	
	Frequency:	1KHz—75KHz	100Hz—100KHz	
	Tolerance:	±.01%, THD ≤5%	±.01%, THD ≤5%	
	Supply:	5Vdc ±10%	8Vdc—15Vdc	
	Package:	All metal, hermetically sealed		
TTL CLOCKS Tight Tolerance	Models:	S10C	S10D	S10E
	Frequency:	31KHz—25MHz		
	Tolerance:	±.001%	±.0025%	±.005%
	Temp. Range:	0°—50°C	0°—70°C	−25°—75°C
	Package:	All metal, hermetically sealed 14 pin DIP		
TTL CLOCKS Stock Frequencies/ Low Cost	Models:	S14R8	S15R8	
	Tolerance:	±.005%	±.01%	
	Supply:	+5Vdc ±10%, 60mA max		
	Frequencies:	1,2,4,5,6,8,10,12,16,20,24,40,70MHz		
	Package:	All metal, hermetically sealed 14 pin DIP		

CONNOR-WINFIELD CORPORATION
West Chicago, IL 60185 USA
Phone: 1-312-231-5270
TWX No. 910-230-3231
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INFO/CARD 58

Now, HP packs more value into its economical RF spectrum analyzers with digital display and rugged portability.

Measuring RF signals? HP's economy RF spectrum analyzers now give you even more value for your money. We've added digital display, versatile data I/O and rugged portability to the excellent performance and operating simplicity of these popular spectrum analyzers. The new HP 853A digital display spectrum analyzer mainframe with the HP 8557A (10 kHz-350 MHz) or 8558B (100 kHz-1500 MHz) spectrum analyzer plug-in combines accurate performance and simple three-knob operation to meet a wide range of RF measurement applications.

Digital display adds clarity and convenience.

The HP 853A provides two independent 480-by 800-point resolution traces for flexibility in storing trace data and monitoring signal changes. You get a crisp, flicker-free, easy-to-read display. And the microprocessor-managed display system includes maximum hold for storing peak signal values, digital averaging over successive sweeps to reduce noise effects, and trace normalization to help detect signal changes in a crowded spectrum.

Rugged portability lets you take it almost anywhere.

The 853A is designed for transportable use in rigorous environments. Weighing less than 48 lbs., the analyzers can be taken outdoors for field test use, or easily moved around lab and production sites. The 853A comes with a tilt-bail handle, rubber bumpers, and a drip-proof front panel cover. What's more, the HP 853A with plug-in installed is type-tested to meet shock, vibration and driptest levels specified under MIL-T-28800 C Type III, Class 3, Style C performance tests.

A choice of RF plug-ins covers your applications.

Notable performance specifications of the 8557A and 8558B plug-ins include 70 dB dynamic measurement range, 1 kHz to 3 MHz variable resolution, full range frequency response of ±1 dB and 70 dB IF substitution amplitude accuracy of ± 1 dB. Basic measurements require only a three-knob sequence: TUNE to a signal and read frequency from the LED display, narrow the FREQUENCY SPAN for closer analysis and adjust REFERENCE LEVEL to read amplitude directly. Resolution and sweep speed are automatically adjusted.

U.S.A. list prices for the plug-ins are: HP 8557A (350 MHz) $6,520; HP 8558B (1500 MHz) $7,925. The new 853A display mainframe is listed at $5,550.*

DESIGNED FOR HP-IB SYSTEMS

For a permanent record or comparison of many displays, the 853A push-button controls can directly operate an HP-IB plotter for hard copy data recording. Or connect the 853A to a computer (like the HP-85) via HP-IB and get trace I/O as well as operator prompts on the CRT.

To add portability and digital display convenience to your RF spectrum analysis applications, call your nearest HP sales office and ask for "Instruments." For the same simplicity and performance in microwave applications, ask about HP's economical microwave plug-in for the 853A. For more information about these instruments, write Hewlett-Packard, 1820 Embarcadero Rd, Palo Alto, CA 94303. *U.S.A. list prices only

5301201

Come to HP's RF & Microwave Symposium: In Maryland—Oct. 3rd & 4th. For details call 301/258-8041. In Boston—Oct. 9th & 10th. For details call 618/861-8960 x614.

HEWLETT PACKARD

INFO/CARD 59

high reliability across a wide spectrum of industries. **Standex Electronics, Cincinnati, OH 45209, INFO/CARD #157.**

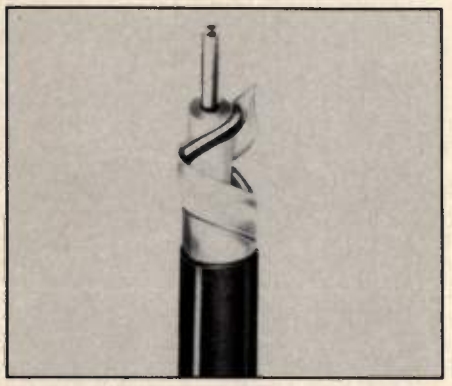
RFI Conductive Coating

MS-485 (black) conductive coating acts as an effective shield against a broad range of RFI/EMI. When applied in a typical 2-mil coating it becomes functional within minutes and dries in approximately 15 minutes. The coating provided attenuation of 78 dB at 1 MHz and 44 dB at 1000 MHz with a surface resistivity of approximately 0.5 ohm/square at 2-mil thickness. MS-485 is recommended for use on plastics and metals. It is available

in 16 oz. aerosol cans and is removable by using MS-114 Conformal Stripper. **Miller-Stephenson Chemical Co., Danbury, CT 06810, INFO/CARD #156.**

Subminiature Teflon Coax Cable

The increasing interest in high speed data communications has led TFC to expand its participation in this growing market.



Times subminiature teflon coax cables are used for transmission lines to transmit computer data at high speeds and at the same time are miniaturized to operate in confined areas. These cables generally have a propagation velocity of 80% or greater and the resulting lower time delay allows the transmission of data at higher speeds. These smaller coaxes with diameters ranging from .055" to .100" have a lower capacitance than cables many times their size.

Times subminiature teflon coax cables

Who gives you dependability in noise figure measurements? HP, of course.

The HP 8970A Noise Figure Meter has a proven performance record—proven accuracy, proven flexibility, proven dependability. All for $10,300.

Dependable equipment

Our latest warranty report data on the HP 8970A reveals a mean time before failure of 18,300 hours, the equivalent of nine years of trouble-free service. This outstanding record is the direct result of our extensive reliability engineering program for de-rating components, stress testing, and bug-free software.

With a choice of three noise sources—the HP 346A ($1500) for mismatch-sensitive devices, the HP 346B ($1400) for general purpose measurements to 18 GHz, and the HP 346C ($1900) for measurements to 26.5 GHz—you can measure mixers, amplifiers, down-converters, or complete systems from 10 MHz to 26.5 GHz.

Dependable measurements

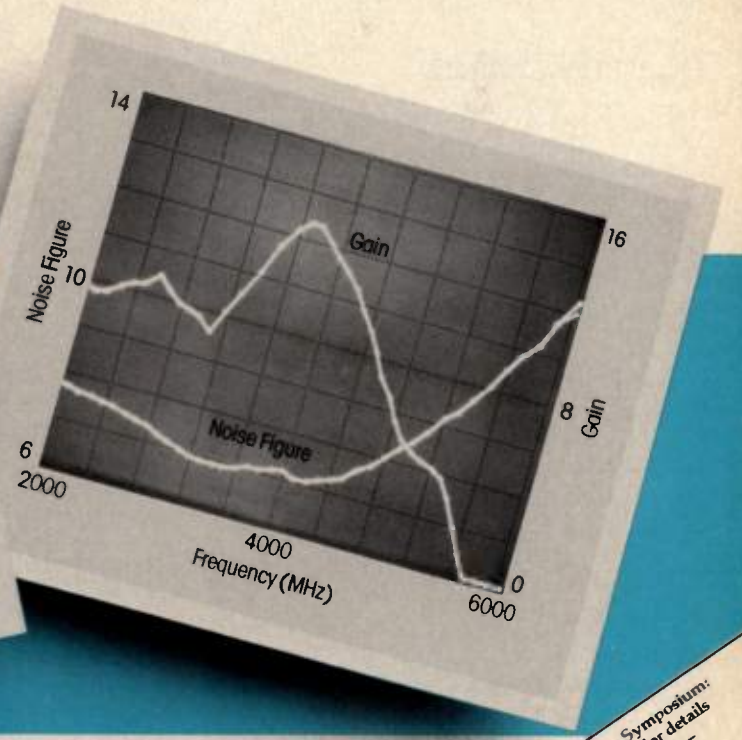
When you assemble an HP noise figure system, you can depend on your results. Tabular lists of NBS-traceable excess noise ratio values are furnished on each noise source. And the sources have low SWR, resulting in low mismatch uncertainty. HP's conservative specifications assure that our numbers and your numbers will agree with those of your customers.

Dependable support

Nobody gives you more technical support than HP—applications literature, seminars, and worldwide engineering assistance. For more information about the dependable HP 8970A, call your local HP sales office listed in the telephone directory white pages. Or write Hewlett-Packard, 1820 Embarcadero Road, Palo Alto, CA 94303.

DESIGNED FOR HP-IB SYSTEMS

U.S. prices



HEWLETT PACKARD

INFO/CARD 62

Come to HP's RF & Microwave Symposium: In Maryland—Oct. 3rd & 4th. For details call 301/258-8041. In Boston—Oct. 9th & 10th. For details call 617/861-8960 x614.

are specially designed for electronic data processing applications. Sheilding techniques such as served wires and aluminum polyester wraps are often used. A drain is generally provided to facilitate termination of the shield. The center conductor and drain wire can be terminated by wire wrap techniques or by soldering. Impedance levels of 90 and 100 ohms are common in order to match digital circuitry requirements. **Times Fiber Communications, Inc., Wallingford, CT 06492, please circle INFO/CARD #155.**

Oscillator

KLQ100 oscillators originated as an interim ovenized design with high stability over extreme temperatures. It was designed with flexibility in that it may be supplied at frequencies as high as 100 MHz merely by changing the crystal frequency and the RF utput board. The output

may be TTL, Sine, or C-MOS compatible. For its size, 2" x 2" x 4", this unit is very stable from -40 degress C to +75 degrees C. Depending on available power, the temperature/frequency stability may be held to a few parts in 10E-9 over this range. The typical short term stability is a few parts in 10E-11 while the aging rate may be as low as 5E-10/day.

The oven is proportionally controlled with the crystal temperature held to within 0.01 degrees C. The phase noise is held to less than -160 dBc at 1000 Hz from the carrier. It weighs approximately 11 ounces.

The KLQ100 is available in both military and commercial versions with the price ranging from $440 to $600 each for quantities of five each, depending on application requirements. **K&L Microwave, Inc. Salisbury, MD 21801, please circle INFO/CARD #154.**

Multiple Output Crystal Controlled Oscillator/Multiplier

This multiple output crystal controlled oscillator/mulltiplier chain utilizes TRAK's thick-film construction techniques for high performance and high reliability. As with most supercomponents, this oscillator is custom designed with regards to frequency and power output levels. Frequency is customer specified between 500 and 1400 MHz. Frequency set accuracy is ±10 ppm; frequency stability is ±30 ppm max.; frequency pulling is ±10 KHz max.

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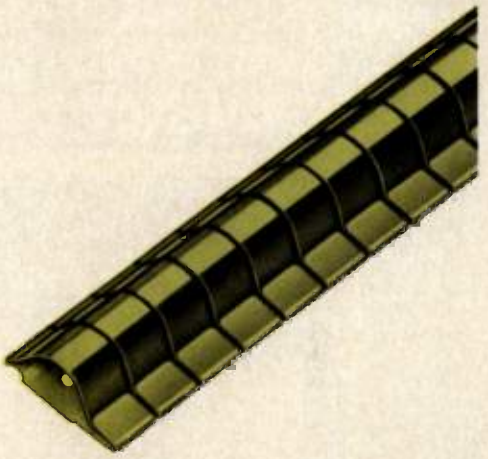


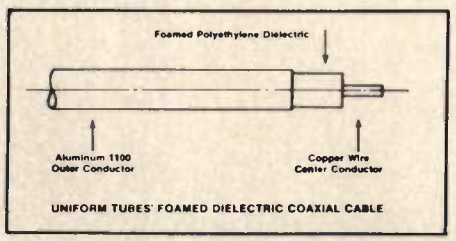
for VSWR up to 3:1, all phase angles; frequency pushing is ±10 KHz/volt max.; isolation (any 2 ports) is 20 dB min.; phase noise is -106 dBc/Hz at 10 KHz from carrier; switching logic is TTL compatible and switching time is 1.5 μs max. The operating voltages are +15 VDC at 150 mA, nominal and +5 VDC at 100 mA, nominal. The operating temperature range is -54°C to +95°C. Size is 4.12 x 3.0 x .65 inches. RF connectors are SMA female. DC connectors are filter solder terminals. **TRAK Microwave Corporation, Tampa, FL 33614, please circle INFO/CARD #153.**

Low Loss Semi-Rigid Coaxial Cable

A lightweight semi-rigid coaxial cable with a polyethylene foam dielectric has been introduced by the MicroDelay Division of Uniform Tubes, Inc., Collegeville, Pennsylvania.

The cable is a joint development of Uniform Tubes and Huber + Suhner, Herisau, Switzerland. It was designed for use in delay lines up to 210 feet, and for antenna lines being used to transmit from remote sites.

The cable, which is 0.250" (6.35mm) in outside diameter, has a lightweight aluminum outer conductor and a foamed, rather than solid, polyethylene dielectric



UNIFORM TUBES' FOAMED DIELECTRIC COAXIAL CABLE

with a copper wire inner conductor. The foamed polyethylene dielectric provides lower loss than solid PTFE materials. Nominal attenuation at 10 GHz is 0.25 dB per foot.

The cable can accommodate Suhner type N connectors which are available from Uniform Tubes, or can be furnished as a complete assembly. The foamed polyethylene cable is marketed throughout Europe by Huber + Suhner. **Uniform Tubes, Inc., Collegeville, PA 19426, please circle INFO/CARD #152.**

Connect, Disconnect Without Signal Break

A series of compact components for use on signal transmission lines where an open circuit cannot be tolerated is now available from Amphenol Products.

The series includes automatic coaxial terminators and an automatic circuit insertion switch.

The automatic coaxial terminators allow the line to be terminated automatically with self-contained resistance load when the output plug or jack is disconnected.

While these components perform like standard connectors, a simple actuation sequence ensures a positive uninterrupted circuit during the manual connect or disconnect of the output connector.

The 362-10007 automatic coaxial terminator has a coaxial terminator has a coaxial line input with crimp-crimp cable affixment, a BNC output connector, and a 93 ohm load which goes on line when the output is disconnected.

The 362-10008 functions as an adapter with a BNC line-input jack and a BNC output plus which performs the automatic termination to a 93 ohm load when disconnected.

The circuit insertion switch, Amphenol

part number 362-1006, allows the user to bridge, tap or insert an equipment unit on line by manually connecting to the switch with no interruption to the system. No power is needed for switch operation.

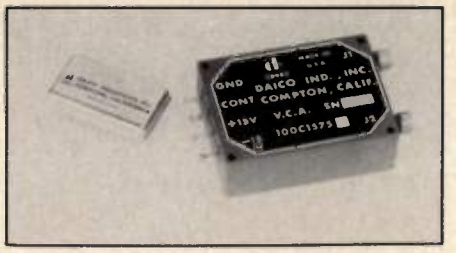
Both the terminators and the circuit insertion switch features a simple but unique all-mechanical make-before-break switch actuation sequence to provide positive, power-free, automatic switching.

Numerous connector configurations and resistance loads are available for the switch and terminators. **Amphenol Products world headquarters, Oak Brook, IL 60521, INFO/CARD #151.**

Phase Compensated Voltage Controlled Attenuators

A new line of phase compensated voltage controlled attenuators is now available from Daico Industries, Inc. These devices provide linear analog attenuation with flat phase variation of less than ±3° over full attenuation range.

Key paramaters of P/N 100C1575 include: frequency 150-250 MHz; attenuation range 40 dB minimum; linearity ±2 dB; insertion loss 4 dB maximum; VSWR 1.25/1 maximum; control 0 to +5 VDC; RF power +15 dBm; DC power ±15 at 40 mA;



impedance 50 ohms; size 1.5" x 2.0" x 0.6"; and SMA connectors. **Daico Industries, Inc., Compton, CA 90220, please circle INFO/CARD #150.**

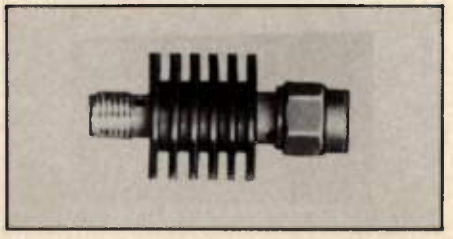
Two New Synthesized Signal Generators

Two new synthesized signal generators, the HP 8642A (100 kHz to 1,057.5 MHz) and HP 8642B (100 kHz to 2.115 GHz), have been introduced by Hewlett-Packard Company. With extremely low noise characteristics, high accuracy, wide output-power range and broad modulation capabilities, these new generators are suitable for the most stringent receiver tests. HP-IB programmability and high reliability also make them ideal for system applications.

The HP 8642A is $21,000 and the HP 8642B is $28,000. Delivery is approximately 20 weeks for the HP 8642A and 30 weeks for the HP 8642A ARO. **Hewlett-Packard Company, Palo Alto, CA 94304, INFO/CARD #149.**

DC to 18 GHz Miniature High Frequency Attenuators

Alan Industries, Inc. now offers two series of precision 50 ohm miniature attenuators with a frequency range of DC to 18 GHz and an attenuation range from 1 to 40 dB. The MP Series, per MIL-A-3933D has a 2 watt power average while the MHP Series is rated at 5 watts. Other electrical specifications are the same for either series. VSWR is 1.15:1 from DC to 4 GHz; 1.20:1 from 4 to 8



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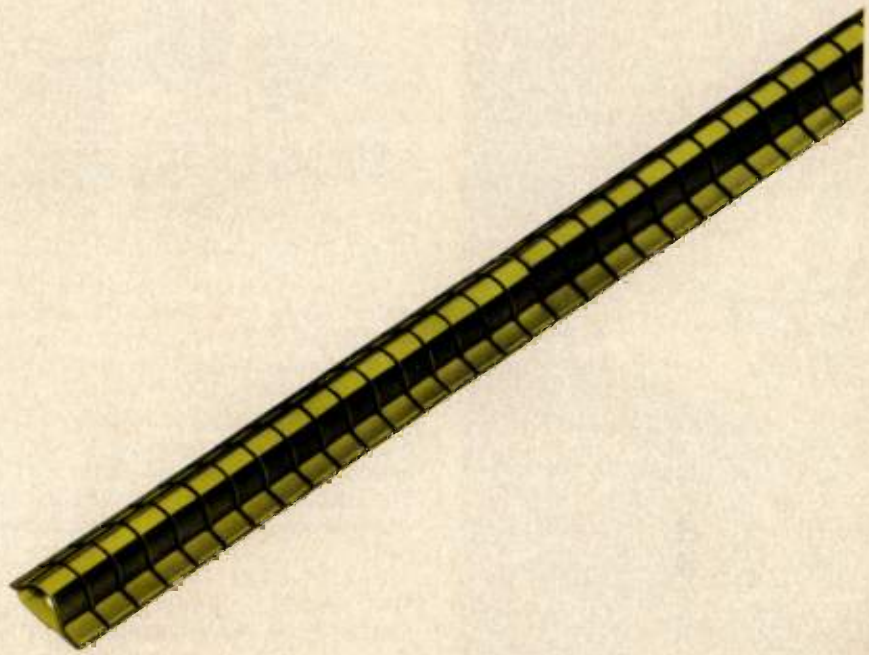
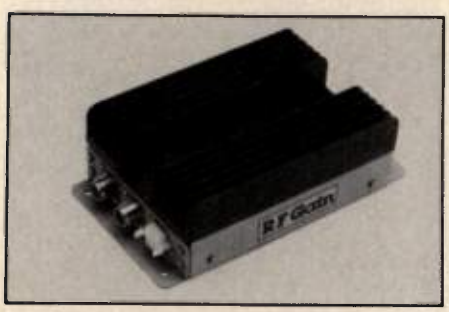


GHz; 1.25:1 from 8 to 12 Ghz and 1.35:1 from 12 to 18 GHz. Accuracy is ±0.3 dB from 1 to 6 dB and ±0.5 dB from 7 to 40 dB.

Both series are available in two sizes. Connectors are SMA stainless steel per MIL-C-39012. Prices are $50 for the MP Series and $65 for the MHP Series. **Alan Industries, Inc., Columbus, IN, 47202, please circle INFO/CARD #147.**

RF Power Amplifier

RF Gain Ltd. expands its amplifier line into low-band, mid-band, and 800 MHz. The new frequency ranges are 35-50 MHz, 66-88 MHz, and 806-890 MHz in addition to its present ranges of 136-174 MHz and 420-475 MHz. Amplifiers are also available in these frequency bands in a 100% duty cycle repeater configuration for 19" rack mount. **Richardson Electronics, Ltd., Franklin Park, IL 60131, INFO/CARD #146.**



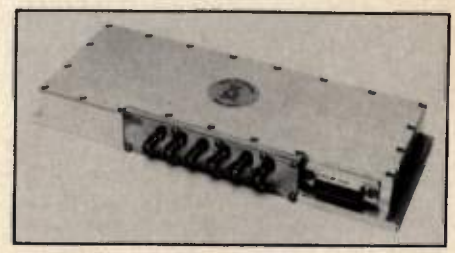
Automatic Spectrum Analyzer

The Electronic Instrumentation Division of Eaton Corporation (EID), long recognized as the leader in high performance spectrum analysis, introduced the Model 787 programmable spectrum analyzer. A number of advanced features take this technically superior unit beyond the state-of-the-art.

The AILTECH 787 is a fully-programmable instrument capable of performing microwave measurements over the broadest frequency range in the industry — 1 kHz to 26.5 GHz with internal mixing. With external mixers, this frequency range is extended beyond 200 GHz. **Eaton Corp., Electronic Instrumentation Division, Ronkonkoma, NY, INFO/CARD #148.**

Multi-Output Oscillator

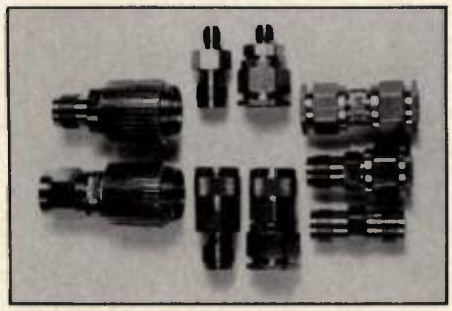
TRAK is now offering a digitally controlled multi-output oscillator. This oscillator is an example of our ability to provide highly sophisticated components or supercomponents. The oscillator generates 3 different fixed frequencies under control of a 3 bit digital word. Frequencies are in the C to Ku band region. Six outputs are provided so the user can have a choice of various frequencies and output power levels. The higher output power level is approximately +10 dBm; frequency accuracy is ±.005%; harmonics are -20 dBc for 2nd and 3rd harmonics of the selected output frequency; input power is +15 VDC at 250 mA and +5 VDC at 65 mA. The operating temperature range is -54°C to +85°C. Dimensions of the components are 8.5" x 3.0" x .98". RF connectors are field replaceable type SMA female. **TRAK Microwave Corporation, Tampa, FL 33614, INFO/CARD #145.**



Mode-Free TNC Connectors To 18 GHz

Solitron/Microwave, a division of Solitron Devices, Inc., Port Salerno,

Florida, has announced an advanced mode-free design which extends the TNC connector/adapter frequency range up to 18 GHz. The company was the first in the industry to introduce the original TNC connector and subsequently a precision TNC version.



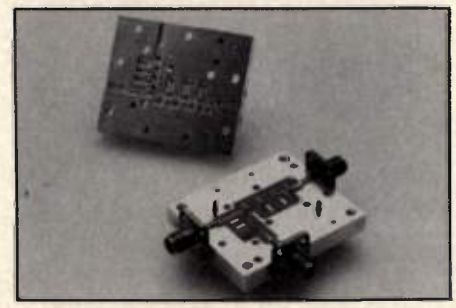
The new mode-free design inter-mates with standard TNC types which meet or exceed MIL-C-39012, as well as assemblies specified in MIL-C-87104 and MIL-T-81490 requirements.

Solitron/Microwave's mode-free TNC type features extremely low VSWR and meets all EW and ECM requirements. The following mode-free model types are now available from the company 6 weeks ARO:

SF4599-6003, SF4596-6003 and SF4598-6003 (In-line adapters); SF1108-6004, SF1109-6005, SF1125-6005 and SF1124-6003 (between line adapters); SF8040-6010 and SF8040-6009 (50 ohm terminations). **Solitron/Microwave Connector Division, Port Salerno, FL, 33902, please circle INFO/CARD #144.**

Suspended Substrate Stripline Diplexers

The low pass and highpass filters used in these diplexers are synthesized in exact singly terminated minimum susceptance configurations and realized in suspended substrate using computer aided synthesis and design techniques developed at Teledyne Microwave. The filter circuits are printed on 10 mil thick dielectric substrate and housed in a machined aluminum body. The printed circuits are easily reproducible requiring only minor tuning to compensate for the differences due to machining and etching tolerances.



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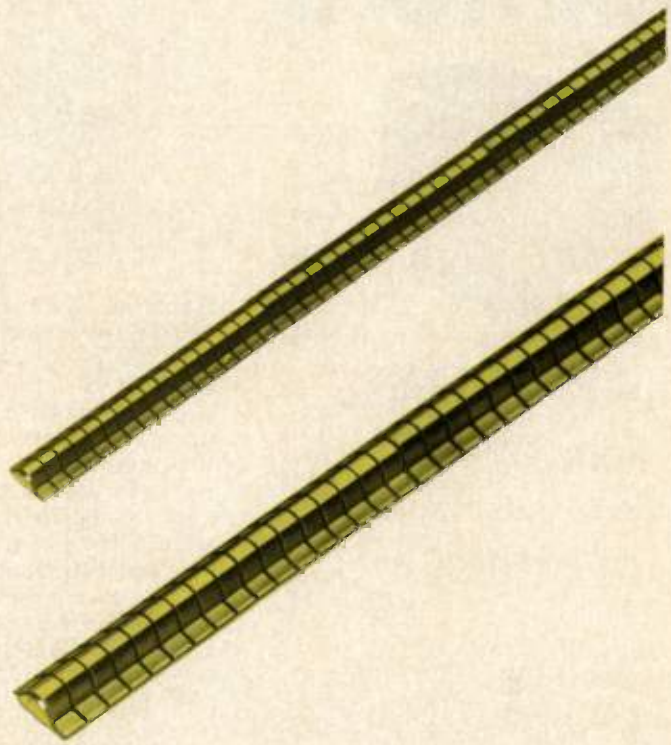
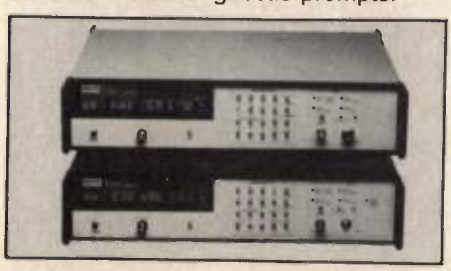


Typical electrical performance in room ambient conditions is:

Crossover accuracy: ±.5%
Passband insertion loss: 1 dB
Crossover insertion loss: 4.5 dB
VSWR: 1.8:1 **Teledyne Microwave, Mountain View, CA 94043, please circle INFO/CARD #143.**

RF/MW Counter

Systron Donner's new 6000 automatic microwave/millimeter counters offer frequency coverage to 110 GHz and 60 dBs of dynamic range, with a guaranteed sensitivity of-30 dBm. The two new 12 digit display models offer optional amplitude measurement for simultaneous display of frequency and power. The same display provides direct English readouts of the calibration and diagnostic prompts.



Systron Donner's Instrument Division (SDID) also claims very high AM/FM tolerance, standard IEEE-488 interface, and an optional CIIL command package for U.S.A.F."MATE" applications. "The match package is the key," says Project Designer Manager, Tom Springer. "We were able to implement three independent memories for each band. In this way such elaborate calculations such as .001 Hz resolution can be obtained even at 26.5 Ghz." Push button control of last reading and previous measurement are among the other standard features.

Model 6020 coves 10 Hz to 18 GHz for $5,500 while the 6030 covers 10 Hz to 26.5 GHz for $6,000, additional frequency extension modules are extra. Delivery on both units is 90 days ARO. **Systron Donner, Instrument Division, Concord, CA 94518, INFO/CARD #142.**

Two Cavity Amplifiers For Low- And High-Band VHF TV Service

Two new cavity amplifiers designed for simple and reliable application in high-power VHF television transmitters were introduced by Varian EIMAC.

The EIMAC CV-2242 and CV-2252 cavity amplifiers are rated for 15 kW peak-of-sync in video service for low- and high-band VHF-TV (USA Channels 2-6 and 7-13).

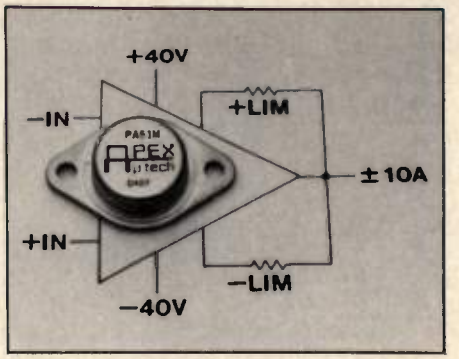
These cavities use the new EIMAC 3CX12,00007 focus triode. With its high gain, the new triode allows 15 and 25 kW television transmitters to be designed with all solid state drive. **Varian EIMAC, San Carlos, CA 94070, INFO/CARD #141.**

Op Amp

APEX introduces the PA51M high current Power Op Amp designed for cost sensitive applications, requiring up to 10 amps drive to resistive, capacitive or inductive loads. The class C output stage configured with monolithic darlington transistors, ensures a very rugged device while holding quiescent power dissapation to a bare minimum. In typical applications they power motors, actuators, coils or heaters.

The PA51M is suitable for dual supplies up to ±40V over the full military temperature range. The amplifier features a monolithic bipolar input stage and internal compensation for use at all gain settings. These hybrid integrated circuits utilize thick film conductors, ceramic capacitors and silicon semiconductors to maximize reliability, minimize size and give top performance. Ultrasonically bonded aluminum wires provide reliable interconnections at all operating temperatures. The 8 pin TO-3 package is hermetically sealed and isolated to allow mounting without use of thermally expensive washers.

Screening procedures are in full com-

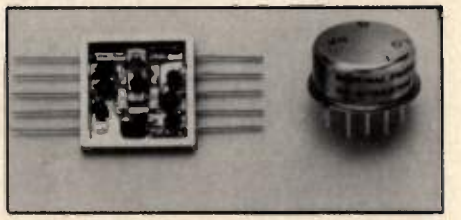


pliance with the new revision C of MIL-STD-883. An added feature is complete testing of all min/max specified parameters at -55° and +125°C rather than simply testing offsets at temperature. The process control required to maintain production yields with more stringent testing further enhanced reliability of the product. Price and delivery for a quantity of 100 is $78.50 and 14-16 weeks. The part does have a second source. To aid the design task, a non-screened version is available from stock to facilitate quick performance evaluations. **APEX Microtechnology Corp., Tucson, AZ 85714, please circle INFO/CARD #140.**

I & Q Network

Merrimac Industries has announced a new I&Q Network either Flat Pack (Model IQF-2-70) or in a TO-8 package (Model IQT-2-70).

RF and LO input characteristics include: frequency (10 to 500 MHz, 10% BW); impedance (nominal 50 ohms); VSWR (maximum 1.5:1); RF power level (0 dBm nominal); LO power level (+10 dBm nominal).



Output characteristics include: video bandwidth (DC up to 5 MHz); output load (nominal 50 ohms); phase range (0-360°); conversion loss, 10 dB typ., 12 dB max. (RF to IF_1 to IF_2).

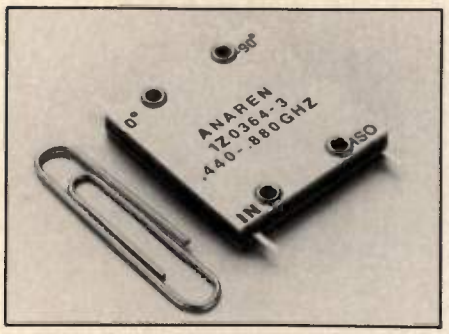
Output accuracy include: phase balance (IF_1 to IF_2), 90 + 5°max; amplitude balance (IF_1 to IF_2), 1.0 dB max. **Merrimac Industries, Inc., West Caldwell, NJ 07007, INFO/CARD #139.**

High Power, Low Cost Coupler

A new, ultra-miniature, hybrid caseless coupler, capable of handing up to 400 watts of power, is available from Anaren

Microwave, Inc., E. Syracuse, NY This high power, low cost coupler is available in frequency bands for military aircraft radios, direct broadcast satellite applications and solid state television transmitters. It may also be integrated with many other systems and components including:

- inexpensive power dividers and combiners
- low cost, high power balanced amplifiers
- matrix amplifiers
- switching networks
- antenna feed networks



The 3 dB 90° coupler is a reciprocal four port stripline network manufactured using a stable, teflon-glass substrate, and is laminated under heat and pressure using a low-loss, dielectric material. This packaging system ensures high reliability, especially under severe environmental conditions.

Model 1Z0364-3 covers the 440-880 MHz frequency band, handles 400 watts CW, is only 0.54 cu. in. in volume, and weighs 0.67 ounces. The case material is aluminum with silver plated copper solder tabs. Priced at $92 in quantities of 16-31, delivery is from 6 to 8 weeks. A variety of models are available. **Anaren Microwave, Inc., E. Syracuse, NY 13057, INFO/CARD #138.**

Conductive Caulk

CONAP introduces a new conductive caulking compound. DP-8469 is a one component silver filled black paste that will provide excellent electrical conductivity and low volume resistivity for R.F. shielding and grounding applications. Its pliability, after curing, makes the material suitable for shielding metal joints and seams that are subject to vibration, warping and/or temperature induced expansion or contraction of the substrate to which it is applied.

CONAP DP-8469 is available in 6 oz. flexible metal tubes, 1 lb. and 1.5 lb. caulking cartridges, and in bulk quantities: quart, gallon, and 5-gallon containers.

CONAP is a materials systems specialist supplying industry with epoxy and polyurethane potting and encapsulating compounds, conformal coatings, adhesives, sealants, and tooling resins for the aerospace, aircraft, computer, defense, electrical/electronics, biomedical, automotive and related markets. **CONAP, Inc., Olean, NY 14760, please circle INFO/CARD #137.**

Spectrum Analyzer

Wavetek Scientific Inc., of Rockleigh, NJ has announced the introduction of their Model 5809A, a basic DC to 100 kHz single channel spectrum analyzer with a 3.5 kHz real time rate, memory for four data traces, non-volatile storage for three front panel setups, zoom analysis, and a CRT for viewing displays of instantaneous or averaged amplitude vs. time or frequency. The U.S. list price for the basic analyzer is $8,400. **Wavetek Scientific,**

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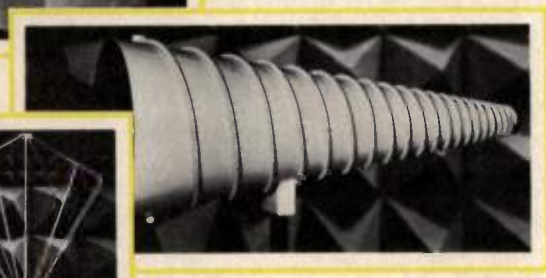

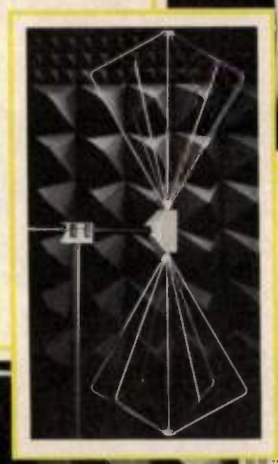

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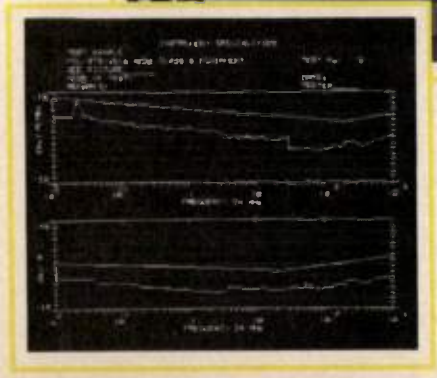

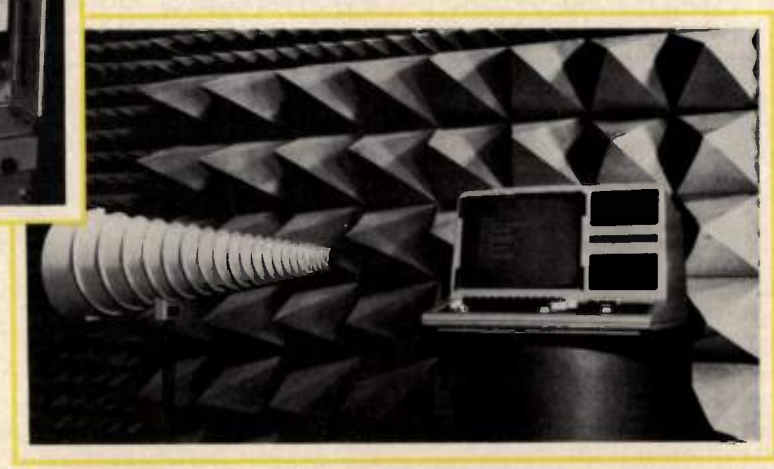

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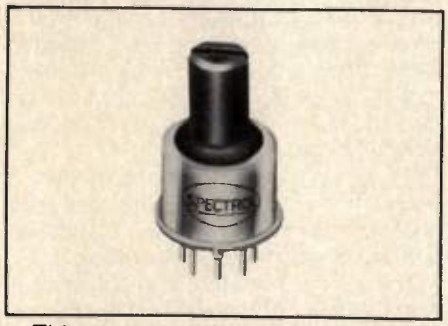
Inc., Rockleigh, NJ 07647, please circle INFO/CARD #136.

Subminiature Rotary Selector Switch

Spectrol's new Model 97 rotary selector switch combines a screwdriver-adjust and flatted-shaft feature in a 5/16-inch diameter TO-5 package. It is available with stops or continuous rotation with up to seven active positions.



This space-saving switch mounts directly on PC boards and permits design versatility. It can be used for logic switching, test-point switching, standardizing PCBs, selecting operational voltages, and it can eliminate the need for jumpers and connectors. **Spectrol Electronics, City of Industry, CA 91749, please circle INFO/CARD #135.**

Compact Remotely Controlled HF Antenna System

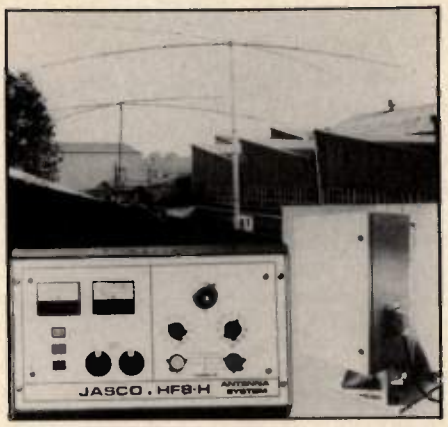
A new HF antenna system, designed to overcome many of the space and interference problems of conventional systems, has been introduced by JASCO International.

The JASCO HF8-H antenna system has been developed as a compact unit for embassy, police, transport services and military applications. Present HF communications generally require four frequencies divided over day and night time periods, necessitating the use of either four separate antennas or one broadband antenna. Either option has the disadvantage of equipment occupying too much space and in both cases there is usually an interference problem.

These shortcomings have now been overcome by JASCO with one small antenna that requires even less space than a dedicated antenna. The HF8-H is very selective in terms of the frequency to which it will respond, thus eliminating interference.

The JASCO antenna system covers the frequency range of 2-30 MHz with a maximum power input of 1kW continuous wave (CW) and 2kW peak emited power (PEP)-single side band (SSB).

A remotely controlled antenna tuning



unit is situated at the mast base, It is pre-programmed via the central console, with up to 100 different channels available. Once programming is complete, any channel can be selected manually at the control console. The tuner wil automatically set itself to the pre-programmed position.

A voltage standing wave ratio (VSWR) of 1:1 is easily achieved by the high Q matching circuitry. This provides a high degree of selectivity both on transmit and receive, thereby significantly reducing the possibility of out of band spurious signals on transmit. It also provides a large degree of attenuation to out of band signals on receive which can cause intermodulation interference.

Selectivity is a very attractive feature if the antenna is to be used in an electrically noisy environment, particularly in close proximity to other radio systems or on a city rooftop site.

As a JASCO International spokesman points out, most automatic tuning systems are based on a principle of automatic selection of a point of minimum standing wave ratio (SWR).

"With the many different combinations of matching component settings which could achieve minimum SWR," he says, "very often the automatically selected setting is highly inefficient in terms of insertion loss — even though return loss (SWR) is low.

"This is not the case with the HF8-H," he maintains. "The JASCO system uses a pre-programmed matching configuration which ensures maximum efficiency."

The HF8-H antenna is supplied with either a 6m or 12m freestanding galvanized steel mast for rooftop mounting. A guyed mast is supplied if no solid foundation is available.

The matching unit is enclosed in a steel fabricated, epoxy coated, splashproof housing and the telescopic anodised aluminim antenna elements are supported in a rugged fiberglass mounting head. **JASCO International (Pty) Ltd., Bramley 2018, South Africa, please circle INFO/CARD #134.**

Flatpack Amplifier

Q-bit Corporation has available two new flatpack amplifiers featuring Power Feedback™ Technology for the highest reverse isolation available in the industry.

The QBH-214 operates from 50 to 200 MHz, 14.5 dB gain. The unit is a high dynamic range amplifier with +37 dBm 3rd Order Intercepts and +25 dBm minimum output compression. Pricing is $145, 1-9 pcs.

The QBH-215 flatpack amplifier operates from 10 to 500 MHz with a minimum compression of +26 dBm, typical +27 mid-band, 12.3 dB gain, and greater than 36 dBm third order intercepts. The VSWR is less than 1.5:1 over the entire band and reverse isolation is greater than 24 dB. Pricing is $150, 1-9 pcs.

Delivery would be stock to 10 weeks ARO. **Q-bit Corporation, Palm Bay, FL 32905, INFO/CARD #133.**

Frequency Synthesizers

Comtech Model CRL 6570 and CRL 7277 are first of a line of high performance frequency synthesizers for both military and commercial OEM and end users. These frequency synthesizers offer the lowest phase noise available in the industry with frequency agility across the full tuning range, operation with external or internal standard, and built-in performance monitors. They are specifically designed to provide a high degree of phase stability under extreme environmental conditions making them ideally suited for multiple PSK modulation applications as well as for low noise FM systems.

The first units introduced in this line tune across the bands from 6.55 to 7.05 GHz (CRL-6570) and from 7.20 to 7.70 GHz (CRL-7277) in 1 KHz steps. Frequency entry is via BCD codes. Options on these synthesizers include step-size in decade increment from 10 Hz to 1 MHz and an RS232 or IEEE488 interface bus.

Models CRL 6570 and CRL 7277 are housed in shock-mounted compact 9" x 4.5" x 7" modularized assembly. **Comtech Microwave Corp., Hauppauge, NY 11788, INFO/CARD #119.**

High-Speed Broadbans Modems

Link Telecommunications, Inc. announced the first in its family of high performance Radio Frequency Modem products called the 5000 Series.

The Model 5010 is a crystal controlled, high-speed modem designed to operate over a broadband dual cable system. The 5010 provides high-performance digital communications for distributed computing and peripheral vendors, LAN sup-

pliers, OEMs, systems integrators of industrial monitoring and process control systems, energy management and security systems, medical imaging equipment vendors and cable CATV companies, to name just a few.

Among the features of the Model 5010 are high-speed data rates (up to 2 Mbps, selected at time of purchase), low error rates (better than 1 bit in 10^{12}), and performance reliability. "In fact," notes Kay Fairweather, LTI's Director of Product Marketing for its 5000 Series, "by using a crystal oscillator, we've avoided the problems associated with frequency drift found in other RF modems. Another measure taken to ensure reliability and predictable RF performance is the anti-jam mechanism. A further indication of high reliability is a predicted mean time between failure (MTBF) of more than 200,000 hours."

Provided as a standard feature of the 5010 Modem is the early generation of a collission detection signal for more efficient bus utilization in contention environments. Availability of the 5010 Modem is planned for November 1. Pricing for the 5010 in quantities of 100 is $495 per unit, with discounts available for larger quantities.

Additional members of the 5000 Series planned for introduction later this year include mid-split fixed frequency modems and frequency-agile modems for dual and mid-split cables. **Link Telecommunications, Inc., Westborough, MA 01581, please circle INFO/CARD #120.**

Transient Suppressors

General Semiconductor's new family of power transient suppressors is specifically designed to protect 120Vac equipment to meet the AC power line surge standards of IEEE STD 587, Categories A and B. The IEEE 587 is a standard describing the transient environment in low voltage AC power circuits (less than 600 volts). The OEM will especially appreciate the design because it is intended to be "hard wired" into the equipment between the power switch and power supply instead of being plugged into the front-end line cord. The series is designed for the heavy-duty transient protection of mainframe computers, sensitive instrumentation, industrial controls, telecommunications, automatic test equipment, motor controls, and audio-video equipment.

The new 587B series meets and exceeds the complete IEEE 587 standard (Categories A and B) and allows the equipment manufacturer to use lower voltage components in his designs. It employs the time-tested solid-state TransZorb® technology designs which guarantee that line-to-neutral voltages will not exceed 350 volts under worst-case

conditions. The series also offers sub-nanosecond response time, short circuit failure mode, and no voltage overshoot. In total, this means the OEM can use 400 volt solid-state components and be safe, even after multiple transients.

Case operating and storage temperature is 0°C to +85°C and current leakage at the 120Vac operating voltage is a very low 1.0 mA, line-to-neutral, and 0.5 mA, neutral-to-ground. Models are available with oeprating currents of 5 amps (587B051), 15 amps (587B151) and 20 amps (587B201).

Delivery is from stock to 6 weeks from General Semiconductor or through its distributor network. Unit prices in 100s start at $50 for the 587B051. **General Semiconductor Industries, Inc., Tempe, AZ 85281, INFO/CARD #121.**

Sealed Cermet Potentiometers

Mouser Electronics announces a new line of space-saving Cermet Potentiometers.

The ME323-6000 series Potentiometers feature a sealed body with a .52" diameter — ideal for crowded control panels. This special design is complemented by a ⅞" slotted shaft and provides a low-cost, high-reliability Pot for all general purpose applications.

They are rated at .5W at 70°C with ±20% tolerance. Linear resistance values

range from 100 ohms to 1M. ohms. Terminal resistance is less than 5 ohms, and insulation resistance is greater than 5G. ohms.

These Pots can withstand a peak voltage of 630VAC with a working limit of 315VDC. Isolation voltage is 450VDC. Rotation is 260° electrical and 295° ± 5° mechanical. They come complete with locknut and cost as little as $3.49 in quantities of 50. **Mouser Electronics, Santee, CA 92071, INFO/CARD #122.**

Illuminated Switches

SMP Series low profile, LED illuminated switches are designed for PC board high-density front panel mounting.

In quantities of 500 pcs., the SMP Switch is priced at $1.89 and the matching indicator is priced at $1.45. They are available for immediate shipment from stock. **Shelley Associates, Tustin, CA 92680, INFO/CARD #123.**

New Literature

Product Line Catalog

The Anzac Division of Adams-Russell presents its newly updated product line, for the next generation of RF and Microwave Systems. The new 440 page catalog provides detailed definitions and illustrations of the following, which includes over 34 new products: RF switches (single and multi throw), biphase, quadraphase and vector modulators, digital attenuators, RF logarithmic and thin filmed amplifiers, microwave and termination insensitve mixers, doublers which operate up to 6 GHz, and 90° flatpack hybrids. Also featured are unique GaAs FET amplifiers covering 150 MHz to 5.2 GHz in a single-drop unit. **Adams-Russels, Anzac Division, Burlington MA 01803, INFO/CARD #132.**

HF Antenna Accessories Catalog

Catalog PC/84 describes Baluns, multiband traps and remote antenna switching relays for the 2-1000 MHz communications bands.

The catalog illustrates the construction of single and multiband dipoles in the 1.8-30 MHz Amateur and HF communication bands and offers other construction accessories such as end insulators, weatherized center feed insulators, wire, cable and connectors.

The system of remote, voltage-controlled antenna switching relays allow selection of up to 9 separate antennas through a single coaxial cable as well as direction changing of antenna arrays and automatic pairing of antenna/transmitter sets. **Microwave Filter Company, Inc., East Syracuse, NY 13057, please circle INFO/CARD #131.**

SAW Filters

Damon Corp./Electronics Div. has published a new catalog describing its line of Surface Acoustic Wave Filters. These filters are currently available on a custom design basis to military specifications. **Damon Corp./Electronics Div., Westwood, MA 02090, please circle INFO/CARD #130.**

Weinschel Catalog

This easy-to-use catalog features 352 pages of photos, specifications, features, outline drawings and prices for Weinschel's complete line of RF and Microwave components and test and measurement systems. Made for both military and commercial applications, Weinschel products cover the frequency range of DC-40 GHz and have power handling capability ranges up to 500 watts.

Designed as a useful reference docu-

ment, nearly a third of the catalog is devoted to technical information such as definitions, terms, explanations of various design considerations and techniques and methods of obtaining microwave measurements. A condensed Microwave & RF related glossary, an IEEE specification on attenautors, and a new product showcase are also included. **Weinschel Engineering, Gaithersburg, MD 20877, INFO/CARD #129.**

MIC Microwave and IF/RF Products Catalog

A new, comprehensive catalog (No. 300) containing product and technical information on their complete line of MIC Microwave and IF/RF Products is available from RHG Electronics Laboratory, Inc.

The 128-page catalog contains four selections of detailed technical data on IF/RF products, MIC mixers and mixer preamps, microwave components, and microwave links and monopulse receivers. Catalog 300, which is 15% larger than the previous catalog, is the largest in RHG's 23 year history.

Another section describes RHG's specific engineering experience and capabilities in the design and production of custom devices and subsystems.

Technical information is also included on log amps, dielectric stabilized oscillators, phase and gain matching, signal-to-noise ratio, linearity measurements and monopulse receivers. Test methods for measurement of standard specifications are also included.

The many new products in the catalog are noted in the Table of Contents with special identifications.

In addition to many photos, graphs and diagrams, the RHG catalog contains ordering information and some general company and personnel descriptions. It is printed in two pleasing colors and has a useful margin index identifying the major sections. **RHG Electronics Laboratory, Inc., Deer Park, NY 11729, INFO/CARD #128.**

EMI Filter Catalog

The San Fernando Electric Division of SFE Technologies has available a new catalog covering its complete line of RFI/EMI Filter products. This 66 page catalog provides detailed technical information on mini-filters, high current tubular filters, miniature and heavy-duty power line filters. **SFE Technologies, San Fernando, CA 91340, INFO/CARD #127.**

RF Devices Selection

A 12 page, comprehensive Selection Guide for the full line of transistors, hybrid amplifiers, and other semiconductor devices manufactured by the RF Devices Division of TRW Electronic Components Group is now available.

Using drawings, diagrams and charts, the guide provides information, in an easy to use format, on: transistors for HF mobile, VHF/UHF, and microwave applications; thin film hybrid amplifiers for CATV and general purpose RF linear applications; a complete line of small signal, low noise transistors for high performance applications.

The RF Devices Division is a leading manufacturer of RF linear hybrids and microwave power transistors. The Electronic Components Group, an operating group of TRW Inc., is a diversified manufacturer of a broad family of high technology, precision electronic components serving consumer, industrial and defense markets worldwide. **RF Devices Division, TRW Electronic Components Group, Lawndale, CA 90260, please circle INFO/CARD #118.**

Resistor Networks Catalog

The new "Thick and Thin Film Resistor Networks" catalog from the Resistive Products Division of TRW provides the engineering information necessary to select a resistor network for almost any application.

The 15-page bulletin features electrical, physical and environmental specifications

and, where appropriate, MIL spec performance data for TRW's entire line of thick and thin film resistor networks. Resistor networks catalogued include a variety of DIP, SIP, flat-pack, ladder, chip carrier and custom networks.

Cutaway drawings, dimensional specification outline drawings, derating and surface temperature graphs and circuit schematics are also provided.

The catalog, designated Bulletin 803A, makes it easy to order components with clear how-to-order information and a full list of TRW distributors.

A recognized leader in resistor technology, the Resistor Products Division is a part of TRW Electronic Components Group, a diversified manufacturer of a broad family of electronic components serving commercial, industrial and defense markets worldwide. The Electronic Components Group is an operating group of TRW. **Resistive Products Division, TRW Electronics Components Group, Philadelphia, PA 19108, please cirlce INFO/CARD #117.**

Transworld Communications Cross Reference

RF GAIN, NY, announces their ability to cross reference and supply replacement semiconductors for transworld communication radios.

This announcement makes available to transworld communication dealers in all parts of the world RF power transistors and ICs for replacement in transworld communication products. **RF GAIN, Rockville Centre, NY 11570, please circle INFO/CARD #116.**

RF Coaxial Connectors Catalog

A new 6-page catalog on RF Coaxial Connectors including BNC, TNC and TWIN-AX connectors, adapters and cable assemblies has been announced by Ava Electronics Corp., Drexel Hill, Pennsylvania.

The new catalog includes information on features, materials, and electrical characteristics of the products. UG-type connectors are cross-referenced where applicable. Standard BNC and TNC male connectors are offered in several types. Standard cable assemblies are provided in 3, 6 and 12-foot lengths. The catalog also contains information on crimp tools and custom connectors and cable assemblies. **Ava Electronics Corp., Drexel Hill, PA 19026, INFO/CARD #115.**

Transformer Design Manual

A new 32-page transformer design manual just introduced by James Electronics, Inc., Chicago, Illinois, describes line matching, audio, hybrid and power transformers as well as inductors, holding rails and retard coils.

Available in a wide range of mechanical

packages including low profile, split bobbin, horizontal, vertical and "dry and wet," these designs are ideal for the telecommunications and data processing industries. **James Industries, Inc., Chicago, IL 60618, INFO/CARD #114.**

MTV Catalog

A comprehensive catalog outlining products and services for the prevention of terrestiral interference in Microwave Television has been released by Microwave Filter Co., Inc.

The catalog is patterned as a troubleshooting guide providing background information on causes of interference and approaches to avoid it.

Described are off-site analysis, field and the Fast Filter Rescue Service performed by a team of MFC experts. Information is given on the TI seminar, a one day educational training session, and ASTI, a staff written handbook on Avoidance and Suppression of TI.

In addition IF and Microwave Traps, Microwave Bandpass Filters, accessories and CATV/SMATV products are featured among others.

Standard data on earth station transponders, determining interference levels, a guide to satellite aiming for SATCOM III, program listing, locating true north and a partial list of frequency coordinators are also mentioned. **Microwave Filters Co., Inc., East Syracuse, NY 13057, please circle INFO/CARD #113.**

RF Anechoic Chamber Test Facilities

Complete descriptions of the various types of RF anechoic chamber test facilities are available in a pamphlet from Keene Corporation's Shielding Division.

Full decriptions are given on Broadband R.A.M., rectangular anechoic chambers, tapering anechoic chambers, and special purpose anechoic chambers. RF shielding for anechoic chambers is also described.

Graphs, photos and equations are used throughout to aid in explanations. **Keene Corporation, Shielding Division, Norwalk, CT 06856-5060, please circle INFO/CARD #112.**

Frequency Synthesizers Data Sheet

Wavetek introduces its new 100 kHz to 1 GHz UHF Frequency Synthesizers with a four page data sheet. model 5155A offers the complete flexibility of both front panel control and remote programming for use as a laboratory instrument. Model 5156A is a remote-only instrument that has the same performance as the Model 5155A but is intended for ATE and OEM applications.

The literature explains that both instruments offer sub-microsecond frequency switching when utilized in the BCD, TTL remote programming mode. Phase and amplitude continuous frequency switching is avialable with the BCD and GPIB interfaces. This simultaneous availability of both interfaces allows fast frequency switching with BCD control while providing the use of the GPIB when simplicity of programming is needed. As a further enhancement, the optional GPIB interface for the remote only Model 5156A has been optimized for data transfer rates in the order of 1 megabyte/second to greatly speed up ATE programs thay use the GPIB interface.

In addition to the fast frequency switching rates that are possible with these synthesizers, excellent frequency resolution of 0.1 Hz is provided throughout the band. because of the direct digital synthesis that has been pioneered by Wavetek, resolution of 1 MHz is possible with a small modification. These features are made more impressive when the close-in SSB phase noise is considered. The phase noise specification for offset frequencies of 1 Hz at a carrier frequency of 500 MHz is 90 dBc/Hz and 100 dBc/Hz for an offset frequency of 10 Hz. **Wavetek, San Diego, CA 92123, please circle INFO/CARD #110.**

IDC Connectors

A new, completely updated 96-page IDC Connector Catalog from Robinson Nugent provides photos, specifications and dimensions on the 2,187 choices offered in the expanded RN line of IDC products. Products include sockets, headers, card edge connectors, D-subs, delta ribbon connectors, transition connectors, DIP cable plugs and flat cable assemblies. **Robinson Nugent, New Albany, IN 47150-1208, INFO/CARD #111.**

RF Power Amplfifiers

A new four-page bulletin from Amplifier Research presents specifications of the company's "W" Series ultra-broadband RF power amplifiers. It covers models that provide linear operation over the spectrum from 100 kHz to 1000 MHz, and are conservatively rated at 1, 5, 10, 50, and 80 watts minimum output.

The bulletin describes each amplifier, its features, advantages, and performance specifications. Also included are dimensions, typical power curves, and related data. **Amplifier Research, Souderton, PA 18964-9990, please circle INFO/CARD #109.**

Microcircuits Brochure

A new, comprehensive 24-page brochure, detailing the capabilities and facilities of the Microelectronics Operation, Beckman Industrial Corporation. Also, the brochure's layout includes the Beckman Industrial Corporation Microelectronics facility. **Microelectronics Operations, Electronic Technologies Division, Beckman Industrial Corp., a subsidiary of Emerson Electric Company, Fullerton, CA 92634, please circle INFO/CARD #108.**

Resistive Products Catalog

A new, comprehensive catalog of all Beckman Industrial Corporation Resistive Products — incuding precision potentiometers, dials, trimmers and resistor networks — is now available, according to Ray Allen, Resistive Products Marketing and Sales Manager.

The 172-page catalog gives complete specifications and detailed outline drawings in the familiar Beckman Industrial Corp. technical specification sheet format, so design and specifying engineers, as well as purchasing personnel, will find this catalog easy to use.

A special feature of the new full line product catalog is the "Terms and Definitions" guide to Trimming and Precision Potentiometers. This section offers concise, easy-to-understand descriptions of the wide variety of potentiometers. Also included are definitions of rotation and translation terms, resistance, electrical

and mechanical terms commonly used in specifying resistive products.

"Special Products" also are included in the catalog, including specifications on Industrial Servo Systems Components and tachometers. **Electronic Technologies Division, Beckman Industrial Corp., Fullerton, CA 92634, INFO/CARD #106.**

Standard Product Selector Guide

This short-form listing of standard products gives typical data on Q-Bit Corporation's line of high reverse isolation amplifiers, featuring Power Feedback Technology™. Q-Bit Corporation amplifiers offer the higher reverse isolation performance available in the industry. **Q-Bit Corporation, Palm Bay, FL 32905, INFO/CARD #105.**

Cellular DC Power Systems Brochure

A new brochure detailing DC Power Systems for the cellular market is released by C-E Elgin Electronics, manufacturer of telecommunications power systems. The company's custom design approach to cellular power is oulined, including a line of 24 volt battery chargers, custom panels, 24 volt input inverters, 24 to 48 volt DC converters and backup batteries. Various panels available for Elgin's 84", 96" or 105" high racks include: counter EMF panels, negative bus, load distribution panels, meter panels, alarm panels, low voltage disconnect panels, equalizer panels, positive bus, battery chargers, 500 VA inverters, plus other specialty combination panels. A return postcard requests specific cellular power requirements. **C-E Elgin Electronics, Erie, PA 16509-3570, please circle INFO/CARD #107.**

Cross Reference Microwave Chip Capacitor

This new bulletin, a supplement to Catalog #58-03, provides a quick reference to Murata Erie's product line versus American Technical Ceramics. Up to 12 different styles are described in this short catalog including ribbon, chip, pellet, microstrip and derivatives thereof. All necessary specification for standard cross reference are included with specials being available on request. **Murata Erie North America, Inc., Marietta, GA 30067, INFO/CARD #103.**

System Power Supplies Data Sheet

A technical data sheet (5952-4108) describing the complete specifications of HP 6023A, 6033A, 6011A, 6012B, 6031A and 6032A system power supplies and discussing features of alternate interface methods is now available at no charge from Hewlett-Packard Company.

This eight-page, four-color publication has application guidelines, outline drawings, photographs, descriptions, specifications, selection guidelines, prices and ordering information.

Hewlett-Packard programmable systems power supplies have been designed to meet the needs of increasingly sophisticated automatic test and control applications.

The new family of DC power supplies is divided into three major interface cateogries: HP-IB programmable, HP 694OB or HP 6942A multiprogrammer controlled, and analog programmable.

These general-purpose system power supplies are used in a diverse range of automatic test system applications from incoming component testing, through board test systems to final production test. Applications include not only supplying controlled DC operating power for the device under test, but also acting as stimulus sources of voltage and current controlled with 12-bit resolution.

Each model in the family features an autoranging output characteristic, meaning they can operate at maximum rated power over a wide range of output voltage and current combinations. Two models,

the HP 6023A and HP 6033A, are rated at 200 watts, 20V maximum at 10A, and 30A maximum at 6.7V. The remaining four models, HP 6011A, 6012A, 6031A, and 6032A, are in the 1000-watt class.

Output up to 60 volts or up to 120 amps is available, depending on which instrument is chosen. Prices range from $1,500 to $3,100 depending on model and system interface selected. **Hewlett-Packard Company, Palo Alto, CA 94303, please circle INFO/CARD #104.**

Micro Networks Product Guide

New 1984, 384-page catalog includes complete specifications and application hints for our ful line of high-speed DIP packaged analog-to-digital (A/D) and digital-to-analog (D/A) converters, track-hold (T/H) amplifiers, complete data acquisition systems (DASs) and linear amplifiers. Contains data sheets for 25 newly introduced products including 16-bit A/Ds, 16-bit D/As, 700nsec 8-bit and 900nsec 12-bit A/Ds, and a 30nsec T/H amplifier. Catalog also includes application notes and detailed tutorial sections on understanding A/D, D/A and T/H specifications, as well as a high reliability processing section and quick-selection guides for engineers. **Micro Networks, Worcester, MA 01606, please circle INFO/CARD #100.**

RF/ANALOG ENGINEERS

E-COM is the dynamically growing high-tech division of AM CABLE TV INDUSTRIES, INC., which has been listed by INC. MAGAZINE for the third consecutive year as being among the 100 fastest growing companies in America.

At AM CABLE TV we are defining the state of the art in the field of CATV Data Communications, forging new frontiers in the development of products for both one-way and two-way Cable TV systems.

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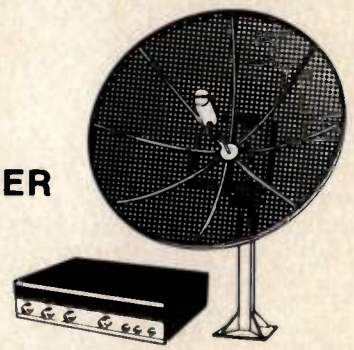
RF ENGINEER
Colorado



Manufacturer of RF products for TV broadcast, CATV and satellite TVRO needs EE's to design new products. Experience in RF/microwave circuit design required.

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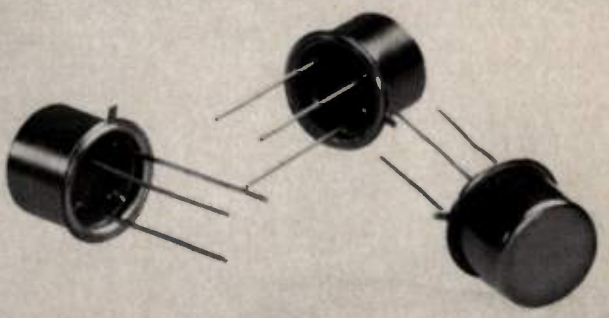

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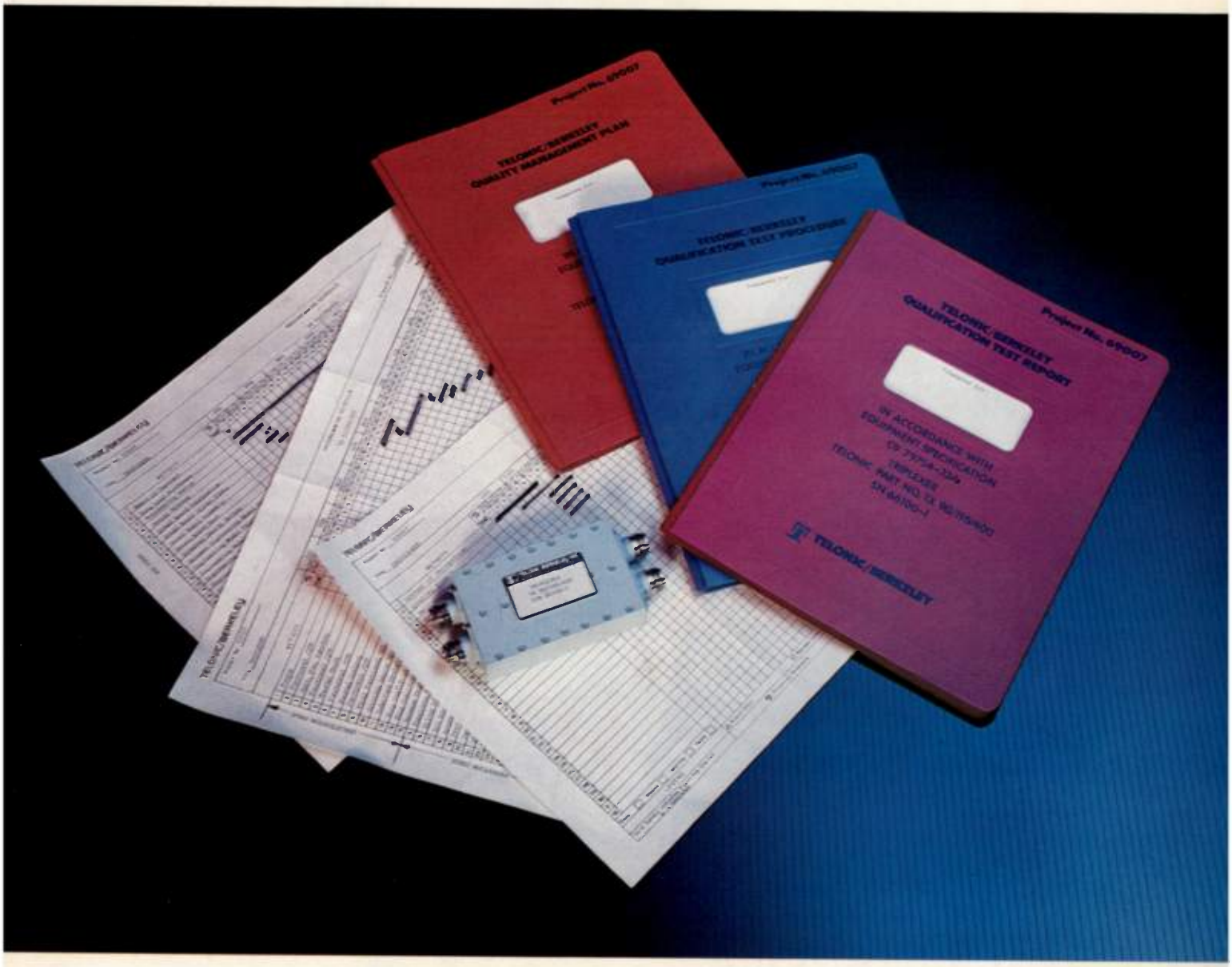

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1. Submit as many entries as you wish.
2. Ideas should be original and non-proprietary. †
3. Entries will be judged by the editorial staff of Microwave Journal and their decisions will be final. The top 25 winning entries will be published in Microwave Journal.
4. All entries become the property of Mini-Circuits Laboratory and must be received by December 31, 1984.
5. Employees of Mini-Circuits Laboratory, Microwave Journal and their sales representatives, are not eligible.
6. Contest void where prohibited by law.
7. Make sure to include your business address and phone number. In addition, for non-U.S. entries, indicate AC power line voltage and frequency.
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†Winners may be asked to sign an affidavit of eligibility & release.

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