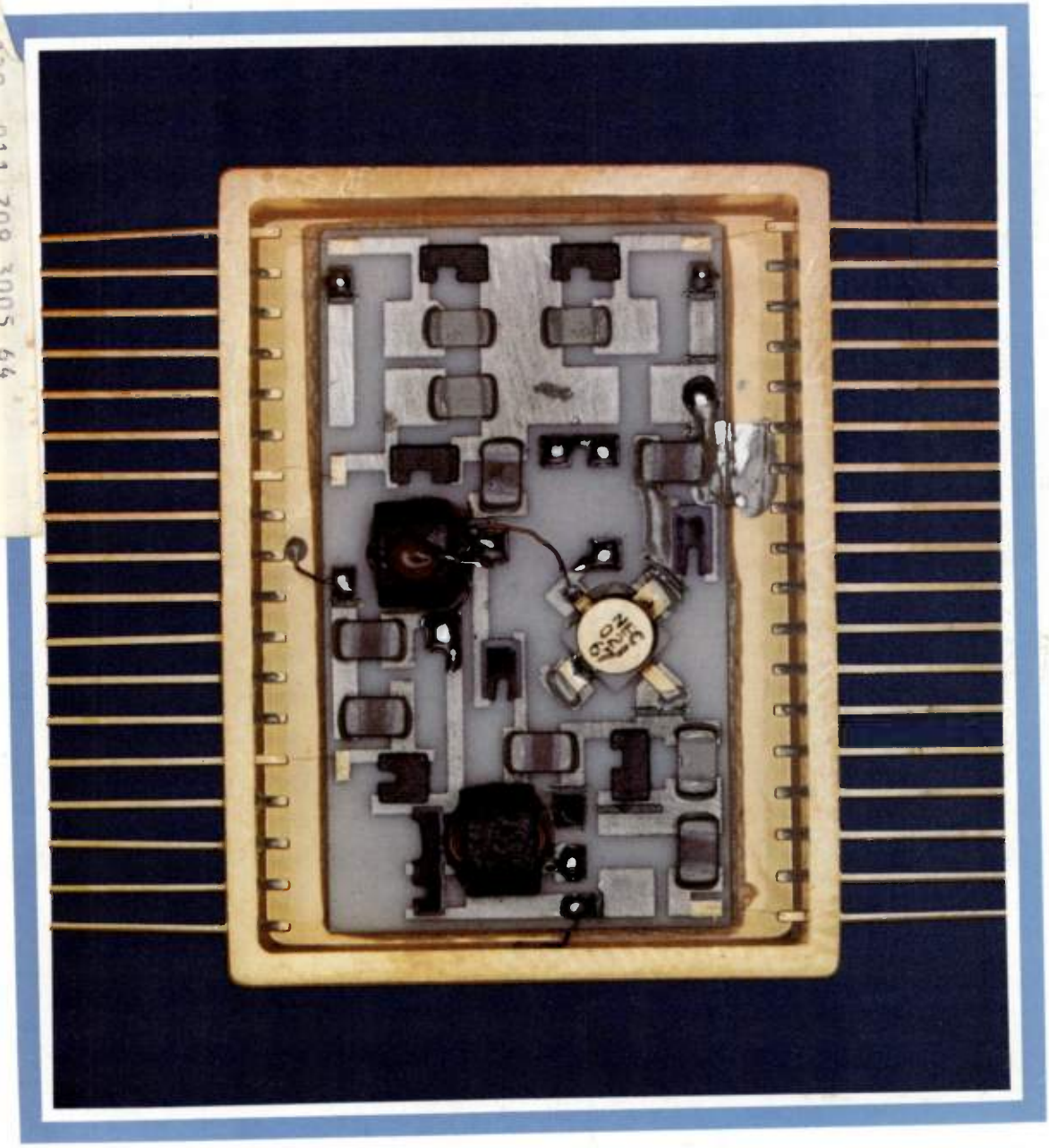
March/April 1979

A Cardiff Publication

rfdesign



Microstrip RF Amplifier ● SAW Filters
Mechanical Filters ● Design with PIN Diodes
Practical 60-Watt Amplifier

GET YOUR FREE SUBSCRIPTION . . . SEE PAGE 9

Once again HP makes your money count.

A universal counter for $375.

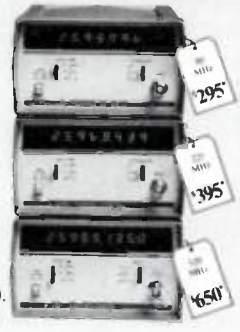
The smart money's on HP's new 5314A Universal Counter because it does so much for so little. Now, in one low-cost counter, you can measure frequency up to 100 MHz, period down to 400 nanoseconds with 100 picosecond resolution, and time interval with 100 ns resolution. Add frequency ratio, ratio averaging, totalizing and a full complement of time interval measurement controls and you've got a package you'd expect to find at almost twice the 5314A's $375 price. Options: internal battery and charger, $95; TCXO time base, $100.

Time interval measurement capabilities are truly outstanding at the 5314A's price. Instead of limited single channel controls, or none at all, the 5314A gives you both input trigger level and slope controls for two input channels. So now you can measure pulse widths or time between pulses with stop and start commands from either one or two input control lines.

HP's frequency counters also save you time *and* money.

Using state-of-the-art components common to HP's most sophisticated counters, the HP5380 frequency counter series offers high accuracy, high input sensitivity, input attenuators and direct counting for rapid, convenient frequency measurement and adjustments.

5381A 80 MHz, $295 • 5382A 225 MHz, $395 • 5383A 520 MHz, $650.



To find out more about HP's low-cost laboratory grade counters and the entire family of sophisticated and versatile HP counters call your nearest HP field office. Or write for the 5314A and 5380 series data sheets and electronic counter brochure.

Prices domestic U.S.A. only

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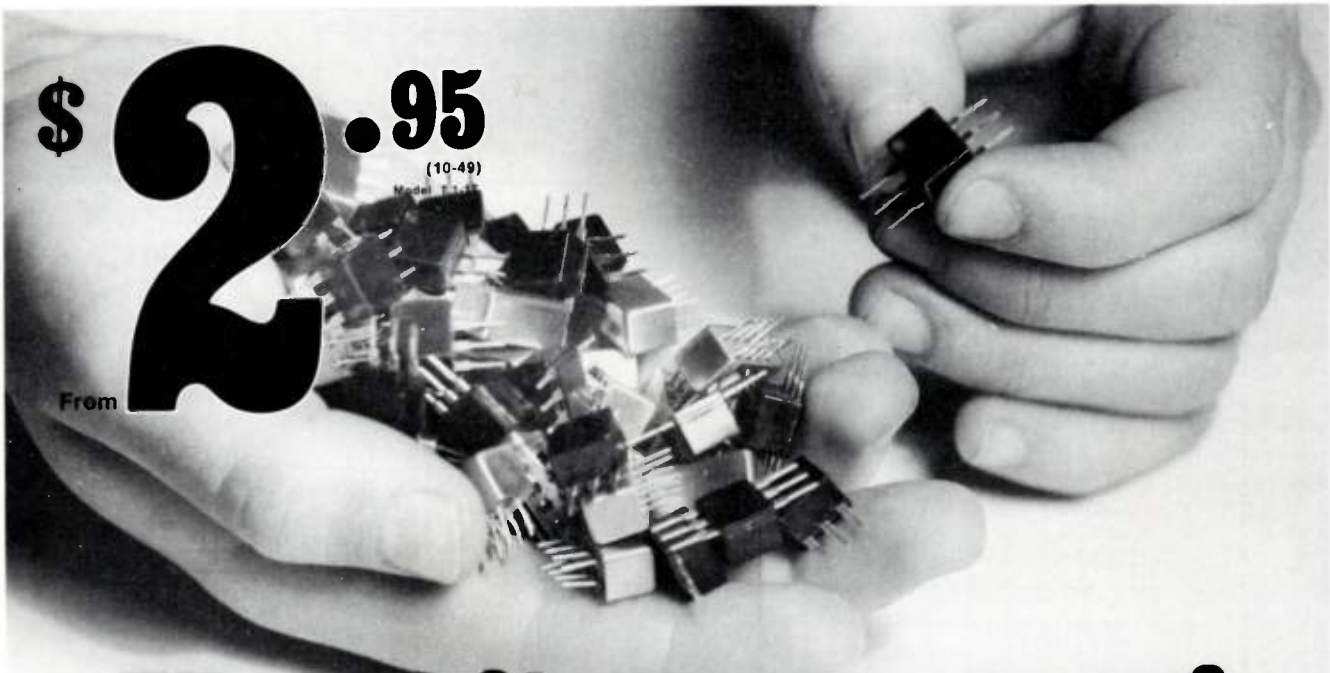
INFO/CARD 1

RF TRANSFORMERS



Have it your way!

36 models to choose from, 10KHz-800MHz

It costs less to buy Mini-Circuits wideband RF transformers. The T-series (plastic case) and TMO series (hermetically sealed metal case) RF transformers operate with impedance levels from 12.5 ohms to 800 ohms and have low insertion loss, 0.5 dB typ. High reliability is associated with every transformer. Every production run is 100% tested, and every unit must pass our rigid inspection and high quality standards. Of course, our one-year guarantee applies to these units.

DC ISOLATED PRIMARY & SECONDARY

N x 50 Ω / 50 Ω

Model						
Metal Case	TMO 1-1	TMO 1.5-1	TMO 2.5-6	TMO 4-6	TMO 9-1	TMO 16-1
Plastic Case	T 1-1	T 1.5-1	T 2.5-6	T 4-6	T 9-1	T 16-1
Freq. Range, MHz	.15-400	.1-300	.01-100	.02-200	.15-200	.3-120
Impedance Ratio	1	1.5	2.5	4	9	16
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz	MHz
3 dB	.15-400	.1-300	.01-100	.02-200	.15-200	.3-120
2 dB	.35-200	.2-150	.02-50	.05-150	.3-150	.7-80
1 dB	2-50	.5-80	.05-20	1-100	2-40	5-20
Price, Model TMO	$4.95	$6.25	$5.95	$5.95	$5.45	$5.95
(10-49) Model T	$2.95	$3.95	$3.95	$3.95	$3.45	$3.95

UNBALANCED PRIMARY & SECONDARY

50 Ω / N x 50 Ω

Model					
Metal Case	TMO 2-1	TMO 3-1	TMO 4-2	TMO 8-1	TMO 14-1
Plastic Case	T 2-1	T 3-1	T 4-2	T 8-1	T 14-1
Freq. Range, MHz	.015-600	.5-800	.5-600	15-250	.2-150
Impedance Ratio	2	3	4	8	14
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz
3 dB	.015-600	.5-800	.2-600	15-250	.2-150
2 dB	.02-400	.2-400	.5-500	25-200	.5-100
1 dB	.05-200		.2-250	.2-100	.2-50
Price, Model TMO	$5.45	$6.25	$5.45	$5.45	$6.25
(10-49) Model T	$3.45	$4.25	$3.45	$3.45	$4.25

DC ISOLATED PRIMARY & SECONDARY CENTER-TAP SECONDARY

N x 50 Ω / 50 Ω

Model							
Metal Case	TMO 1-1T	TMO 2-1T	TMO 2.5-6T	TMO 3-1T	TMO 4-1	TMO5-1T	TMO 13-1T
Plastic Case	T 1-1T	T 2-1T	T 2.5-6T	T 3-1T	T 4-1	T 5-1T	T 13-1T
Freq. Range, MHz	.05-200	.07-200	.01-100	.05-250	2-350	.3-300	.3-120
Impedance Ratio	1	2	2.5	3	4	5	13
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz	MHz	MHz
3 dB	.05-200	.07-200	.01-100	.05-250	2-350	3-300	.3-120
2 dB	.08-150	.1-100	.02-50	.1-200	35-300	.6-200	.7-80
1 dB	2-80	.5-50	.05-20	.5-70	2-100	5-100	5-20
Maximum Amplitude Unbalance MHz							
.1 dB	.5-80	1-50	1-20	1-70	5-100	10-100	5-20
.5 dB	.05-200	.07-200	.01-100	.05-250	2-350	3-300	3-120
Maximum Phase Unbalance Degrees MHz							
1°	.5-80	1-50	1-20	1-70	5-100	10-100	5-20
5°	.05-200	.07-200	.01-100	.05-250	2-350	3-300	.3-120
Price (10-49)							
Model TMO	$5.95	$6.25	$6.25	$5.95	$4.95	$6.25	$6.25
Model T	$3.95	$4.25	$4.25	$3.95	$2.95	$4.25	$4.25

	TMO-series	T-series
Primary Impedance: 50 ohms		
Total Input Power: ¼ watt	.25 cu. inches	.02 cu. inches
	.07 ounces	.01 ounces

Designers Kit Available

(TK-1) — 2 transformers of each type T1-1, T2-1, T4-1, T9-1, T16-1 **$32.00**

(TMK-2) — 2 transformers of each type TMO1-1, TMO2-1, TMO4-1, TMO9-1, TMO16-1 **$49.50**

World's largest manufacturer of Double Balanced Mixers

Mini-Circuits

A Division of Scientific Components Corp

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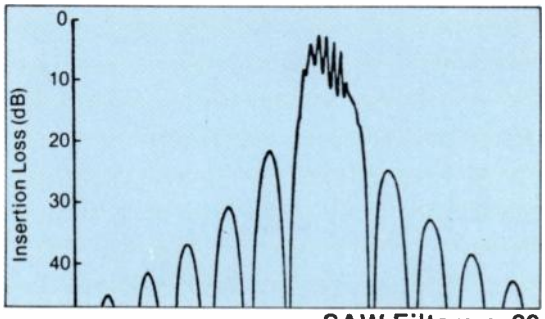
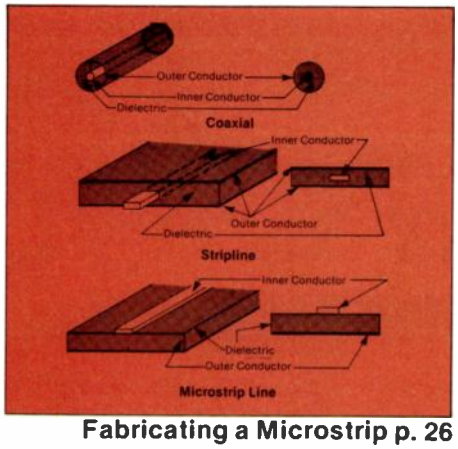
22/REV/H ☐☐☐

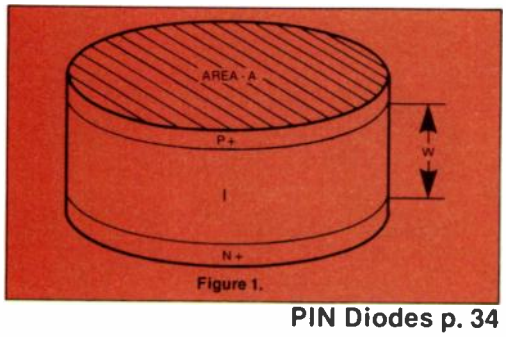
INFO/CARD 2

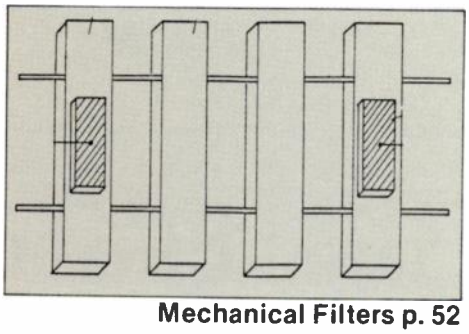
r.f. microwave design

March/April 1979









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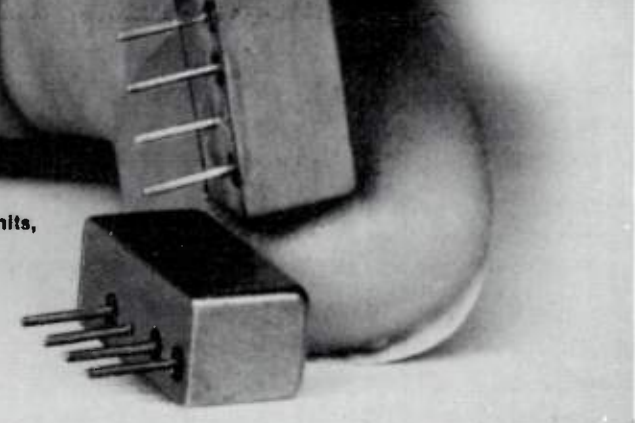
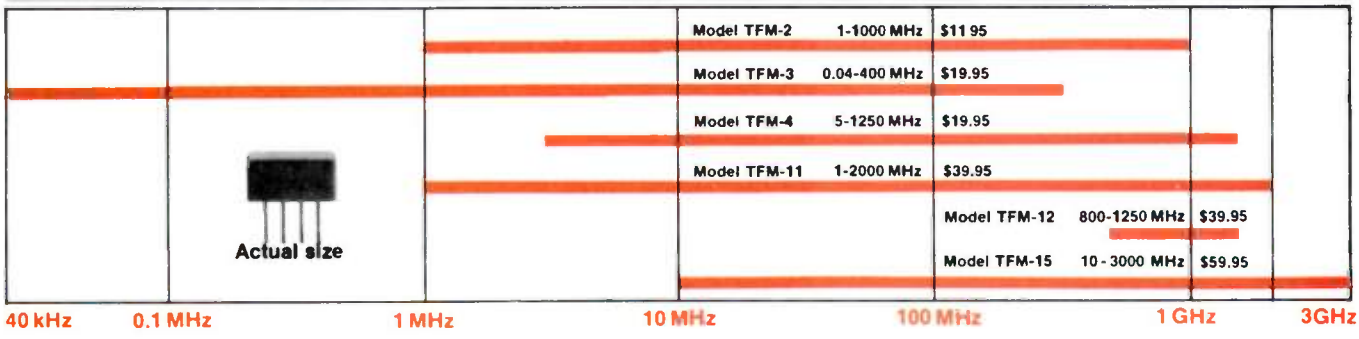
Introducing the SMALLEST BROADBAND MIXERS available!

40 kHz - 3 GHz

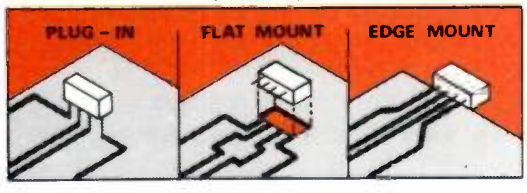
$11.95



ACT NOW TO IMPROVE YOUR SYSTEM DESIGNS.
Increase your packaging density, and lower your costs . . . specify Mini-Circuits new microminiature TFM series. These tiny units, 0.5" x 0.21" x 0.25" the smallest off-the-shelf Double Balanced Mixers available today, cover the 40 kHz - 3 GHz range and offer isolation greater than 45 dB and conversion loss of 6 dB. Each unit carries with it a 1-year guarantee by MCL. Upgrade your new system designs with the TFM, rapidly becoming the new industry standard for high performance at low cost.



Simple mounting options offer optimum circuit layout.
Use the TFM series to solve your tight space problems. Take advantage of the mounting versatility—plug it upright on a PC board or mount it sideways as a flatpack.



Model	Frequency, MHz			Conv. loss, dB		Isolation, dB						Cost	
				One Octave From Band Edge	Total Range	Lower Band Edge To one Decade Higher		Mid Range		Upper Band Edge To Octave Lower			
						LO-RF	LO-IF	LO-RF	LO-IF	LO-RF	LO-IF		
Model No.	LO	RF	IF	Typ Max	Typ Max.	Typ Min	Typ Min	Typ Min	Typ Min	Typ Min	Typ Min	Quantity	Price
TFM-2	1-1000	1-1000	DC-1000	6.0 7.5	7.0 8.5	50 45	45 40	40 25	35 25	30 25	25 20	6-49	$11.95
TFM-3	.04-400	.04-400	DC-400	5.3 7.0	6.0 8.0	60 50	55 40	50 35	45 30	35 25	35 25	5-49	$19.95
TFM-4	5-1250	5-1250	DC-1250	6.0 7.5	7.5 8.5	50 45	45 40	40 30	35 25	30 25	25 20	5-49	$19.95
TFM-11	1-2000	1-2000	5-600	7.0 8.5	7.5 9.0	50 45	45 40	35 25	27 20	25 20	25 20	1-24	$39.95
TFM-12	800-1250	800-1250	50-90	— —	6.0 7.5	35 25	30 20	35 25	30 20	35 25	30 20	1-24	$39.95
*TFM-15	10-3000	10-3000	10-800	6.3 7.5	6.5 9.0	30 20	30 20	30 20	30 20	30 20	30 20	1-9	$59.95

Signal, 1 dB compression level +1 dBm. Impedance, all ports 50 ohms. Total input power 50 mW. Total input, current peak 40 mA. Operating and storage temperature -55°C to +100°C. Pin temperature 510°F (10 sec).
*LO power +10 dBm, 1 dB compression +5 dBm

World's largest manufacturer of Double Balanced Mixers

Mini-Circuits
A Division of Scientific Components Corp.

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INFO/CARD 3

r.f. design

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Nothing Happens Until Somebody *Designs* Something

The other day, a salesman whom I know told everyone within earshot about the importance of selling. "Nothing happens until somebody sells something," he said with great conviction. Every salesman has 50 people depending on him to provide income and a need for products."

To an extent this is all very true. On the other hand, this huge electronics industry (more than $45 billion this year!) wouldn't exist if it weren't for innovative design. Responsible for the growth of this industry is the solid engineering which is built on the solid engineering of the past.

For example, two months ago, a friend came over to our house and brought a spelling machine made by Texas Instruments. This "toy" actually spoke words and sentences to the user. Well designed and effective, it retails for $50. I then heard last week that someone has taken this design and is building upon it. He is planning to build a one-way pager that is programmed to speak sentences to its owner. It will have a built-in memory, which is controlled by the operator at the base station. Out in the field, the pager will automatically "speak" one of a number of messages that the operator selects.

Another good example of innovative design is on page 59 of this magazine. It describes a new method of measuring capacitance, which is interesting and is low cost. This impressive meter, developed through good engineering, will help a lot of people to do some things faster and cheaper.

Selling is important to all of us. We all need good sales organizations, but, when it comes to electronics, nothing happens until somebody *designs* something. □

Pat Wiesner

The Ultimate "Brickwall" Filters

Up to 230 dB/octave. 1 Hz to 100 KHz, local/remote programming, dual Low Pass or Band Pass, built-in gains, >80dB dynamic range.

IMPOSSIBLE? 230dB/octave attenuation in a moderately priced, wide-range programmable filter with superb passband and stopband characteristics? Not impossible, but it *did* take a decade of technological leadership in signal processing to develop these state-of-the-art elliptic filters.

WHAT DO YOU NEED? We offer two versions: Model 752A is dual-channel low-pass, tunable over 1Hz—100Khz, by remote digital or local manual means. Each channel provides passband flatness within 0.5dB p-p, 115dB/octave rolloff. Phase match between channels, typically, is 1° or better. Use them separately for two-channel anti-aliasing, cross-correlation, etc; *and cascade them to get 230dB/octave rolloff* . . . for the ultimate in alias rejection.

Or choose Model 751A, a tunable high-pass/low-pass (adjustable bandpass) elliptic. Independently programming Low and High cutoffs allows you to set both center frequency and bandwidth anywhere in the 1Hz to 100KHz band; same rolloff rates, same programming. Speaking of programming, choose BCD or optional IEEE STD 488 . . . both built in.

Model 751A. Bandpass. Brickwall.

THERE'S MORE? You bet. Too much for this space. More than 80dB dynamic range. Programmable gains (e.g., 0 dB to +60dB in 10dB steps in the Model 751A) . . . exceptional frequency-setting resolution and much more.

GET THE FACTS ON THESE BRILLIANT NEW DESIGNS. Call or write for the catalogs, engineering notes, and our 24-page "mini-textbook" on filter theory and applications.

Rockland Systems Corporation,
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INFO/CARD 12

ROCKLAND

DSI COMMUNICATIONS SERIES

1.3GHz — 1GHz — 700MHz

MODEL C1000 10Hz to 1GHz

$499.95

- INCLUDES BATTERY PACK
- AUTO ZERO BLANKING
- AUTO DECIMAL POINT
- 10MHz TIME BASE

Accuracy . . . that's the operational key to this rugged advanced design Model C1000 1GHz frequency counter . . . a significant achievement from DSI. That's because you get . . . **.1 PPM** 0° to 40°C proportional oven time base . . . Built in 25DB preamplifier with a 60DB adjustable attenuator . . . x10 & x100 audio scaler which yields .01 Hz resolution from 10Hz to 10KHz equivalent to 10 sec. & 100 sec.Gate Time . . . Selectable .1 & 1 sec. time base and 50 ohms or 1 meg ohm input impedance . . . Built-in battery charging circuit with a Rapid or Trickle Charge Selector . . . Color keyed high quality push button operation . . . All combined in a rugged black anodized (.125" thick) aluminum cabinet. The model C-1000 reflects DSI's on going dedication to excellence in instrumentation for the professional service technician, engineer, or the communication industry.

MODEL C700 50Hz to 700MHz

$369.95

- INCLUDES BATTERY PACK
- AUTO ZERO BLANKING
- AUTO DECIMAL POINT
- 10MHz TIME BASE

ALL NEW! All UNPARALLELED DSI QUALITY! The model C 700 700 MHz frequency counter features . . . **.2 PPM** 0° to 40° C proportional oven time base . . . 25db preamplifier with a 60db adjustable attenuator. Built in battery charger with a rapid or trickle charge selector . . . Combined in a rugged (.125" thick) aluminum cabinet makes the C700 ideal for the communication industry and professional service technician.

3600A OWNERS: Up date your 3600A frequency counter to a C 700 includes, new back board, **.2PPM** proportional oven, 25db preamplifier, rugged .125" thick aluminum cabinet, order 3600A-700. Unit must be returned to DSI factory for modification.

DSI — GUARANTEED SPECIFICATIONS — FACTORY ASSEMBLED — MADE IN USA

Model	Frequency Range	Proportional Oven Accuracy Over Temperature	50Hz To 75MHz	75MHz To 500MHz	500MHz To 1GHz	Number Of Digits	Size Of Digits	Power Requirements	Size
C700	50Hz to 700MHz	.2PPM 0° to 40°C	50MV	10MV	NA	8	.5 Inch	115 VAC-BATT 8 to 15VDC	3"H x 8"W x 6"D
C1000	10Hz to 1GHz	.1PPM 0° to 40°C	20MV	1MV	>50MV	9	.5 Inch	115VAC-BATT 8 to 15VDC	4"H x 10"W x 7½"D

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

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Atlanta (800) 241-4545
Georgia Exchanges Call Collect (404) 977-2225
53 Old Stone Mill Road, Atlanta, GA 30067

Model C 700	**$369.95**
3600A-700 Factory Update (3600A only) Includes Labor & Re-Calibration	**$199.95**
Model C 1000	**$499.95**
Opt. 01 1.3 GHz (C1000 only)	**$ 99.95**
Opt. 02 .05 PPM 10MHz Double Oven 0° to 50° C Time Base (C1000 only)	**$129.95**
Ant. 210 Telescopic Ant./BNC Adapter	**$11.95**

INFO/CARD 5

Attenuator manufacturers used to hide when they saw us coming.

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

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

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

And then there were all those special custom requirements we needed.

Everybody probably sighed with relief when we gave up and started making our own attenuators.

But not for long.

Because we became an even tougher competitor than we were a customer.

We pioneered Distributed Field Resistor Technology, which has set new industry standards for attenuator accuracy and repeatability.

And we offer a very wide range of off-the-shelf attenuator types in fixed and variables, plus custom designs to meet your special needs.

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INFO/CARD 6

Electro/79

In the Electronic Industry's No.1 Marketplace/New York

Electro takes a penetrating look at the technology, products and ideas that will dominate the industry in the approaching decade of the 80's. It begins Monday, April 23, with an all-day marketing seminar and a keynote address by Charles L. Brown, Chairman of the Board of the American Telephone and Telegraph Company.

Then, three days of exhibits and professional program sessions. There will be more than 700 exhibit booths and 120 technical presentations exploring topics like microprocessing, fiber optics, memory, minicomputers, testing, LSI, home computing and others.

Electro/79

Electro/79 in New York
April 24, 25 and 26, 1979
New York Coliseum/Exhibition
Americana Hotel/Professional Program
INFO/CARD 36

Articles like "Microstrip RF AMP Design" are extremely handy for those of us with an engineering background but no particular experience in designing RF systems. I'd love to see an article containing a broad view of RF antennas from both a practical and a theoretical viewpoint.

Scott Winick
Senior Engineer
Megapulse

I just returned from a three-week trip around Europe to find in my basket the January/February issue of *r.f design.* May I add my voice to what is undoubtedly a strong swell of congratulations on a job well done! Your January/February issue is a superb publication. The quality of the articles, as well as the general overall quality of your magazine, is certainly a step above.

Keep up the good work, and as always, whenever we can be of assistance to you, please call on us.

Sincerely,

Norbert Laengrich
International Marketing Manager
Racal-Dana Instruments Inc.

The need for a publication like yours is very obvious. What took you so long?!! This is definitely not a throwaway type magazine but a state-of-the-art continuously updated RF design reference. Looking forward to future issues.

David K. Wolfe
Adv. Dev. Eng.
GTE Sylvania CSD

Excellent magazine. This is one of a few publications that has achieved the art of presenting highly innovative and technial material in a manner this is still understandable to the recent college graduate in E.E. your article in Jan./Feb. '79 "Microstrip RF Amplifier Design" was most interesting and evidence of my above statements.

M.J. Key
Associate Engineer
Sperry Microwave Electronics

Reading your excellent magazine and especially the information on the new Hewlett-Packard synthesized signal generator, I would like to draw your attention to a paper on Frequency Synthesizer Design which I had published in

1976 in *Ham Radio* Magazine.

Additional techniques, including the one used by Hewlett-Packard have been discussed there and these techniques are only responsible for the noise outside the loop bandwidth. Inside the loop bandwidth, very carefully filtered low noise frequency standards are responsible for the performance. Equal noise performance is achieved in my communication receiver HF 1030, which is an absolute novelty for synthesizers in communications receivers.

Cordially yours,

Dr. Ulrich L. Rohde
President
Rohde and Schwarz

I wish to congratulate you on your excellent RF publication. There has been a long overdue necessity for a RF Design publication — with all the other publications going "BIT" nuts — and totally ignoring RF Receivers, Transmitters, etc. I treasure your publication and wouldn't let them out of my sight. I would be honored to contribute original design articles on transmitter and receiver section designs. Your publication is the best!

Berford A. Turke, Ph.D.E.E.
Chief Engineer
Audio Intelligence Devices

I didn't know *r.f. design* publication exhisted until a fellow worker left a copy with me. I have been in RF design for over 10 years and its what I've always wanted in a work related publication. I just sent off for a free subscription, many thanks!

Robert C. Henderlong
Sr. Research Engr.
Seiscor

This is the magazine that I would now rate as #1 in usefulness to my profession. RF designers are a unique breed and deserve a unique magazine. You have a good start and maybe someday we will be able to receive this publication monthly.

Lloyd Cline
Trans World Communications

If the first two issues are any indication of what is to come, then an important gap has been filled. I particularly like the "How To" article of Thomas Litty. This type is very helpful for good design.

Frank Raso
Senior Design Engineer
IEC Electronics

Looks like a magazine long incoming — I've read both issues and have enjoyed both. Keep the design articles coming. Can hardly wait for the coming issues. The reindoctrination into the Smith Chart was quite welcome in this issue. Stay with the total field of RF rather than specializing in one RF field.

Howard Houke
Chief Engineer
Rucker Ultrasonics

You've got a winner here. Congratulations on a job well done. I expect that *r.f. design* will be influential in revitalizing an interest in RF circuit design, and perhaps motivate others to enter the world of RF.

James L. Gordon
Engineering Manager
Linkabit Corp.

Fantastic! As a lab technician I work with HF, VHF, and UHF on the job and also enjoy it as a hobby (Amateur Radio). I would like to know your policy regarding subscriptions to engineering technicians.

Gary L. Anderson
Engineering Technician
Rockwell/Collins

I find it very helpful and informative, and I enjoy receiving *r.f. design* magazine. Old issues will become part of my library for researching new projects because of their accessibility.

Alan Rutz
President
Community Systems Co. □

With the new improved bandstacking feature in our Model 2002A sweeper, you can now cover the entire 1 to 2500 MHz range in one fell swoop. You can also start and stop anywhere in between. Anywhere.

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Besides all this standard equipment, the 2002A has options. Like a deluxe harmonic marker system that provides 1, 10, 50 and 100 MHz markers over the entire frequency range. Or you can order specific single-frequency markers when you buy your 2002A, or whenever a specific application comes along.

But the important thing to remember is that the Model 2002A gets you from 1 to 2500 MHz in a single sweep. And you can't get this anywhere for just $3,400. Not anywhere. Wavetek Indiana, P.O. Box 190, Beech Grove, Indiana 46107. (317) 783-3221. TWX 810-341-3226.

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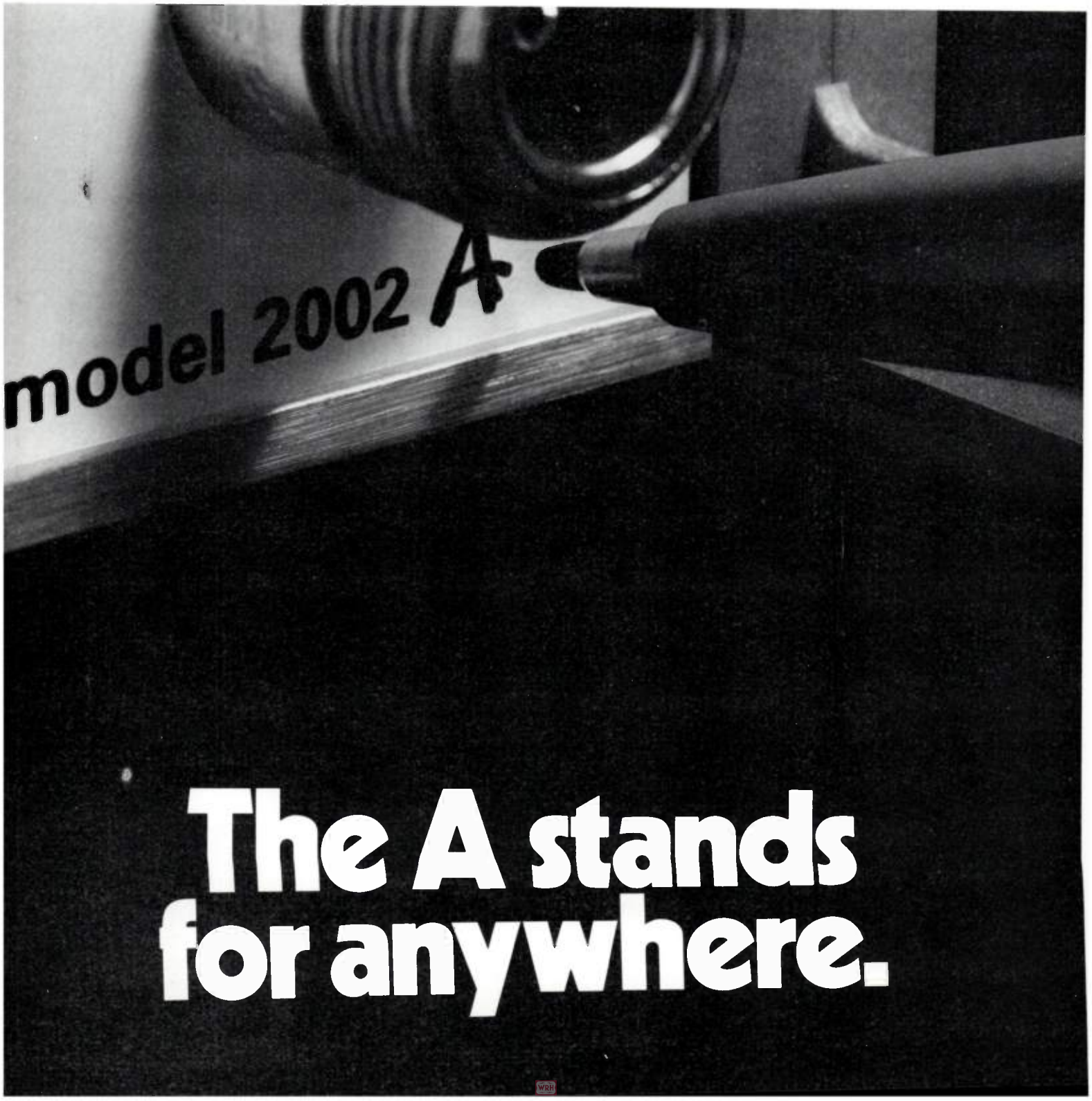
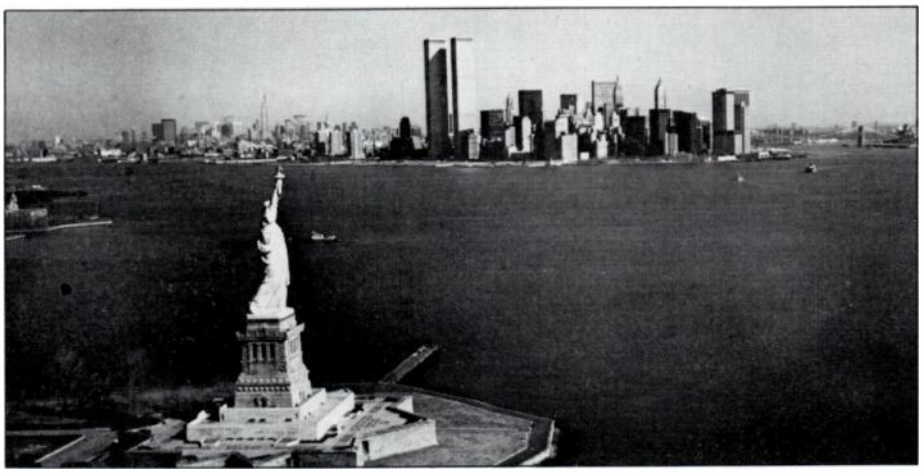


April in N.Y. Brings Out the Engineers

Electro '79 opens April 24, 25, & 26

Something on the order of 30,000 design engineers and engineering managers will come to New York City for Electro '79 in April. Again this year the exhibits will occupy three floors of the coliseum, and the professional program will be held at the Sheraton Centre (Americana Hotel). Exhibits will be open Tuesday, Wednesday and Thursday, April 24 through 26. There will be hundreds of exhibits, a lot to see and a lot to think about as engineers get ready to go into the '80's with new designs.



Get in Free! (Maybe!)

Maybe you won't have to wait in line at the typing station, maybe you will be able to get in free. If you are one of the first one hundred people to call or write *r.f. design* magazine, we will be happy to send you a complimentary registration for the exhibits and the show. Why should you have to pay the $10.00 entry ($5.00 for IEEE members)? Go to the Electro on *r.f. design* magazine. Just give us a call or write, and if you're *one of the first one hundred, we'll send you by return mail the* complimentary registration card.

Be Sure to See Booth #3616

Be sure to drop by the *r.f. design* booth while you are at Electro. Meet a couple of the *r.f. design* editors or sign up for a free subscription, if you haven't already.

Over One Hundred Technical Presentations

On page 18 and 19 you will find a complete breakdown of all the sessions which will be held at *the Sheraton Center (previously* known as the Americana). Those sessions which we think might be particularly of interest to the r.f. engineer, we have screened the entire box.

The professional program with an average of four speaking presentations at each technical session will cover the gamut from communications satellites, memory, fiber optics, energy management, LSI, to computer imagery and microprocessing. The impact of the microprocessor is certainly evident, since more sessions will be devoted to this topic than any other. The technical program has *been developed and organized* and will be presented by engineers, scientists and professionals.

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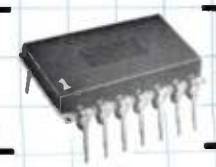

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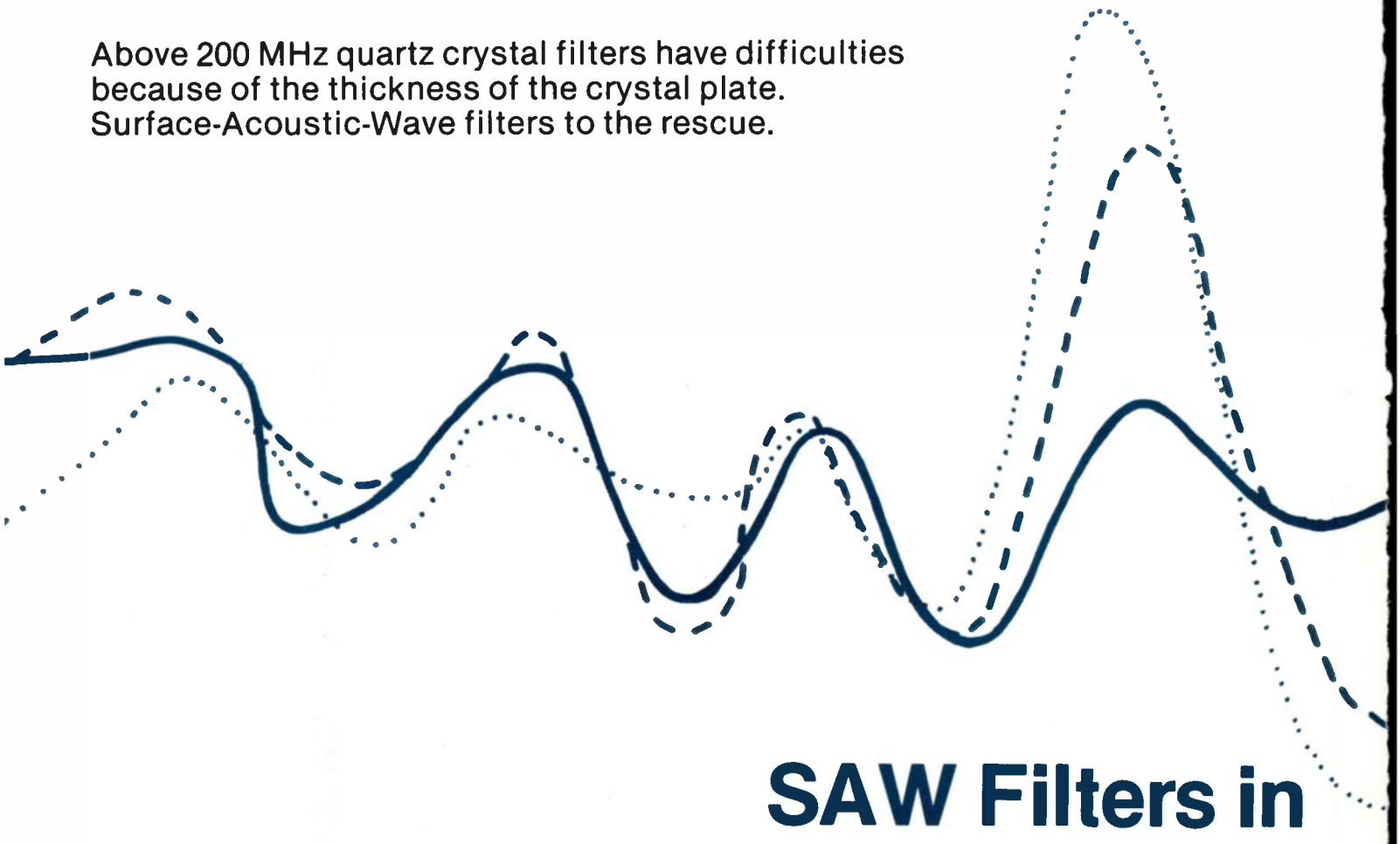
Electro/'79

Tuesday April 24			Wednesday
10 AM	1 PM	2 PM	10 AM
Keys to Successful Engineering Management P. Peirce AF Syst. Com.	SPECIAL SESSION INTERNATIONAL ELECTRONICS EXECUTIVES FORUM	The Engineer and Public Policy J. Casey IEEE	Engineering and Purchasing: Chaos or Co-Existence? R. Singer CMP
Analog-to-Digital LSI R. Walker Intel		Advances in Digital Signal Processing W. Koral TRW	Logic Analyzers as Tools in Developing Processor Systems Sam Lee Hewlett-Packard
Marketing Personal Computers F. Burge Regis McKenna		The Personal Computer: Hobby-Horse or Work-Horse? F. Burge Regis McKenna	Desktop Computers P. Welch Hewlett-Packard
Software Manufacturing in a Distributed Environment J. Sternberg Conversational Systems		Microcomputer Data Base Systems S.B. Yao N.Y. University	Reducing Risks in Microcomputer Development C.A. Ogdin EDN
Space Surveillance Technology J. Burgess Rome ADC		Adaptive Antennas C. Luvera Rome ADC	Edison Centennial (Life Members) H.M. Hess PES History Com.
Plastic Packaging for EMI Shielding John Reilly Electro-Kinetic Syst.		Non-Ionizing Radiation on Man FAA John Osepchuk Raytheon	Bomb and Weapon Detection Technology G. Carp FAA

Professional Program

	April 25	Thursday April 26	
	2 PM	10 AM	2 PM
	Corporate Venture Capital K. Rind Xerox Corp.	Women on the Steps of the Electronics Pyramid E.H. Williams Lockheed M&S	Minorities in Engineering S. Lawrence Bronx College
	Impact of 64K RAMs on the Computer Indus. S. Young Mostek	Non-Volatile Storage for Small Processors E. Pugh IBM	
	Electronics in the Graphic Arts R. Landsman LogEtronics	Microcomputer Industrial Control Networks J. Winegardner Western Electr.	Advanced Automation K. Fu, G. Saridis Purdue Univ.
	Self-Testing Instrumentation G. Partridge GenRad	Batteries for Modern Applications J. Wiseman Gould	The Future of Switching Power Supplies W. Hirschberg ACDC Electr.
	RF Communications, Present and Future Doug DeMaw ARRL	Interactive Tele-communications Systems in Social Uses M. Elton N.Y. University	Latest Advances in Printed Board Testing Ken Whittaker Fluke Trendar Corp.
	Environmental Monitoring and Assessment H. Perlis N.J. Inst. of Tech.	Engineering and Economics B. Blewitt Public Service Elect. & Gas	All sessions at Sheraton Center

Above 200 MHz quartz crystal filters have difficulties because of the thickness of the crystal plate. Surface-Acoustic-Wave filters to the rescue.



SAW Filters in

J. Otomo. S. Nishiyama, Y. Konno
Nihon Dempa Kogyo Co., Ltd.
and
K. Shibayama
Research Institute of Electrical Communication
Tohoku University

Group-type uni-directional interdigital transducers (IDT) are fabricated on a $LiNbO_3$ substrate by electron beam exposure and chemical etching. A small inductor is employed as a 90° phase-shifter, resulting in a practical SAW filter providing low insertion loss and small ripple in the 400 MHz to 800 MHz frequency range.

Low insertion loss is inconsistent with small passband ripple in SAW filters with conventional bi-directional transducers. This problem is caused by the second order effect resulting from the bi-directionality of the transducer.

Group-type uni-directional transducers have recently been proposed. They have already solved the problem for the VHF range. This type of transducer has many advantages in mass production because of simple fabrication.

Equivalent Circuit of Group-Type Uni-directional IDT

As shown in Figure 1, two interdigital transducers, S and R, with number of electrodes, N, are arranged with a distance of (N·L/2 + L/4) and are connected to a source with 90° phase difference for each set. The surface acoustic waves are propagated in the forward direction. Generally, it is difficult to get a good directionality using only one group of transducers having a small number of electrodes. In order to obtain good characteristics, it is necessary to arrange many groups so that the signals from each group can be summed in-phase. Then the electrode structure in Figure 2(a) is called N-2 type. The one in Figure 2(b) is called N-4 type.

The equivalent circuit of the group-type uni-directional transducer can be represented as shown in Figure 3. It can be represented as a three port network adding one electric port to the bi-directional IDT equivalent circuit.

In a SAW filter with a bi-directional IDT, the passband ripple is caused by triple transit echo, which is reflection between the acoustic ports. So the study of impedance missmatching at the port is very important. The admittance Y_{out} at the acoustic port under the condition that R_{in} is connected to the electric port as shown in Figure 3 is given by:

$$Y_{out} = \frac{T_{21} \cdot R_{in} + T_{11} \cdot Z_d}{Z_d (T_{22} \cdot R_{in} + Z_d \cdot T_{12})} \qquad (1)$$

the UHF Range

$|Y_{out}|$ of 6-group transducers (N-4-6) for various values of electric source resistance R_{in} are shown in Figure 4. The electromechanical coupling coefficient K is assumed as $K^2 = 0.0554$, which corresponds to that of rotated Y 128° $LiNbO_3$.

As shown in the equivalent circuit of Figure 3, transmitting transducer TR1 and receiving transducer TR2 are connected by a transmission line having the characteristic impedance Z_d, propagation constant γ and length ℓ. The total transfer matrix of the circuit is given by the product of the individual transfer matrix.

$$\begin{pmatrix} E_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} T_{11} & T_{12} \cdot Z_d \\ T_{21}/Z_d & T_{22} \end{pmatrix} \begin{pmatrix} E_2 \\ I_2 \end{pmatrix} \qquad (2)$$

Therefore, the operating attenuation is given by:

$$S_D = 20 \log \left| \frac{R_{out} \cdot T_{11} + Z_d \cdot T_{12} + (R_{in} \cdot R_{out} \cdot T_{21}) / (Z_d + R_{in} \cdot T_{22})}{2\sqrt{R_{in} \cdot R_{out}}} \right| \qquad (3)$$

where R_{in} and R_{out} are the resistance of the source and load. From equation (3), operating attenuation S_D is calculated for group type N-4-6 transducer as shown in Figure 6. In this case, R_{in} and R_{out} are $0.1785 \times 10^{-3} \cdot Z_d$, where Z_d is equal to $0.28011 \times 10^6 (\Omega)$.

Experimental Results

The 400 MHz to 800 MHz range filters were built where rotated 128° Y-cut, X-propagation $LiNbO_3$ plates were used. Aluminum of 1500-3000 A° thickness deposited and interdigital electrodes fabricated by electron beam exposure and chemical etching processes.

Insertion loss and passband ripple results were in good agreement with the calculation of the equivalent circuit.

In order to obtain characteristics with suppressed sidelobes, we combined an N-2 type transducer weighted by the weighting function $\pi^2 \mathrm{Sin}x/(\pi^2 + X^2)x$ with an unweighted N-4 type transducer. Sidelobe suppression is 35 dB, minimum insertion loss is 5.2 dB and the passband ripple is less than 0.2 dB. The increase of insertion loss is due to mismatching at electric port.

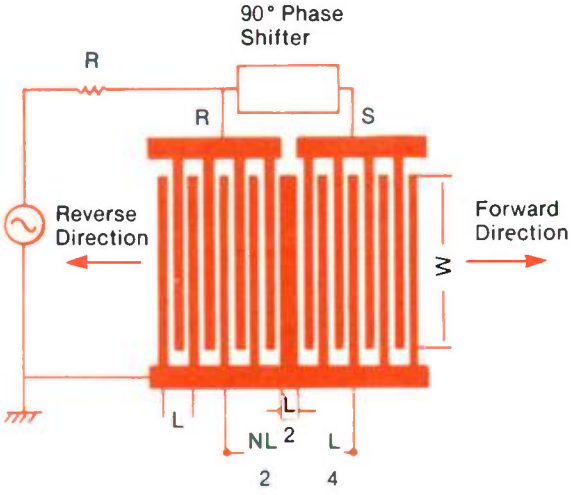


Figure 1. Group-Type Uni-directional Interdigital Transducers with 90° Phase Shifter.

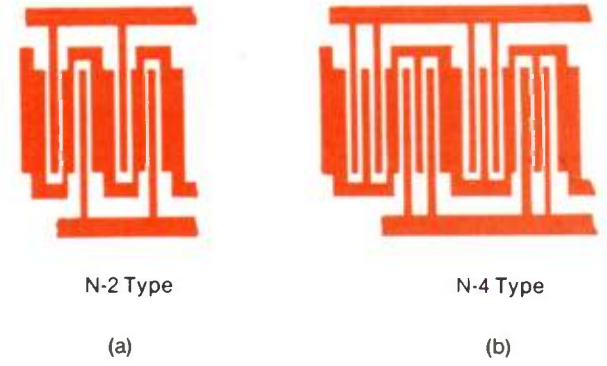
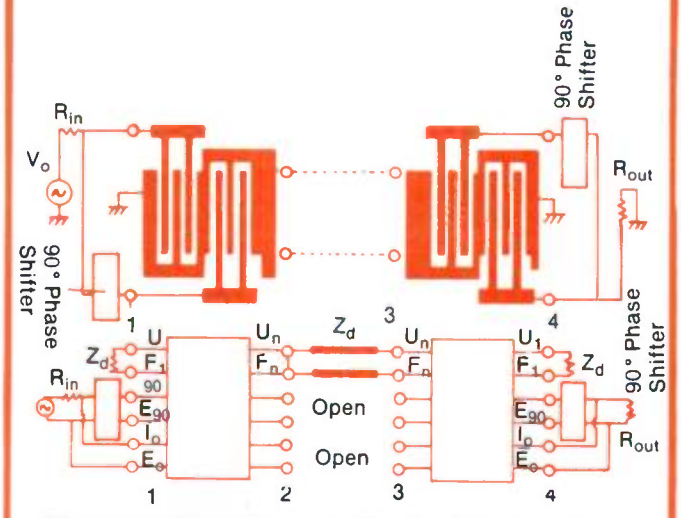


Figure 2. The Examples of Group-Type Uni-directional IDT.



TR_1 : Transmitting Transducer TR_2 : Receiving Transducer
F : Force U : Particle Velocity
Z_d : Characteristic Impedance of Transmitting Material
E : Voltage ! : Current

Figure 3. Schematic Diagram of Group-Type Uni-directional IDT Including Propagation Line.

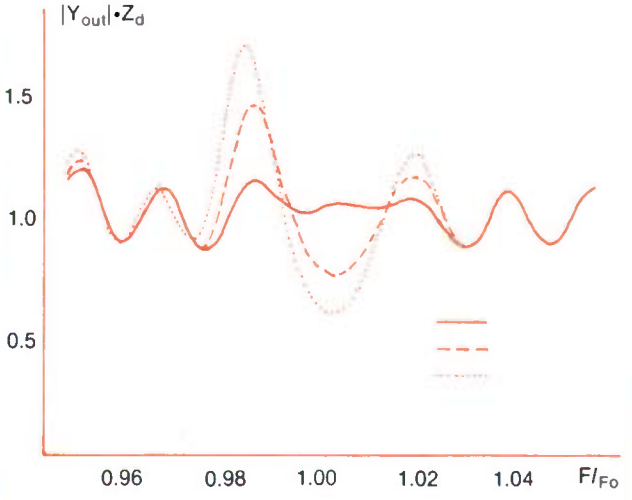


Figure 4. Admittance |Y-out| at Acoustic Port of Group-Type Uni-directional IDT.

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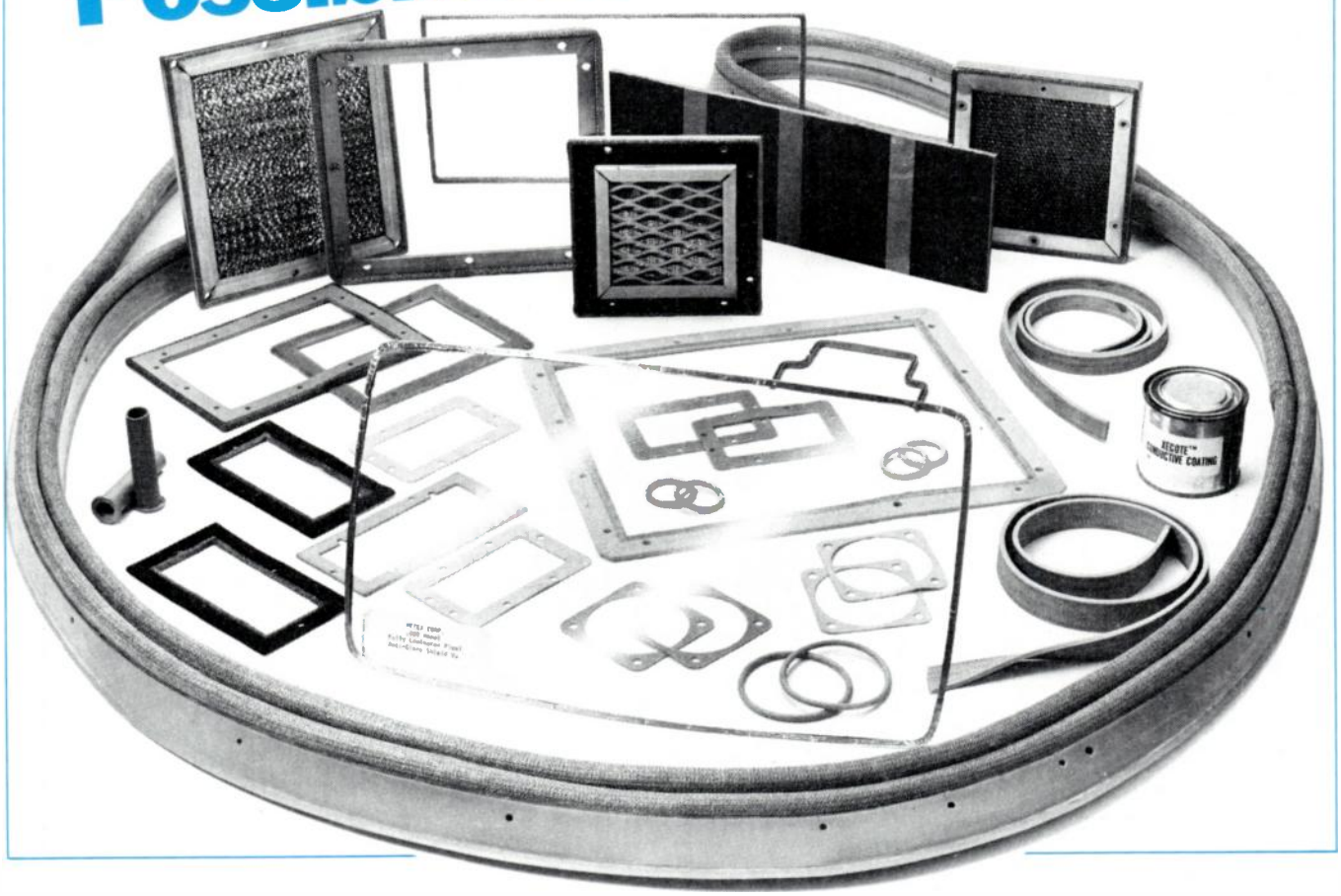

Metex EMI/RFI shielding comes in an infinite assortment of shapes and sizes for every conceivable electronics application, from sophisticated mobile communications and radar systems to fluorescent lighting fixtures. Fact is, we're the most experienced company in the business, worldwide.

That's why, when you get hung up on an interference problem, call your Metex representative. No matter what kind of shielding your application requires, the chances are Metex has a design for it. If not, we'll create one, just for you.

Part of our problem-solution technology is the use of knitted metal. Another is our Xecon® Conductive Elastomer. When we combine the two, the result is Metex Armored Xecon® Gasketing. The most advanced EMI/RFI shielding available. Anywhere.

Metex Shield Vu™ Windows allow you to see clearly (98% visibility) into any cabinet, chamber or digital display without EMI/RFI leakage. Again, we use knitted metal – between panes of acrylic or glass.

Omni Cell® Panels, with our transverse-oriented honeycomb configuration for ventilation shielding, are opaque to all electrostatic polarization vectors.

Metex Combo® Gaskets can be designed to accommodate any pressure differential application regardless of joint unevenness. They're available in combinations of six different standard elastomers and two different knitted metals. The knitted metal strip comes with or without an elastomer core.

Metalex® Shielded Frames are a combination of knitted metal gasketing mounted within an extruded aluminum cross section.

So, whether you can best use custom designed Combo® or Pola® Shielding Gaskets in sheets, rings or strips, or conductive coatings, Metex should be your first thought when it comes to EMI/RFI shielding.

And, to help you realize the infinite possibilities of Metex shielding, we want you to have, free of charge, our 124 page EMI/RFI Shielding Handbook, acclaimed the world over as the "textbook" of the field. Write to us on your company letterhead, at 970 New Durham Road, Edison, N.J. 08817, or on the west coast, 20437 S. Western Ave., Torrance, Ca. 90501.

Or, if you need an answer right away, talk to one of our applications engineers in N.J. at 201•287-0800, or in California on 213•320-8910. Also ask about samples and our free video seminars, offered periodically.

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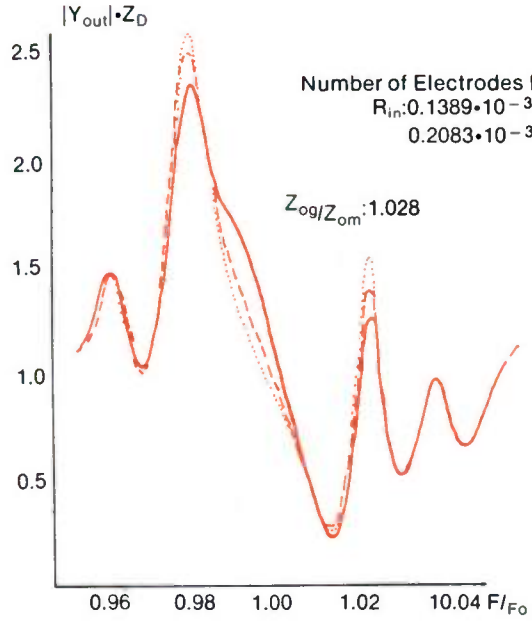


Figure 5. Admittance |Y-out| at Acoustic Port of Bi-Directional IDT.

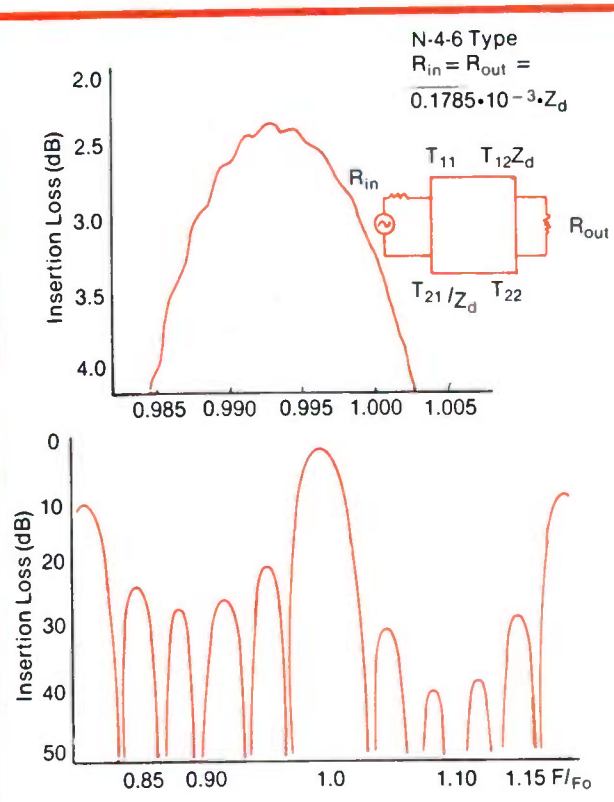


Figure 6. Calculated Operating Attenuation of Group-Type Uni-directional.

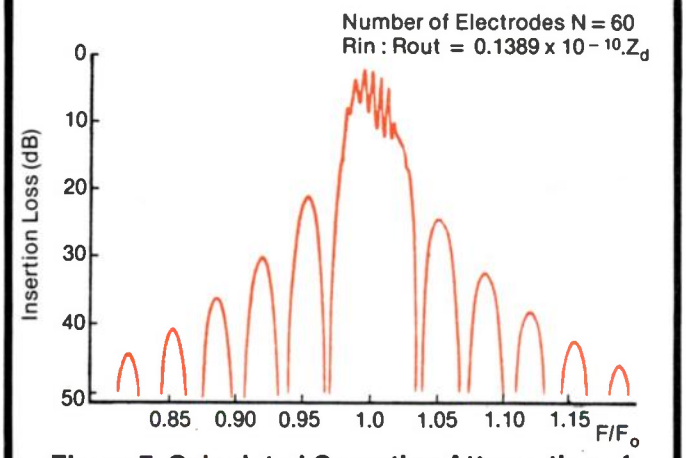


Figure 7. Calculated Operating Attenuation of Bi-directional IDT.

Conclusion

Group-type uni-directional IDT can be used to obtain low insertion losses and small passband ripple filters in UHF range. The results of experiments for the 400 MHz range are minimum insertion loss of 2.6 dB and less than 0.1 dB passband ripple. Similarly, for the 800 MHz range, minimum insertion loss of 5.6 dB and less than 0.2 dB passband ripple were obtained. The calculated results using the equivalent circuit model are in good agreement with the experimental results. The equivalent circuit is useful for analysis of group-type uni-directional IDT.

Reference

(1) H. Sato, K. Yamanouchi, K. Shibayama and S. Nishiyama "On the Design of Elastic Surface Wave Filters with No Tuning Coil," Proceeding of the 28th Annual Symp. Freq. Cont., 1974, P. 286.

(2) A.J. DeVries, J.F. Dias, J.N. Rypkema and T.J. Wojcik, "Characteristics of Surface-Wave Integratable Filters (SWIFS)," *IEEE Trans.*, Vol. BTR-17, No. 1, Feb. 1971, P. 16.

(3) M.F. Lewis, "Triple-transit Suppression in Surface Acoustic-Wave Devices," *Electronics Letters* Vol. 8, 16th Nov. 1972, P. 553.

(4) K. Nishikawa, "Suppression of Multiple-Transit-Echoes in Narrowband Acoustic Surface Wave Filters," Report of the 1974 Spring Meeting of the Acous. Soc. of Japan, June 1974, P. 513.

(5) J. Minowa, F. Ishihara and S. Yoshikawa, "Characteristics of Low Loss Elastic Surface Wave Filters," Report of the 1974 Spring Meeting of the Acous. Soc. of Japan, June 1974, P. 525.

(6) R.C. Rosenferd, R.B. Brown and C.S. Hartman, "Unidirectional Acoustic Surface Wave Filters with 2 dB Insertion Loss," Ultras, Symp. Proceedings IEEE 1974, P. 425.

(7) K. Yamanouchi, F.M. Nyffeler and K. Shibayama, "Low Insertion Loss Acoustic Surface Wave Filter Using Group-Type Uni-directional Interdigital Transducer," Ultras. Symp. Proceedings IEEE 1975, P. 425.

(8) W.R. Smith, H.M. Gerard and W.R. Jones, "Analysis and Design of Dispersive Interdigital Surface-Wave Transducers," *IEEE Trans.* MTT-20, No. 7, July 1972, P. 458.

(9) K. Shibayama, K. Yamanouchi, H. Sato and T. Meguro, "Optimum Cut for Rotated Y-cut $LiNbO_3$ Crystal using as the substrate of Acoustic-surface-wave Filters," proceedings IEEE May 1976, P. 595. □

Fabricating a Microstrip RF Amplifier

What is microstrip transmission line and how can amplifier design be translated into microstrip?

Tom Litty
V.P. Marketing
Digicast Systems, Inc.

Basic Transmission Line Theory

Let us briefly review the theory of transmission lines and their electrical characteristics. The lumped component equivalent circuit of a transmission line appears in Figure 1.

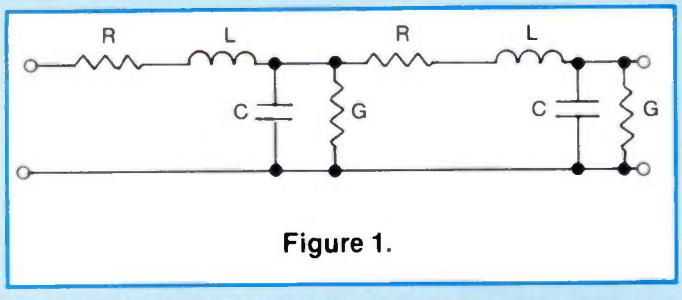


Figure 1.

The impedance of this line, Z_o, is given by the following formula:

$$Z_o = \sqrt{\frac{R + jwL}{G + jwC}} \qquad (1)$$

For most practical applications the shunt conductance, G, and the series resistance, R, are extremely small and therefore can be ignored. The equation for the transmission line impedance then becomes:

$$Z_o = \sqrt{\frac{L}{C}} \qquad (2)$$

Transmission Line Impedance Transforming Characteristics

The input impedance, Z_{in}, of a transmission line of impedance Z_o, terminated by a load impedance of Z_L is given by equation 3. For clarification see Figure 2.

$$Z_{in} = Z_o \left(\frac{Z_L + \tanh\gamma\ell}{Z_o + Z_L \tanh\gamma\ell} \right) \qquad (3)$$

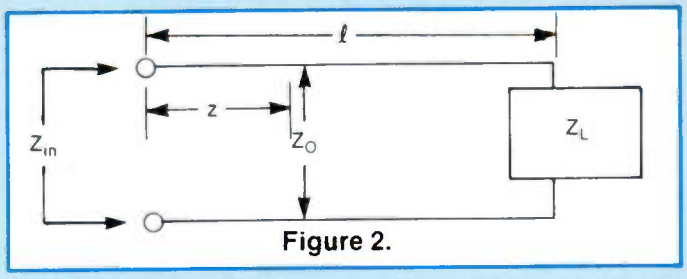


Figure 2.

In equation 3 the following relationship exists:

$$\gamma = \alpha + jB \qquad (4)$$

In equation 4, α is the real DC resistance of the transmission line; however, as stated before, the DC resistance is usually so small that it can be ignored. Equation 4 therefore becomes:

$$\gamma = jB, \tanh jB\ell = j\tan B\ell \qquad (5)$$

Entering this value of γ into equation 3 results in the following expression for Z_{in}:

$$Z_{in} = Z_o \left(\frac{Z_L + j Z_o \tan B\ell}{Z_o + j Z_L \tan B\ell} \right) \qquad (6)$$

Substituting the value for Z_o obtained in equation 2 into equation 6 and substituting additional known relationships into that equation result in the following important equations:

$$X_L = Z_o' \tan \theta \qquad (7)$$

$$\theta = \tan^{-1}\left(\frac{X_L}{Z_o}\right) \qquad (8)$$

$$X_c = Z_o \cot \theta \qquad (9)$$

$$\theta = \cot^{-1}\left(\frac{X_c}{Z_o}\right) \qquad (10)$$

Z_o' is the new value of transmission line impedance that will be used to simulate a lumped component.

Now with equations 8 and 10 we can calculate ℓ, the length of transmission line necessary to simulate either an inductor or a capacitor on a given transmission line in the following manner:

$$\ell = \frac{\theta \lambda_o}{(360°)(\sqrt{\in_r})} \qquad (11)$$

where: θ comes from equation 8 or 10
360° converts θ to a fraction
λ_o wavelength in free space
$\in_r$ effective dielectric constant

Examples

1. For an inductor on a microstrip transmission line:

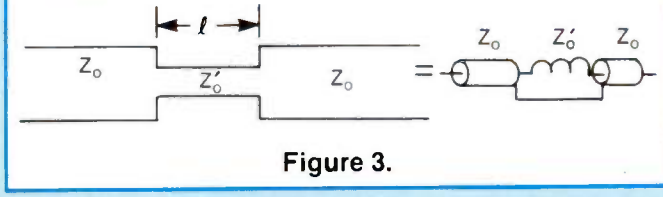


Figure 3.

$$\theta = \tan^{-1}\left(\frac{X_L}{Z_o'}\right) \qquad \textit{using equation 8.}$$

2. For a capacitor on microstrip:

$$\theta = \cot^{-1}\left(\frac{X_c}{Z_o'}\right) \qquad \textit{using equation 10.}$$

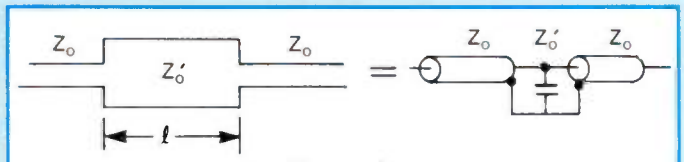


Figure 4.

Several important considerations should be noted at this time.

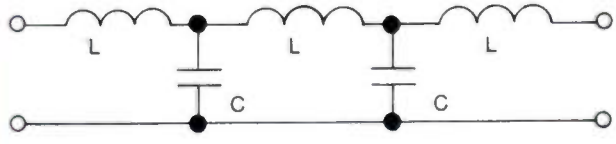
Z_o' can be any impedance desired; however, if an inductor is contemplated, then the higher the value of $Z_o' \ell$, the shorter ℓ will be to realize that component value. The converse is true of a transmission line simulating a capacitor.

I have mentioned microstrip in the illustrations above; however, a transmission line such as coaxial having the desired impedance could be used. Unfortunately, using this type of transmission line is limited in practicality since there are only a limited number of impedances available. Additionally, the difficulty in interconnection can, in certain cases, cause severe mismatches.

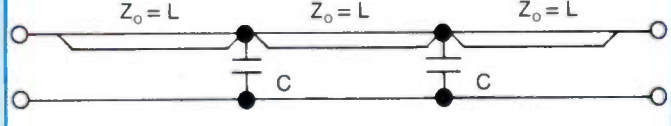
This section of the article is intended to familiarize the reader with the characteristics of transmissions lines and not to serve as a design basis for amplifiers. If this approach were used the designer would first have to calculate the lumped component values and then convert these values to transmission line equivalents, thus adding unnecessary and awkward steps to the design procedure.

These techniques are useful in designing filters and other passive circuits. For example, a five pole low pass filter:

Lumped components and transmission line circuit.



Lumped component circuit diagram.



All transmission line fitter circuit.

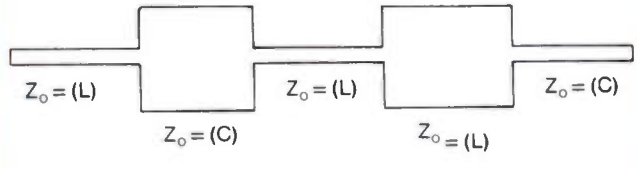


Figure 5.

What is Microstrip?

There are many types of transmission lines zip cord, coaxial cable, twisted pairs, stripline, microstripline etc. Actually, anything that conducts power from one point to another is considered transmission line and has a characteristic impedance. This characteristic impedance is based upon several factors. Among the more important are the spacing between conductors and the dielectric properties of the material between the conductors.

The most practical form of transmission line for the RF power amplifier designer is the microstripline. Figure 6 illustrates coaxial, stripline and microstripline RF transmission line. From these illustrations it is clear how microstripline evolved.

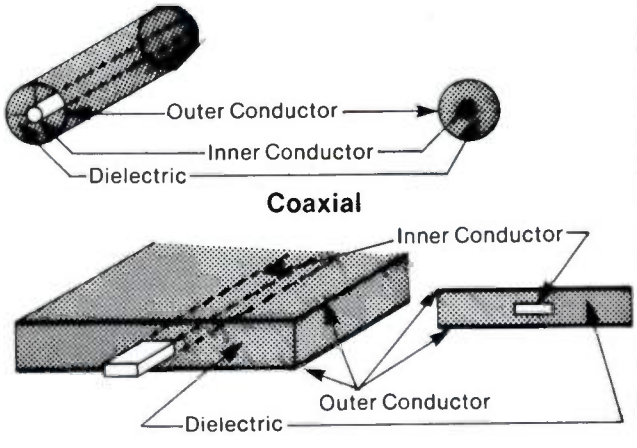


Figure 6.

Microstrip is more lossy than the coaxial and stripline counterparts because of the partial air dielectric and lack of symmetrical shielding. This is usually of little concern since the lengths used in impedance matching are relatively short. This type of transmission line is simple to fabricate and design, since it can be constructed on almost any commonly available printed circuit board materials such as G-10, FR 4, Westinghouse Super punch and Rexalite. The obvious but important consideration in selecting the material is that it be copper clad on both sides. Depending on the frequency and power level, some materials will be more suitable than others. A lower dielectric material such as Rexalite usually provides the lowest loss, but will require more real estate for a given design. No significant advantage can be seen in using this material below 600 MHz at moderate power levels (100 watts and below).

Experimentation and information from the printed circuit board materials manufacturers will provide the designer with an abundance of valuable material — characteristic data which is beyond the scope of this article.

Microstrip Transmission Line Design

To design a microstrip line for a given requirement of impedance, Z_o, and length, ℓ, we must know certain characteristics of the material. These characteristics are dielectric constant($\in$) and dielectric thickness (t). See Figure 7.

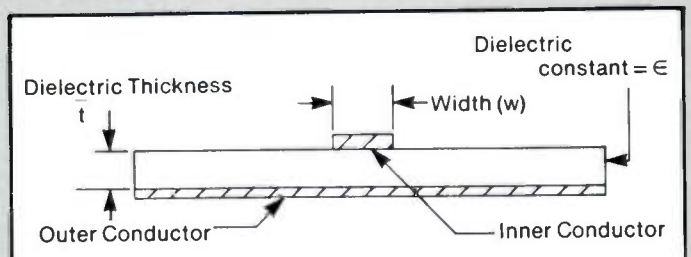


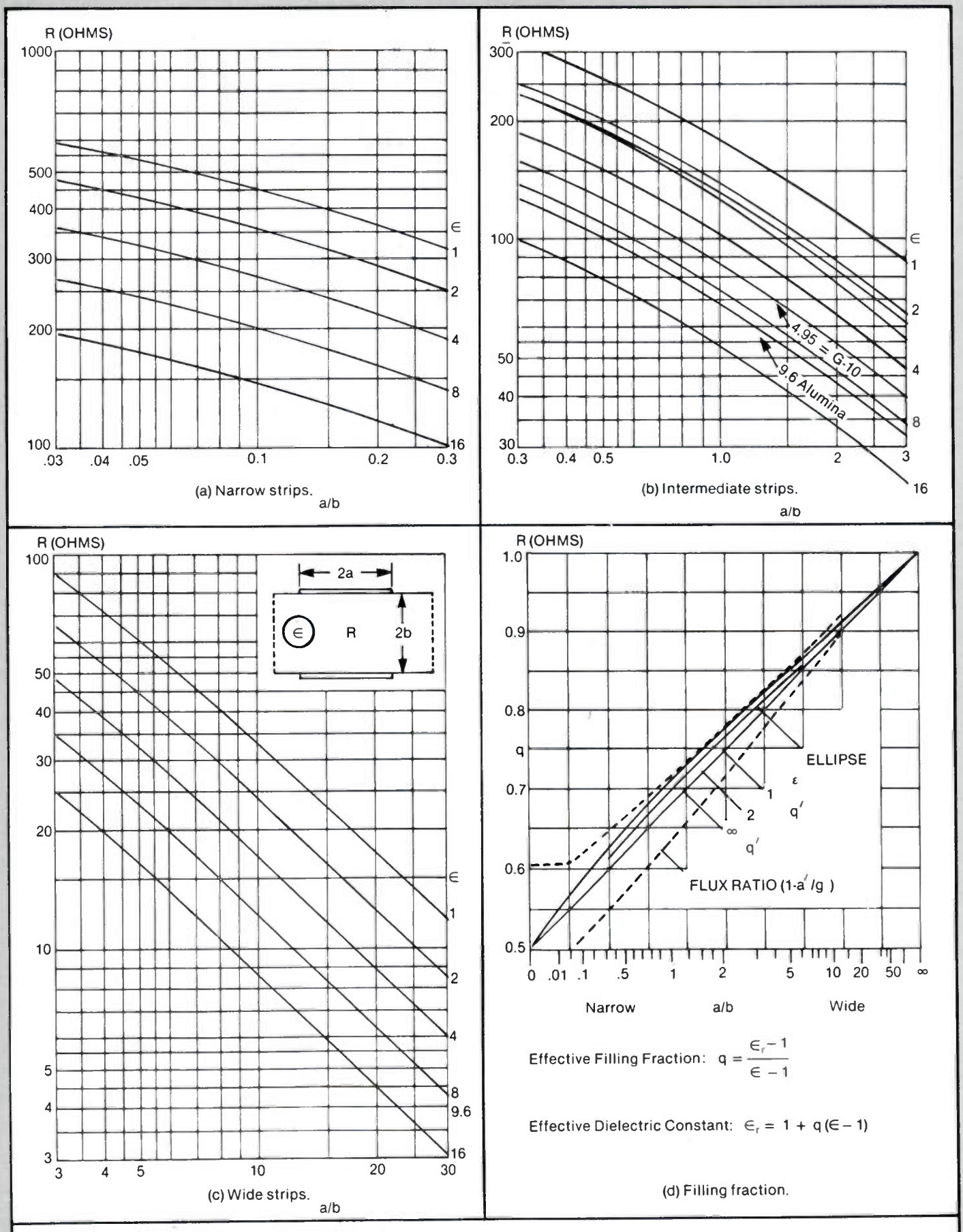
Figure 7.

Knowing the material characteristics we can then determine the physical transmission line characteristics of the width (w) for a given impedance Z_o; and the guiding wavelength, λ_g, which is the length the wavelength becomes in the material dielectric due to the lowering of the propagation velocity.

With the physical characteristics determined it is then a very simple process to transform our theoretical Smith Chart design, consisting of transmission line impedances (Z_o) in wavelengths (λ), to a practical physical design.

Actual Design Procedure

1. Organize the Data. Gather the following data.
   a. Z_o — the desired transmission line impedance.
   b. $\in$ — the dielectric constant of the material.
   c. b — the thickness of the dielectric material.
   d. λ_o — the actual wavelength of the geometric mean frequency in free space.
2. Determine the Microstripline Physical Width.
   a. Refer to chart a, b or c (pD), whichever is the most convenient.
   b. Find the intersection of $\in$ and 2 (Z_o).
   c. Record this intersection value, which is called a/b.
   d. Calculate the microstripline width (w) from the formula: width W = 2 (a/b) t (thickness of the material).
3. Determine the Guiding Wavelength.
   a. Use chart (d).
   b. Find q from chart (d) by plotting the intersection of a/b with the diagonal line.



(a) Narrow strips.

(b) Intermediate strips.

(c) Wide strips.

(d) Filling fraction.

Figure 9. IEEE Transactions On Microwave Theory And Techniques.

c. Find the relative dielectric constant ϵ_r by using in the following equation the value of q found in step b.

$$\epsilon_r = 1 + q(\epsilon - 1) \qquad (12)$$

d. Find the effective dielectric constant ϵ_r.

$$\epsilon_r' = \sqrt{\epsilon_r} \qquad (13)$$

e. Find the guiding wavelength from the following equation:

$$\lambda_g = \frac{\lambda_o}{\epsilon_r'} \qquad (14)$$

where λ_o = wavelength in free space.

A Practical Example

1. Organize Data.
   a. Z = 50 ohms
   b. ϵ = 4.95 (dielectric for g-10 fiberglass PC board).
   c. t = .0625 (the thickness of the dielectric in the G-10 board in inches).
   d. λ_o = 187 cm @ 160 MHz.
2. Determine the Microstripline Physical Width.
   a-c. (a/b) from chart (b) is found by plotting the intersection of the R = 100 ohms ($2Z_o$) and the ϵ = 4.95 curve. The value of (a/b) is equal to 0.82
   d. The microstripline width, (w) is found as follows:
   w = 2 (a/b) t (material thickness)
   w = (2) (.82) (.0625 in)
   w = 0.1025 inches
   In practice, because of manufacturers' processes and consequent changes from batch to batch in dielectric properties, I have found .125 inches to be the optimum value for 50 ohms. However, the difference in characteristic impedance is negligible between .102 and .125 inches for most applications.
3. Guiding Wavelength.
   a. Use chart (d).
   b. The intersection of (a/b), 0.82 in the example, with the diagonal line is equal to q and therefore q = 0.66
   c. $\epsilon_r = 1 + q(\epsilon - 1)$
   d. $\epsilon_r = 1 + .66(4.95 - 1) = \epsilon_r = 3.6$
   e. $\epsilon_r = \epsilon_r = 3.6$
   $\epsilon_r = 1.89$ *(Effective Dielectric Constant)*
   f. To find the guiding wavelength

$$\lambda_g = \frac{\lambda_o}{\epsilon_r'} = \frac{187\ cm}{1.89} = \boxed{98.95\ cm}$$

A Practical Application

Remember the amplifier we designed last month using the smith Chart? If you don't, refer to Figure 10 below reprinted from page 35 of the January/February issue of *r.f. design*. You will notice that Figure 10 lists the microstrip lines in wavelengths. The impedance of the lines, T_1 through T_6 are also given in the text. With the information just covered we can now complete the design of the amplifier.

Assume that this amplifier will be assembled on .0625 inch thick G-10 fiberglass printed circuit board. This PC board has a dielectric constant, ϵ = 4.95, as in the previous example.

Design Chart

Line	Impedance	Width	Smith Chart Length λ_o	Actual Length @ 160 MHz λ_g
T4	50 ohm	.125 in	.074λ	7.32 cm
T3	50 ohm	.125 in	.074λ	7.32 cm
T5	50 ohm	.125 in	.036λ	3.56 cm
T2	50 ohm	.125 in	.036λ	3.56 cm
T6	33 ohm	.230 in	.022λ	_____
T1	40 ohm	_____	.014λ	_____

We have left three blanks in the chart above. Calculate these values and see how they compare against the actual values in the next issue. At that time we will present the actual fabricated amplifier along with all the trimmings that make it a practical design. □

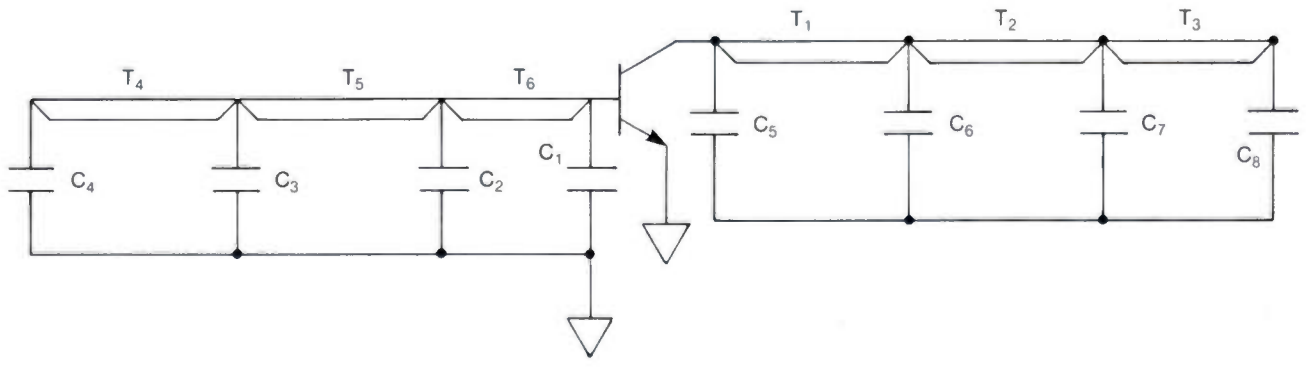
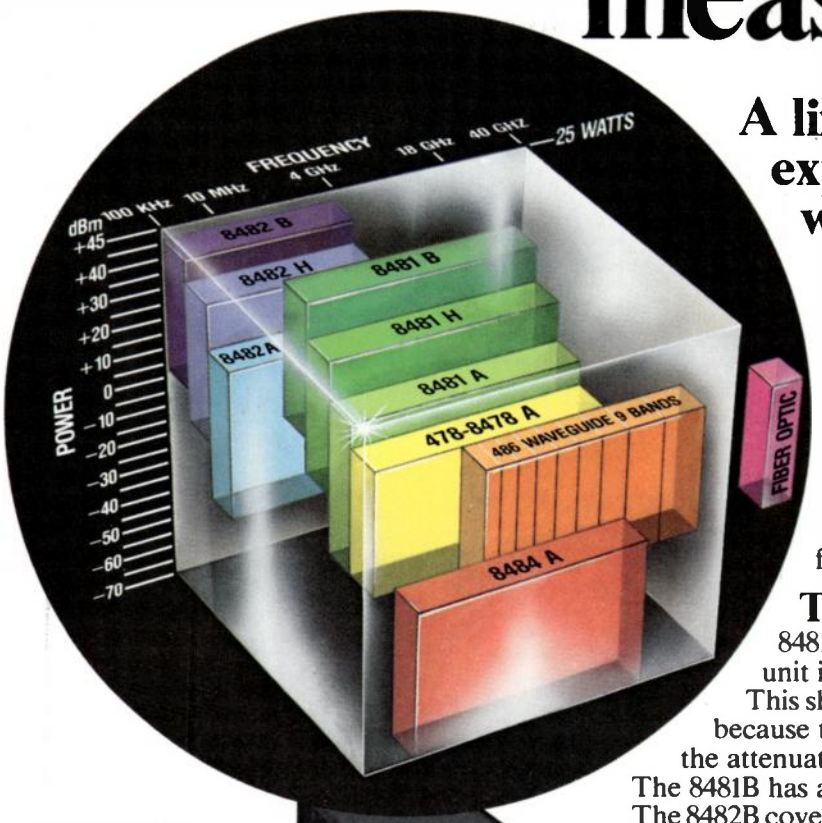


Figure 10. from January/February r.f. design.

HP's spectrum of power measurements



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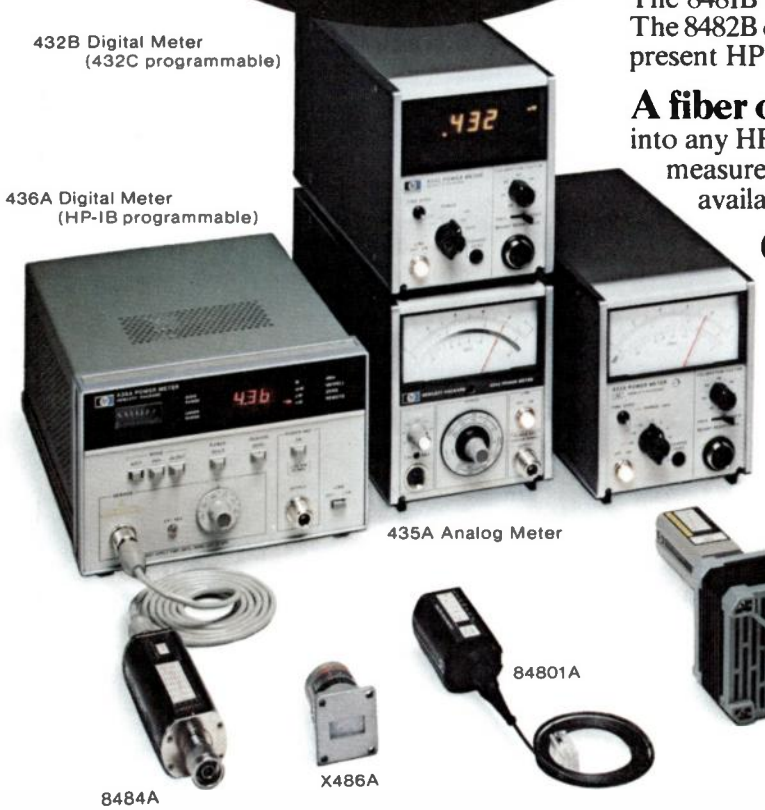

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436A Digital Meter
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435A Analog Meter

432A Analog Meter

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X486A

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A Practical 60-Watt 225-400 MHz Amplifier

This amplifier may be used singly as a 60 watt output stage in a 225-400 MHz transmitter, or by using two of these amplifiers combined with quadrature couplers, a 100 watt output amplifier stage may be constructed. Typical performance curves of gain, efficiency, and input SWR are shown in Figures 5, 6, and 7.

Circuit Design

This circuit is designed to be driven from a 50 ohm source and work into a nominal 50 ohm load. The input network consists of two microstrip L-sections composed of Z1, Z2 and C2 through C6. C1 serves as a DC blocking capacitor. A 4:1 impedance ratio coaxial transformer T1 completes the input matching network. L1 and ferrite bead serve as a base decoupling choke.

The output circuit consists of shunt inductor L2 at the collector, followed by two mirostrip L-sections composed of Z3, Z4 and C8 through C11. C12 serves as a DC blocking capacitor, and is followed by another 4:1 impedance ratio coaxial transformer.

Collector decoupling is accomplished through the use of L3, L4, C14 through C16 and R1.

Construction

The circuit is constructed on a 3.375 x 2.5 inch (8.57 x 6.35 cm) double sided PC board. Board material is 3M Glass Teflon™, with a thickness of 0.031 inch (0.0787 cm). Glass Teflon was selected for its low loss and dielectric consistency. Figure 2 is a 1:1 photomaster print of the top side of the board. Eyelets are placed at the points marked by a plus sign to carry the top ground to the bottom side ground return. The edges of the transistor mounting hole beneath the emitter leads are also wrapped, using copper foil soldered in plate to insure a solid emitter ground. Construction details of the 4:1 transformers are shown in Figure 4.

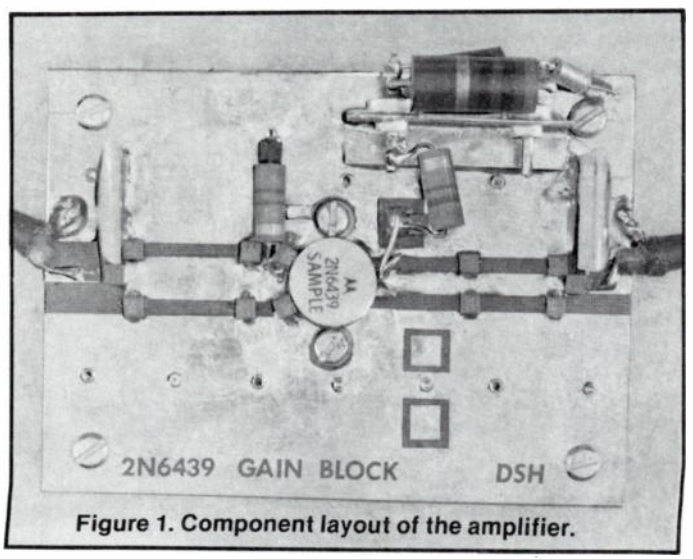


Figure 1. Component layout of the amplifier.

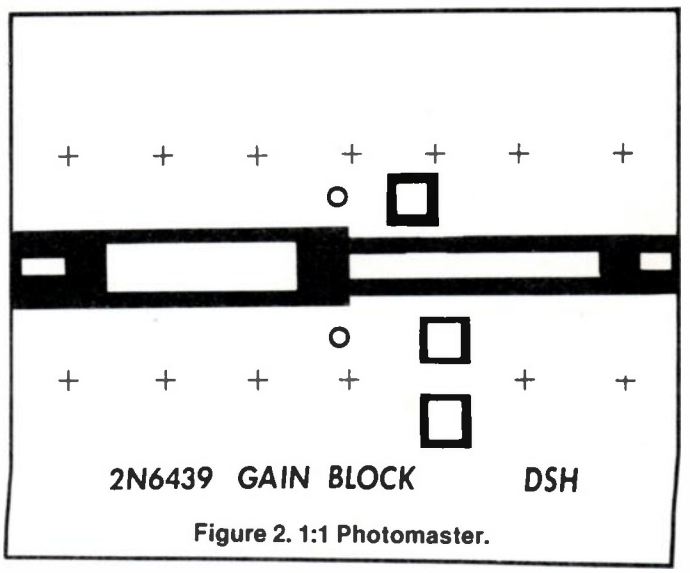
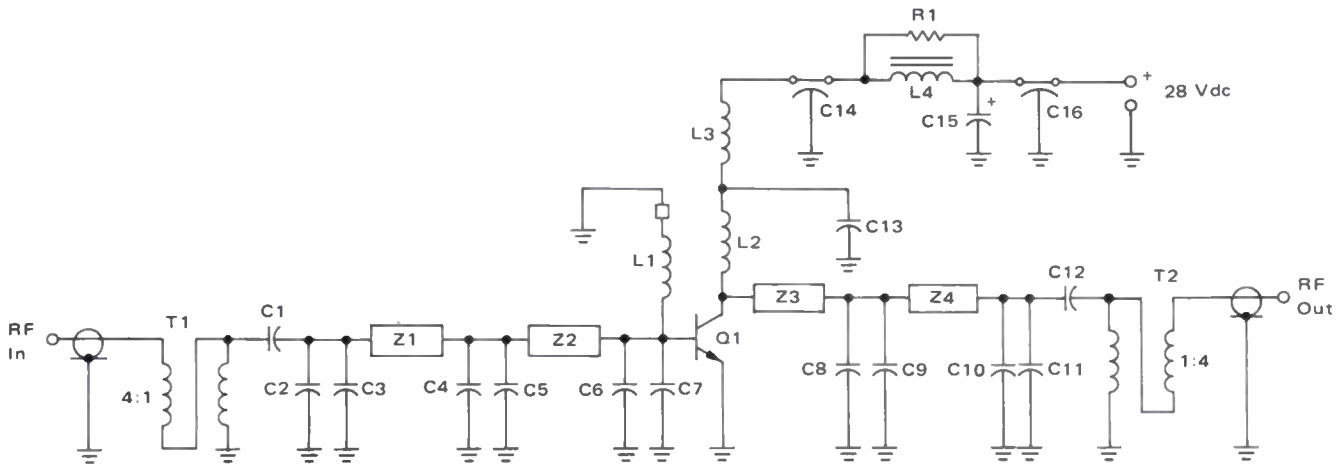


Figure 2. 1:1 Photomaster.



C1 – 63 pF Chip
C2, C8 – 27 pF Chip
C3 – 24 pF Chip
C4 – 15 pF Chip
C5, C9 – 30 pF Chip
C6, C7 – 50 pF Chip
C10 – 10 pF Chip
C11 – 5.1 pF Chip
C12 – 150 pF Chip
C13 – 270 pF Chip
C14, C16 – 680 pF Feedthru
C15 – 1.0 μF 50 V Tantalum

All Chip Capacitors are 100 mil TDK-ACI Co, Style FC282 BAG
L1 – 0.15 μH Molded Choke with Ferroxcube Bead #56-590-65/4B on ground end of coil
L2 – 1 Turn #22 AWG, 1/8" ID
L3 – 0.15 μH Molded Choke
L4 – Ferroxcube VK-200-19/4B

Q1 – 2N6439

R1 – 10 Ω 2 Watt

T1, T2 – 25 Ω Subminiature Coax (Type UT25) 2.25 inches (57.15 mm) long

Z1 – Microstrip Line
800 mils L X 225 mils W
20.32 mm L X 5.715 mm W
Z2 – Microstrip Line
200 mils L X 225 mils W
5.08 mm L X 5.715 mm W
Z3, Z4 – Microstrip Line
550 mils L X 125 mils W
13.97 mm L X 3.175 mm W

Board – 0.031" (0.787 mm) Glass Teflon ϵ_r = 2.56

Figure 3. – 2N6439 60 Watt Building Block 225-400 MHz.

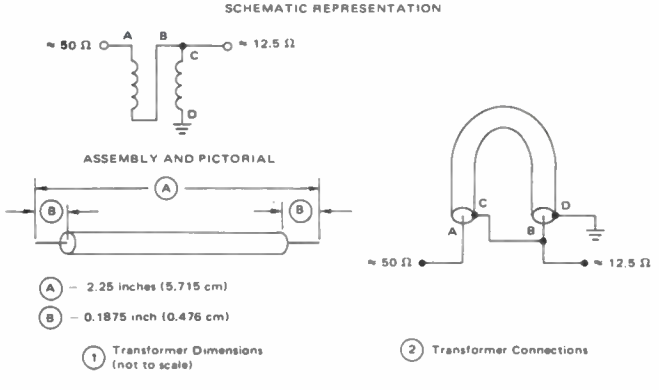


Figure 4 — Construction Details of the 4:1 Unbalanced to Unbalanced Transformers.

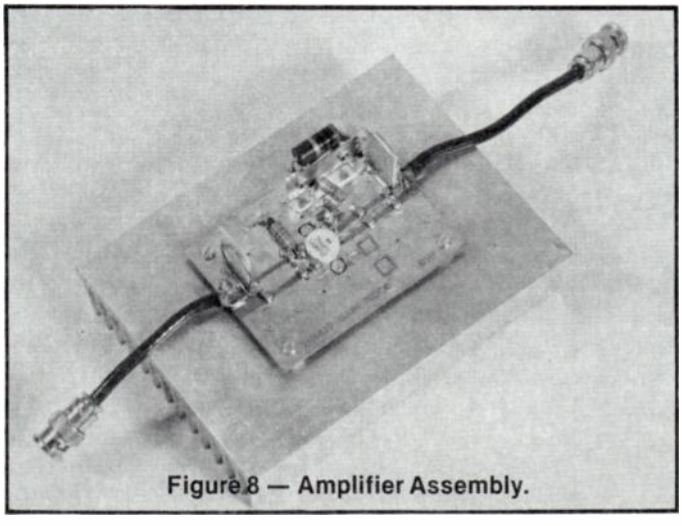


Figure 8 — Amplifier Assembly.

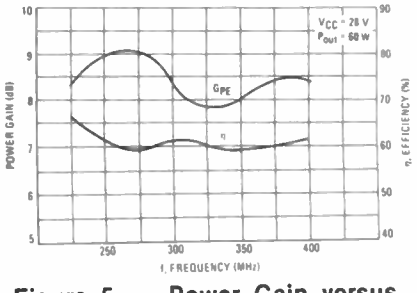


Figure 5 — Power Gain versus Frequency Efficiency versus Frequency.

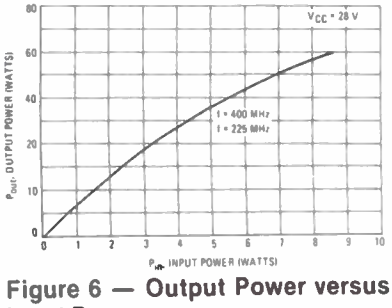


Figure 6 — Output Power versus Input Power.

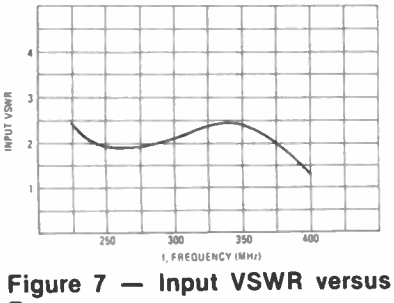


Figure 7 — Input VSWR versus Frequency.

Design With PIN Diodes, Part I

The PIN diode finds wide usage in RF, UHF and microwave circuits. It is fundamentally a device whose impedance, at these frequencies, is controlled by its DC excitation. A unique feature of the PIN diode is its ability to control large amounts of RF power with much lower levels of DC.

Gerald Hiller
Unitrode Corporation
Watertown, Mass.

PIN Diode Modeling

The PIN diode is a current controlled resistor at radio and microwave frequencies. It is a silicon semiconductor diode in which a high resistivity intrinsic I-region is sandwiched between a P-type and N-type region. When the PIN diode is forward biased, holes and electrons are injected into the I-region. These charges do not immediately annihilate each other; instead they stay alive for an average time called the carrier lifetime, τ. This results in an average stored charge, Q, which lowers the effective resistance of the I-region to a value, R_S.

When the PIN diode is at zero or reverse bias there is no stored charge in the I-region and the diode appears as a capacitor, C_T, shunted by a parallel resistance R_P.

PIN diodes are specified for the following parameters:

R_S — series resistance under forward bias
C_T — total capacitance at zero or reverse bias
R_P — parallel resistance at zero or reverse bias
V_R — maximum allowable DC reverse bias voltage
τ — carrier lifetime
θ_{AVE} — average thermal resistance

P_D — maximum average power dissipation
θ_{pulse} — pulse thermal impedance

P_P — maximum peak power dissipation

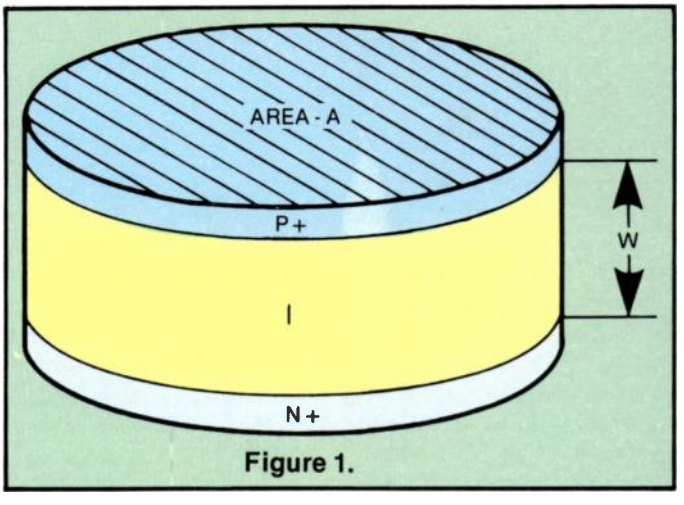


Figure 1.

By varying the I-region width and diode area it is possible to construct PIN diodes of different geometrics to result in the same R_S and C_T characteristic. These devices may have similar small signal characteristics. However, the thicker I-region diode would have a higher bulk or RF breakdown voltage and better distortion properties. On the other hand, the thinner device would have faster switching speed.

There is a common misconception that carrier lifetime, τ, is the only parameter that determines the lowest frequency of operation and the distortion produced. This is indeed a factor, but equally important is the thickness of the I-region, W, which relates to the transmit time frequency of the PIN diode.

Low Frequency Model

At low frequencies (below the transmit time frequency of the I-region) and DC the PIN diode behaves like a silicon PN junction semiconductor diode. Its I-V characteristic determines the DC voltage at the forward bias current level. PIN diodes often are rated for the forward voltage, V_F, at a fixed DC bias.

The reverse voltage ratings on a PIN diode, V_R, are a guarantee from the manufacturer that no more than a specified amount, generally 10μA, of reverse current will flow when V_R is applied. It is not necessarily the avalanche or bulk breakdown voltage, V_B, which is determined by the I-region width (approximately 10V/μm). PIN diodes of the same bulk breakdown voltage may have different voltage ratings. Generally, the lower the voltage rating the less expensive the PIN diode.

Large Signal Model

When the PIN diode is forward biased the stored charge, Q, must be much greater than the incremental stored charge added or removed by the RF current, I_{RF}. To insure this the following inequality must hold:

$$Q >> \frac{I_{RF}}{2\pi f}$$

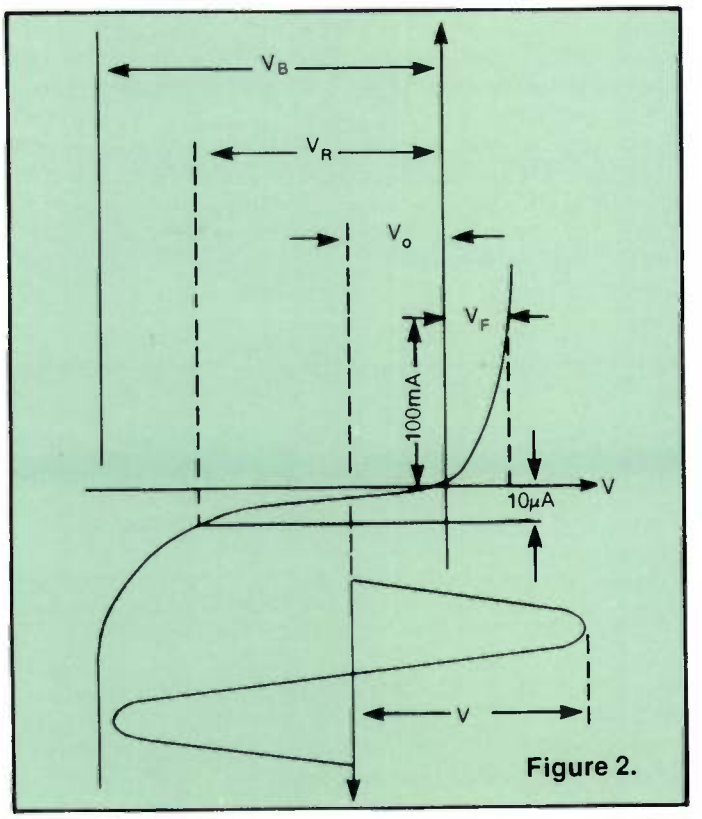


Figure 2.

RF Electrical Modeling of PIN Diode

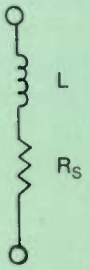
Forward Bias Model

$$R_S = \frac{W^2}{(\mu_n + \mu_p)\,Q} \quad (ohms)$$

Where

$Q = I_F \times \tau$ *(couls)*

W = I-region width
I_F = forward bias current
τ = carrier lifetime
μ_n = electron mobility
μ_P = hole mobility



Notes:

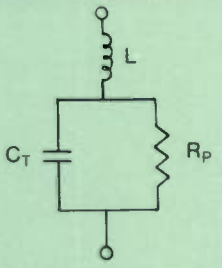
1. In a practical diode the parasitic resistance of the diode package and contact limit the lowest resistance value.
2. The lowest impedance will be affected by the parasitic inductance, L, which is generally less than 1 nHy.
3. The equation is valid at frequencies higher than the I-region transmit time frequency, i.e.,

$$f > \frac{1300}{W^2}$$ *(where frequency is in MHz and W² in μm).*

4. The equation assumes that the RF signal does not affect the stored charge.

Zero or Reverse Bias Model

$$C_T = \frac{\varepsilon A}{W}$$



Where

ε = dielectric constant of silicon
A = area of diode junction

Notes:

1. The above equation is valid at frequencies above the dielectric relaxation frequency of the I-region, i.e.

$$f > \frac{1}{2\pi_\rho \varepsilon}$$ *(where ρ is the resistivity of the I-region). At lower frequencies the PIN diode acts like a varactor.*

2. The value R_P is proportional to voltage and inversely proportional to frequency. In most RF applications its value is higher than the reactance of the capacitance, C_T, and is less significant.

Under reverse bias the diode should not be biased beyond its DC voltage rating, V_R. The avalanche or bulk breakdown voltage, V_B, of a PIN diode is proportional to the I-region width, W, and is always higher than V_R. In a typical application maximum negative voltage swing should never exceed V_B. An instantaneous excursion of the RF signal into the positive bias direction generally does not cause the diode to go into conduction because of the slow reverse to forward switching speed, T_{RF}, of the PIN diode. Refer to Figure 2.

Switching Speed Model

The switching speed in any application depends on the driver circuit as well as the PIN diode. The primary PIN properties that influence switching speed may be explained as follows:

A PIN diode has two switching speeds: from forward bias to reverse bias, T_{FR}, and from reverse bias to forward bias, T_{RF}. The diode characteristic that affects T_{FR} is τ, carrier lifetime. The value of T_{FR} may be computed from the forward current, I_F, and the initial reverse current I_R, as follows:

$$T_{FR} = log_e(1 + \frac{I_F}{I_R})\,\pi \qquad (Secs)$$

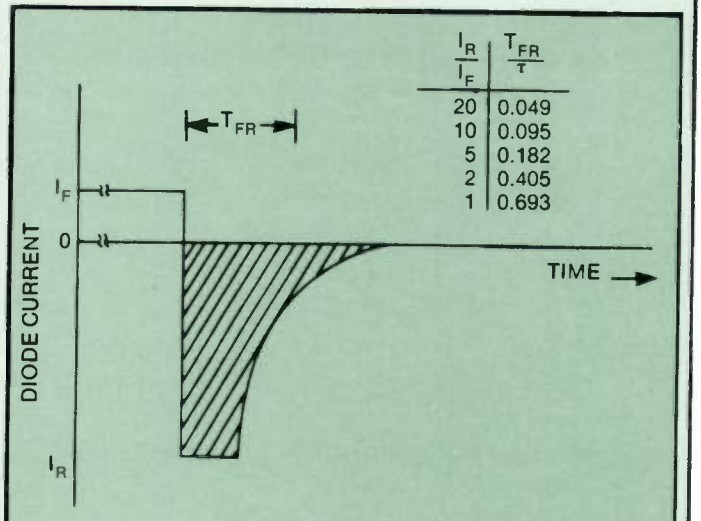


Figure 3.

T_{RF} depends primarily on I-region width, W, as indicated in the following chart which shows typical data:

I-Width μm	To 10mA from 10V	100V	To 50mA from 10V	100V	To 100mA from 10V	100V
175	7.0μS	5.0μS	3.0μS	2.5μS	2.0μS	1.5μS
100	2.5μS	2.0μS	1.0μS	0.8μS	0.6μS	0.6μS
50	0.5μS	0.4μS	0.3μS	0.2μS	0.2μS	0.1μS

Thermal Model

The maximum allowable power dissipation, P_D, is determined by the following equation:

$$P_D = \frac{T_J - T_A}{\theta} \qquad Watts$$

where T_J is the maximum allowable junction temperature (usually 175°C) and T_A is the ambient or heat sink temperature. Power dissipation may be computed as the product of the RF current squared multiplied by the diode resistance, R_S.

For CW applications the value of thermal resistance, θ, used is the average thermal resistance, θ_{AV}.

In most pulsed RF and microwave applications where the duty factor, DF, is less than 10 percent and the pulse width, t_p, is less than the thermal time constant of the diode, good approximation of the effective value of θ in the above equation may be computed as follows:

$$\theta = DF \times \theta_{AV} + \theta_{tp} \qquad °C/W$$

Where θ_{tp} is the thermal impedance of the diode for the time interval corresponding to t_p.

The following diagram indicates how junction temperature is affected during a pulsed RF application.

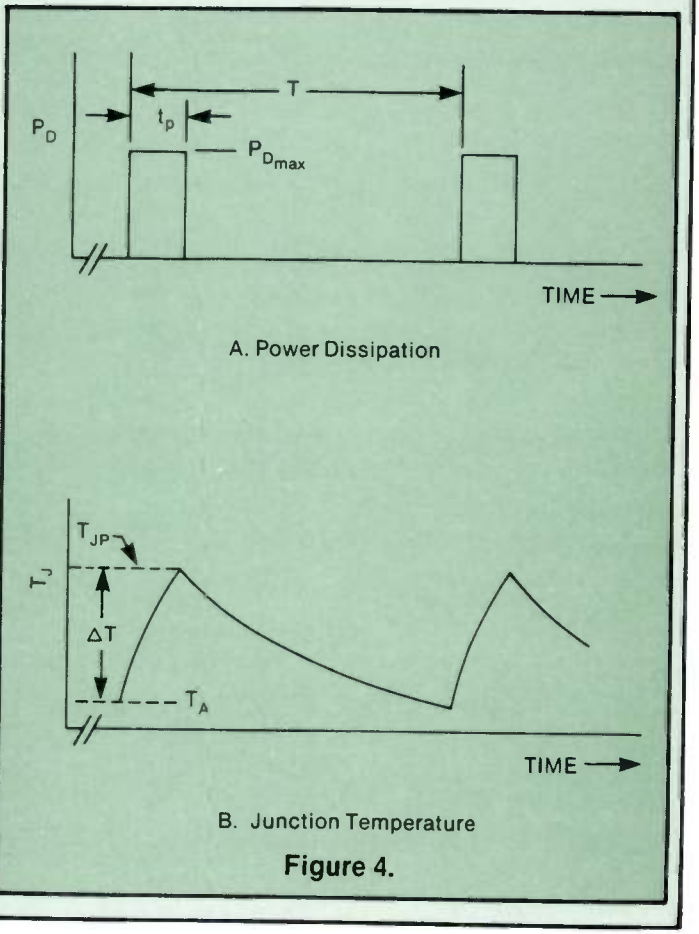


Figure 4.

PIN Diode Applications

Switches

PIN diodes are commonly used as a switching element to control RF signals. In these applications, the PIN diode can be biased to either a high or low impedance device state, depending on the level of stored charge in the I-region.

A simple untuned single-pole, single-throw (SPST) switch may be designed using either a single series or shunt connected PIN diode as shown in Figure 5. The series connected diode switch is commonly used when minimum insertion loss is required over a broad frequency range. This design is also easier to physically realize using printed circuit techniques, since no through holes are required in the circuit board.

A single shunt mounted diode will, on the other hand produce higher isolation values across a wider frequency range and will result in a design capable of handling more power since it is easier to heat sink the diode.

Multi-throw switches are more frequently used than single-throw switches. A simple multi-throw switch may be designed employing a series PIN diode in each arm adjacent to the common port. Improved performance is obtained by using "compound switches," which are combinations of series and shunt connected PIN diodes, in each arm.

For narrow-band applications, quarter-wave spaced multiple diodes may also be used in various switch designs to obtain improved operation. In the following section, we shall discuss each of these types of switches in detail and present design information for selecting PIN diodes and predicting circuit performance.

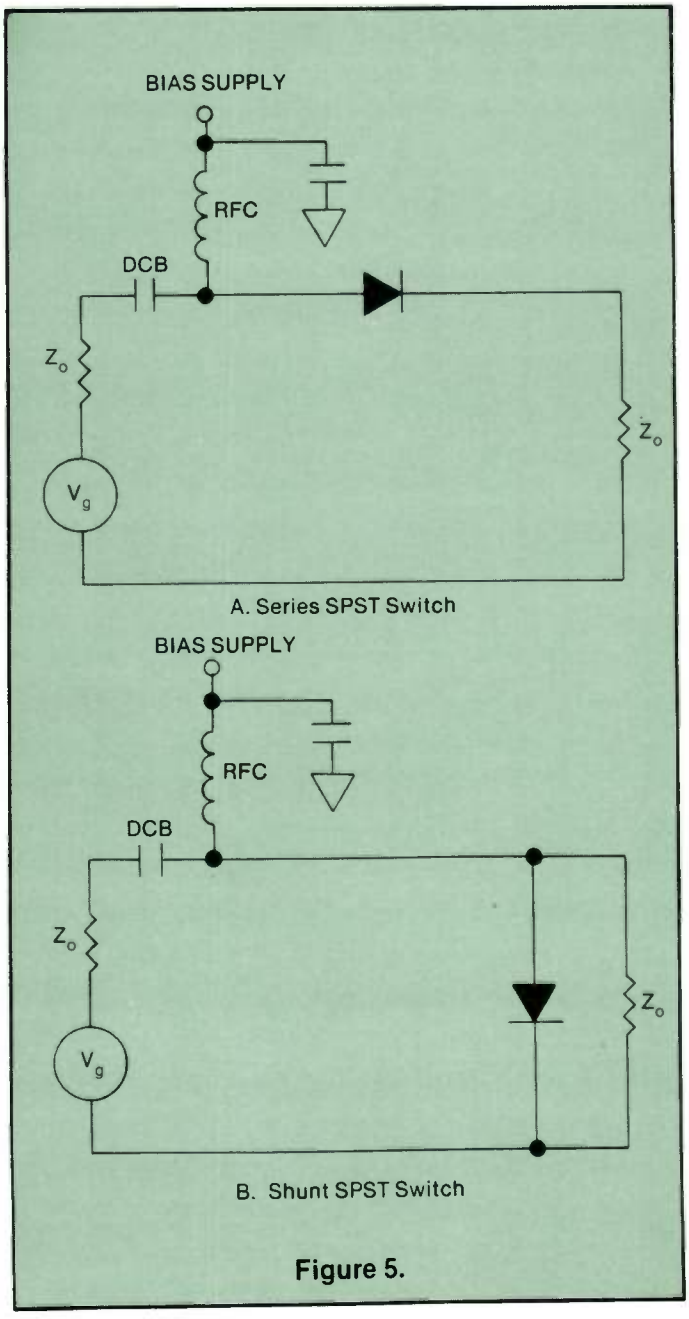


Figure 5.

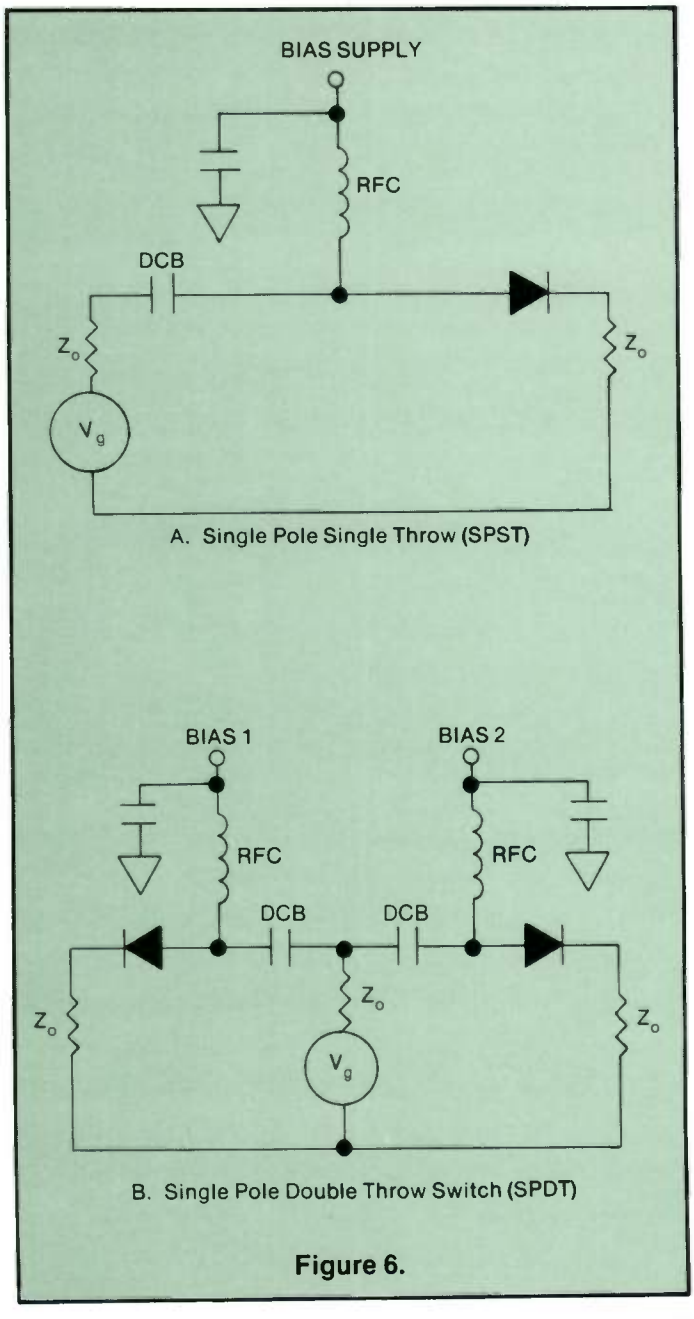


Figure 6.

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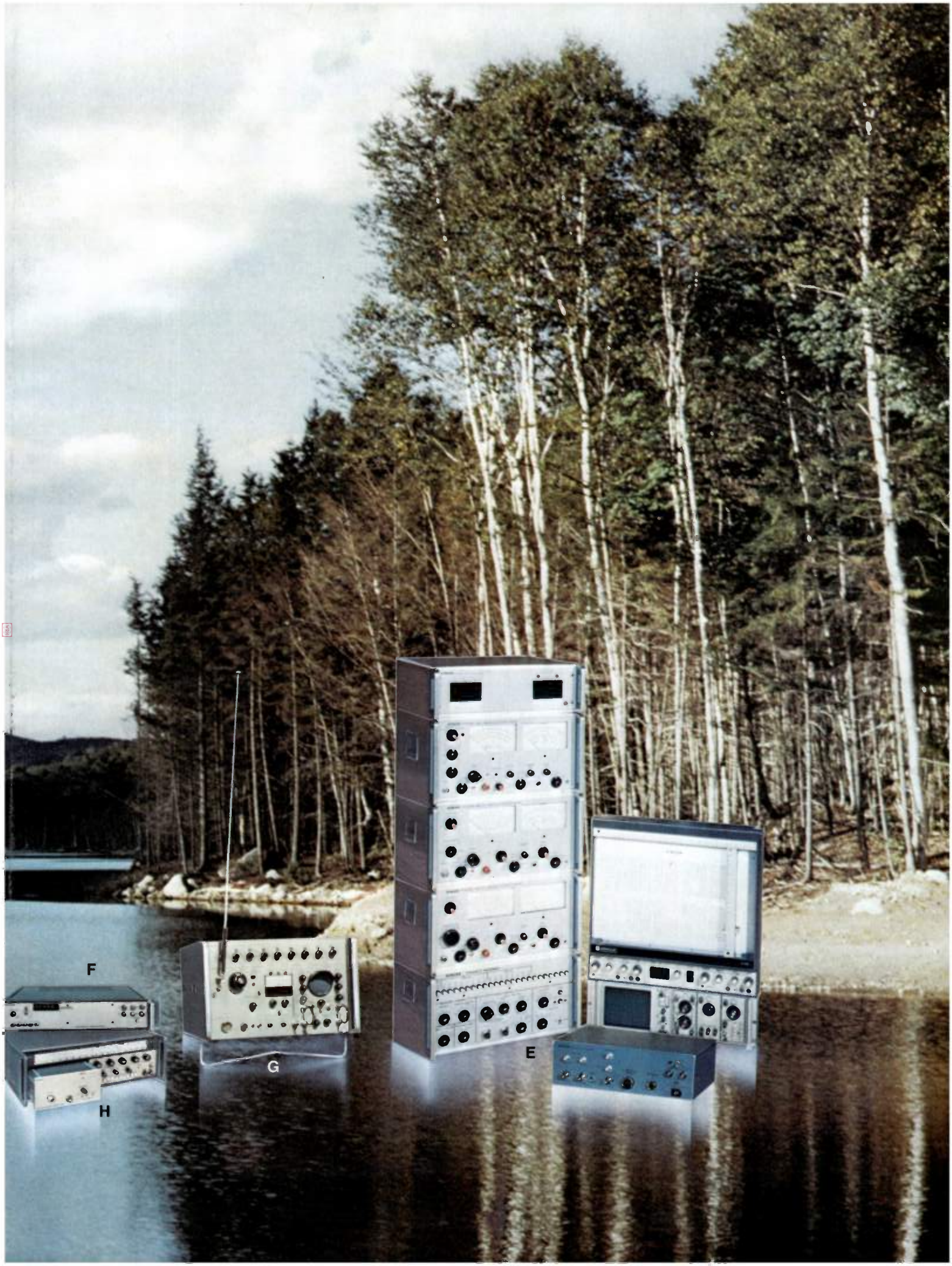
F
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E

Series Connected Switch

Figure 6 shows two basic types of PIN diode series switches, (SPST and SPDT), commonly used in broadband designs. In both cases, the diode is in a "pass power" condition when it is forward biased and presents a low forward resistance, R_S, between the RF generator and load. For the "stop power" condition, the diode is at zero or reverse bias so that it presents a high impedance between the source and load. In series connected switches, the maximum isolation obtainable depends primarily on the capacitance of the PIN diode, while the insertion loss and power dissipation are functions of the diode resistance. The principal operating parameters of a series switch may be obtained using the following equations:

- INSERTION LOSS (Series Switch)

$$IL = 20 \log_{10}[1 + R_S/Z_o] \quad dB \quad (1)$$

This equation applies for a SPST switch and is graphically presented in Figure 7 for a 50 ohm impedance design. For multi-throw switches, the insertion loss is slightly higher due to any mismatch caused by the capacitance of the PIN diodes in the "off" arms. This additional insertion loss can be determined from Figure 10 after first computing the total shunt capacitance of all "off" arms of the multi-throw switch.

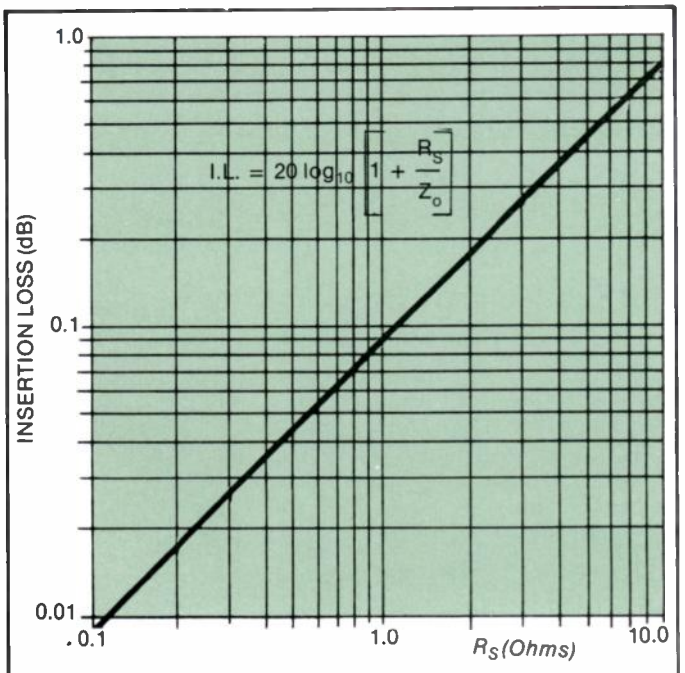


Figure 7.
Insertion loss for PIN Diode series switch in 50Ω system.

- ISOLATION (Series Switch)

$$I = 10 \log_{10}[1 + (4\pi f C Z_o)^{-2}] \quad dB \quad (2)$$

This equation applies for a SPST diode switch. Add 6 dB for a SPNT switch to account for the 50 percent voltage reduction across the "off" diode due to the termination of the generator in its characteristic impedance. Figure 8 graphically presents isolation as a function of capacitance for simple series switches. These curves are plotted for circuits terminated in 50 ohm loads.

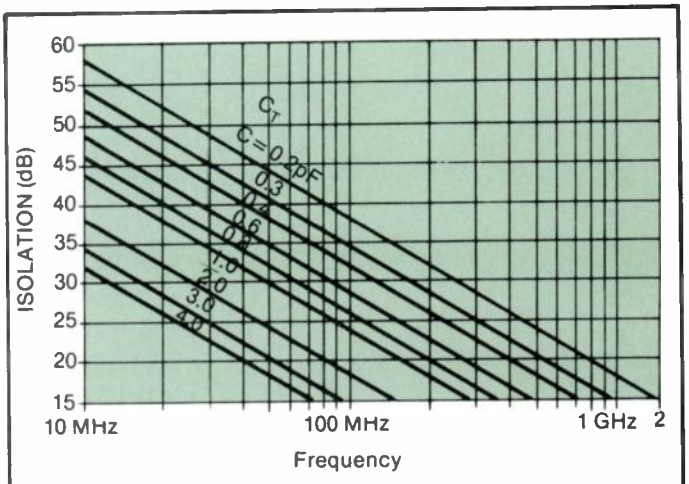


Figure 8.
Isolation for SPST Diode series switch in 50Ω system. Add 6 dB to isolation for multi throw switches (SPNT).

- POWER DISSIPATION (Series Switch in Forward Bias)

$$P_D = \frac{4 R_S Z_o}{(2 Z_o + R_S)^2} \cdot P_{AV} \quad [watts] \quad (3)$$

For $Z_o >> R_S$, this becomes:

$$P_D \approx \frac{R_S}{Z_o} \cdot P_{AV} \quad [watts] \quad (4)$$

where the maximum available power is given by:

$$P_{AV} = \frac{V_g^2}{4 Z_o} \quad [watts] \quad (5)$$

It should be noted that Equations 3 and 4 apply only for perfectly matched switches. For SWR (σ) values other than unity, multiply these equations by $[2\sigma / (\sigma + 1)]^2$ to obtain the maximum required diode power dissipation rating.

- PEAK RF CURRENT (Series Switch)

$$I_P = \sqrt{\frac{2 P_{AV}}{Z_o}} \cdot \left(\frac{2\sigma}{\sigma + 1}\right) \quad [amps] \quad (6)$$

In the case of a 50 ohm system, this reduces to:

$$I_P = \frac{\sqrt{P_{AV}}}{5}\left(\frac{2\sigma}{\sigma + 1}\right) \quad [amps] \quad (7)$$

- PEAK RF VOLTAGE (Series Switch)

$$V_P = \sqrt{8 Z_o P_{AV}}; \quad [volts] \quad (SPST)$$

$$V_P = \sqrt{2 Z_o P_{AV}}\left(\frac{2\sigma}{\sigma + 1}\right) \quad [volts] \quad (SPNT) \ (8)$$

For a 50 ohm system, this becomes:

$$V_P = 20\sqrt{P_{AV}} \quad [volts] \quad (SPST)$$

$$V_P = 10\sqrt{P_{AV}}\left(\frac{2\sigma}{\sigma + 1}\right) \quad [volts] \quad (SPNT) \ (9)$$

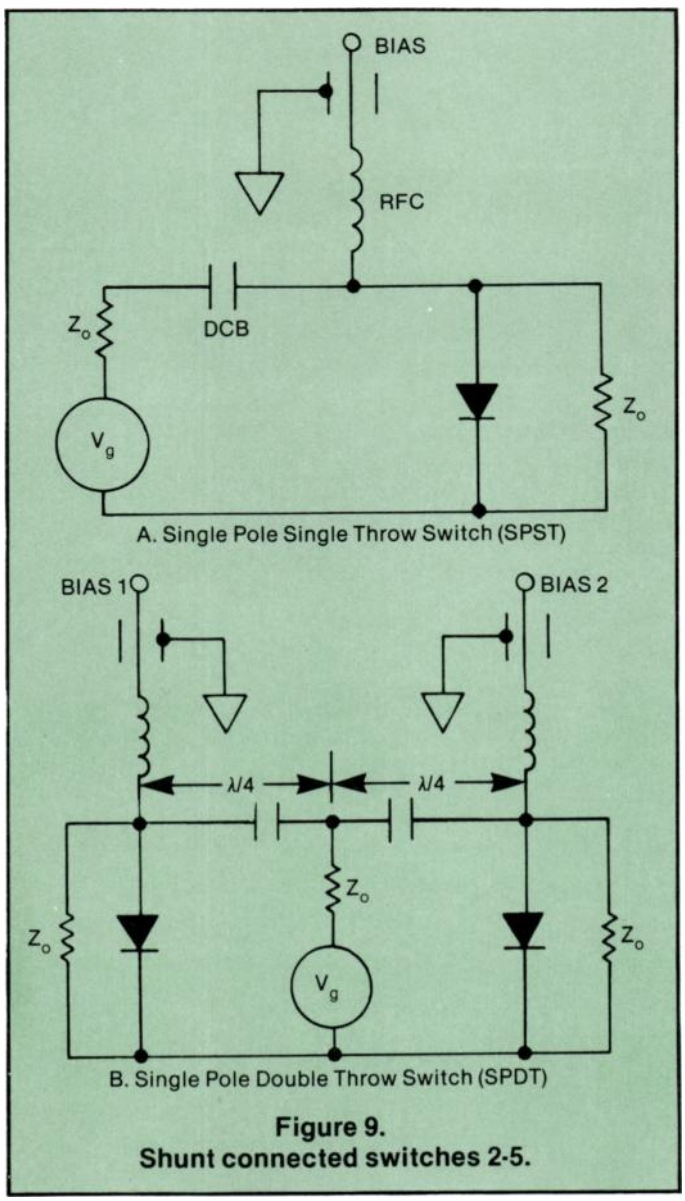


Figure 9.
Shunt connected switches 2-5.

Shunt Connected Switch

Figure 9 shows two typical shunt connected PIN diode switches. These shunt diode switches offer high isolation for many applications and since the diode may be heat sinked at one electrode, it is capable of handling more RF power than a diode in a series type switch.

In shunt switch designs, the isolation and power dissipation are functions of the diode's forward resistance, whereas the insertion loss is primarily dependent on the capacitance of the PIN diode. The principal equations describing the operating parameters of shunt switches are given by:

- INSERTION LOSS (Shunt Switch)

$$IL = 10 \log_{10}[1 + (\pi f C_T Z_o)^2] \quad [dB] \quad (10)$$

This equation applies for both SPST and SPNT shunt switches and is graphically presented in Figure 10 for a 50 ohm load impedance design.

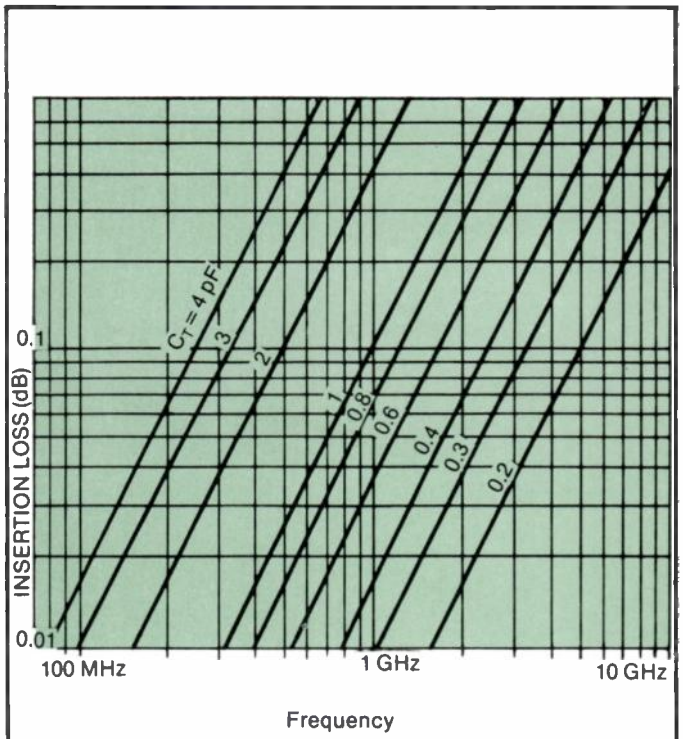


Figure 10.
Insertion loss for shunt PIN switch in 50Ω system.

- ISOLATION (Shunt Switch)

$$I = 20 \log_{10}\left[1 + \frac{Z_o}{2 R_S}\right] \quad [dB] \quad (11)$$

This equation, which is illustrated in Figure 11, applies for a SPST shunt switch. Add 6 dB to these values to obtain the correct isolation for a multi-throw switch.

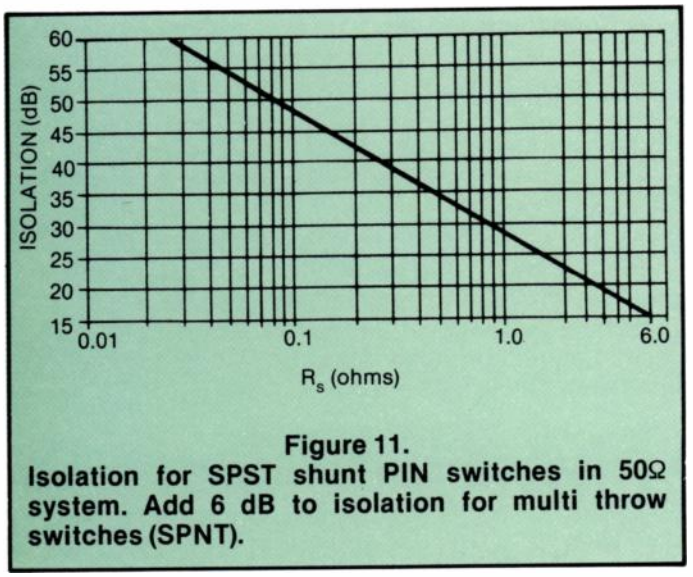


Figure 11.
Isolation for SPST shunt PIN switches in 50Ω system. Add 6 dB to isolation for multi throw switches (SPNT).

● POWER DISSIPATION (Shunt Switch in Forward Bias)

$$P_D = \frac{4 R_S Z_o}{(Z_o + 2 R_s)^2} \cdot P_{AV} \qquad \text{[watts]} \qquad (12)$$

For $Z_o >> R_S$, this becomes:

$$P_D \approx \frac{4 R_S}{Z_o} \cdot P_{AV} \qquad \text{[watts]} \qquad (13)$$

where the maximum available power is given by:

$$P_{AV} = \frac{V_g^2}{4 Z_o} \qquad (14)$$

● POWER DISSIPATION (Shunt Switch in Reverse Bias)

$$P_D = \frac{Z_o}{R_P} P_{AV} \qquad \text{[watts]} \qquad (15)$$

where R_P is the reverse biased diode's parallel resistance.

● PEAK RF CURRENT (Shunt Switch)

$$I_P = \sqrt{\frac{8 P_{AV}}{Z_o}} \qquad \text{[amps]} \quad \text{(SPST)}$$

$$I_P = \sqrt{\frac{2 P_{AV}}{Z_o}} \left(\frac{2\sigma}{\sigma + 1}\right) \qquad \text{[amps]} \quad \text{SPNT (16)}$$

For a 50 ohm system, this becomes:

$$I_P = 0.4 \sqrt{P_{AV}} \qquad \text{[amps]} \quad \text{(SPST)}$$

$$I_P = 0.2 \sqrt{P_{AV}} \left(\frac{2\sigma}{\sigma + 1}\right) \qquad \text{[amps]} \quad \text{(SPNT) (17)}$$

- PEAK RF VOLTAGE (Shunt Switch)

$$V_P = \sqrt{2 Z_o P_{AV}} \left(\frac{2\sigma}{\sigma + 1}\right) \quad [volts] \quad (18)$$

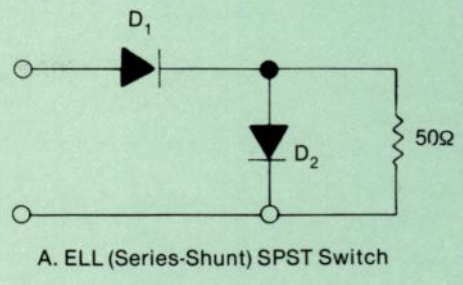
In the case of a 50 ohm system, this reduces to:

$$V_P = 10 \sqrt{P_{AV}} \left(\frac{2\sigma}{\sigma + 1}\right) \quad [volts] \quad (19)$$

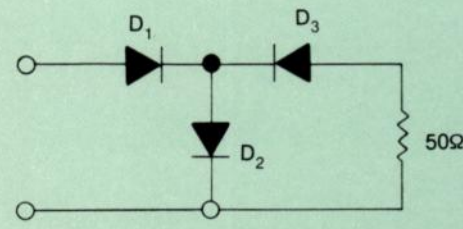
Compound and Tuned Switches

In practice, it is usually difficult to achieve more than 40 dB isolation using a single PIN diode, either in shunt or series, at RF and higher frequencies. The causes of this limitation are generally radiation effects in the transmission medium and inadequate shielding. To overcome this there are switch designs that employ combinations of series and shunt diodes (compound switches) and switches that employ resonant structures (tuned switches) affecting improved isolation performance.

The two most common compound switch configurations are PIN diodes mounted in either ELL (series-shunt) or TEE designs as shown in Figure 12. In the insertion loss state for a compound switch the series diode is forward biased and the shunt diode is at zero or reverse bias. The reverse is true for the isolation state. This adds some complexity to the bias circuitry in comparison to simple switches. A summary of formulas used for calculating insertion loss and isolation for compound and simple switches is given in Figure 13.



A. ELL (Series-Shunt) SPST Switch

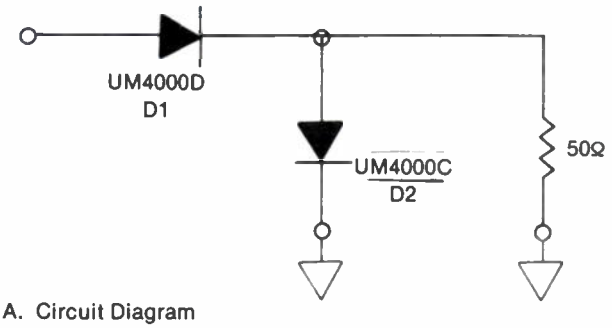


B. TEE SPST Switch

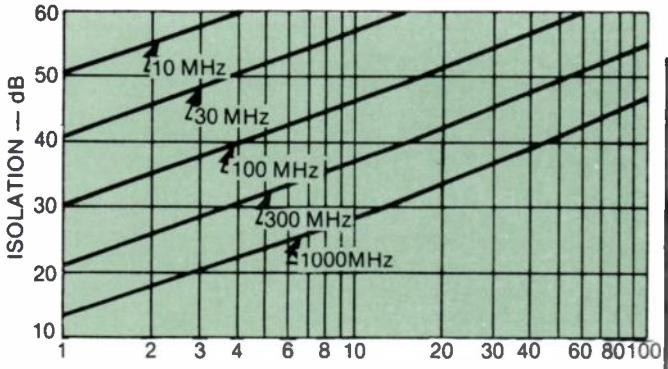
Figure 12. Compound Switches

Figure 13. Summary of Formulas for SPST Switches.
(Add 6 dB to isolation to obtain value for single-pole multiple throw switch.)

TYPE	ISOLATION (dB)	INSERTION LOSS (dB)
SERIES	$10 \log_{10} \left[1 + \left(\frac{X_C}{2Z_o} \right)^2 \right]$	$20 \log_{10} \left[1 + \frac{R_S}{2Z_o} \right]$
SHUNT	$20 \log_{10} \left[1 + \frac{Z_o}{2R_S} \right]$	$10 \log_{10} \left[1 + \left(\frac{Z_o}{2X_C} \right)^2 \right]$
SERIES-SHUNT	$10 \log_{10} \left[\left(1 + \frac{Z_o}{2R_S} \right)^2 + \left(\frac{X_C}{2Z_o} \right)^2 \left(1 + \frac{Z_o}{R_S} \right)^2 \right]$	$10 \log_{10} \left[\left(1 + \frac{R_S}{2Z_o} \right)^2 + \left(\frac{Z_o + R_S}{2X_C} \right)^2 \right]$
TEE	$10 \log_{10} \left[1 + \left(\frac{X_C}{Z_o} \right)^2 \right] + 10 \log_{10} \left[\left(1 + \frac{Z_o}{2R_S} \right)^2 + \left(\frac{X_C}{2R_S} \right)^2 \right]$	$20 \log_{10} \left[1 + \frac{R_S}{Z_o} \right] + 10 \log_{10} \left[1 + \left(\frac{Z_o + R_S}{2X_C} \right)^2 \right]$

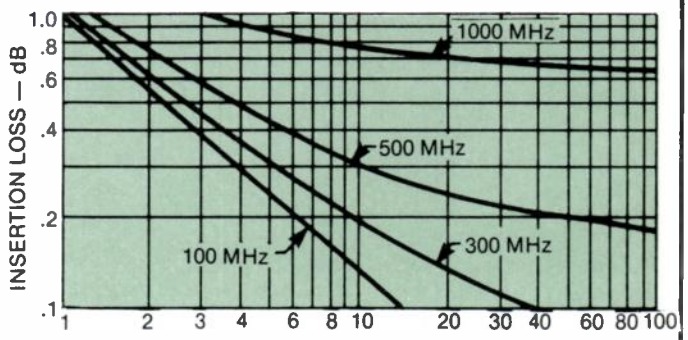


A. Circuit Diagram



B. Isolation

Bias Current in D2 -mA (D1 Reverse Biased)
Note: Add 6 dB for SPNT Switch



C. Insertion Loss

Bias Current in D1-mA (D2 Reverse Biased)

Figure 14. Series Shunt Switch

Figure 14 shows the performance of an ELL type switch utilizing Unitrode UM4000 series diodes. These diodes are rated at 0.3pf, maximum capacitance, and 0.5Ω, R_S maximum at 100 mA. In comparison, a simple series connected using the same diode switch would have similar insertion loss to the < 100 MHz contour and the isolation would be 15 dB maximum at 100 MHz, falling off at the rate of 6 dB per octave.

A tuned switch may be constructed by spacing two series diodes or two shunt diodes a quarter wavelength apart as shown in Figure 15. The resulting value of isolation in the tuned switch is twice that obtainable in a single diode switch. The insertion loss of the tuned series switch is higher

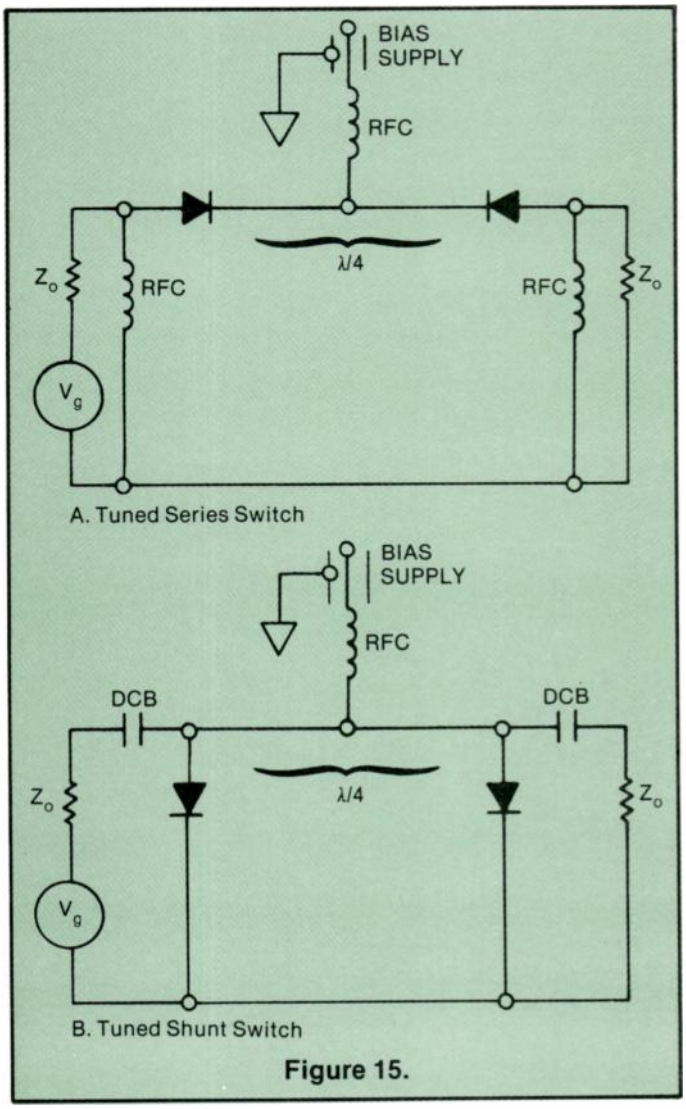


Figure 15.

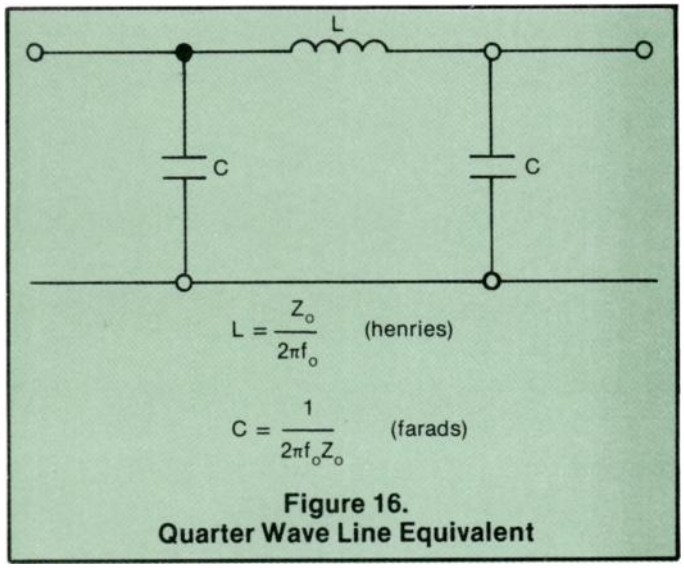


Figure 16.
Quarter Wave Line Equivalent

than that of the simple series switch and may be computed using the sum of the diode resistance as the R_S value in equation 1. In the tuned shunt switch the insertion loss may even be lower than in a simple shunt switch because of a resonant effect of the spaced diode capacitances.

Quarter-wave spacing need not be limited to frequencies where the wavelength is short enough to install a discrete length of line. There is a lumped circuit equivalent which simulates the quarter-wave section and may be used in RF band. This is shown in Figure 16. These tuned circuit techniques are effective in applications having bandwidths on the order of 10 percent of the center frequency.

Transmit-Receive Switches

There is a class of switches used in transceiver applications whose function is to connect the antenna to the transmitter (exciter) in the transmit state and to the receiver during the receiver state. When PIN diodes are used as elements in these switches they offer higher reliability, better mechanical ruggedness and faster switching speed than electro-mechanical designs.

The basic circuit for an electronic switch consists of a PIN diode connected in series with the transmitter, and a shunt diode connected a quarter wavelength (λ/4) away from the antenna in the direction of the receiver section.

Lumped elements can be used to simulate the λ/4 section (Figure 16) and, of course, are preferable for transceivers that operate at long wavelengths.

When switched into the transmit state each diode becomes forward biased. The series diode appears as a low impedance to the signal heading toward the antenna, and the shunt diode effectively shorts the receiver's antenna terminals to prevent overloading. Transmitter insertion loss and receiver isolation depend on the diode resistance, R_S. If the diode R_S is 1Ω greater than 30 dB isolation and less than 0.2 dB insertion, loss can be expected. This performance is achievable over a 10 percent bandwidth.

In the receive condition, the diodes are at zero or reverse bias and present essentially a low capacitance, C_T, which creates a direct low-insertion-loss path between the antenna and receiver. The off-transmitter is isolated from this path by the high impedance series diode.

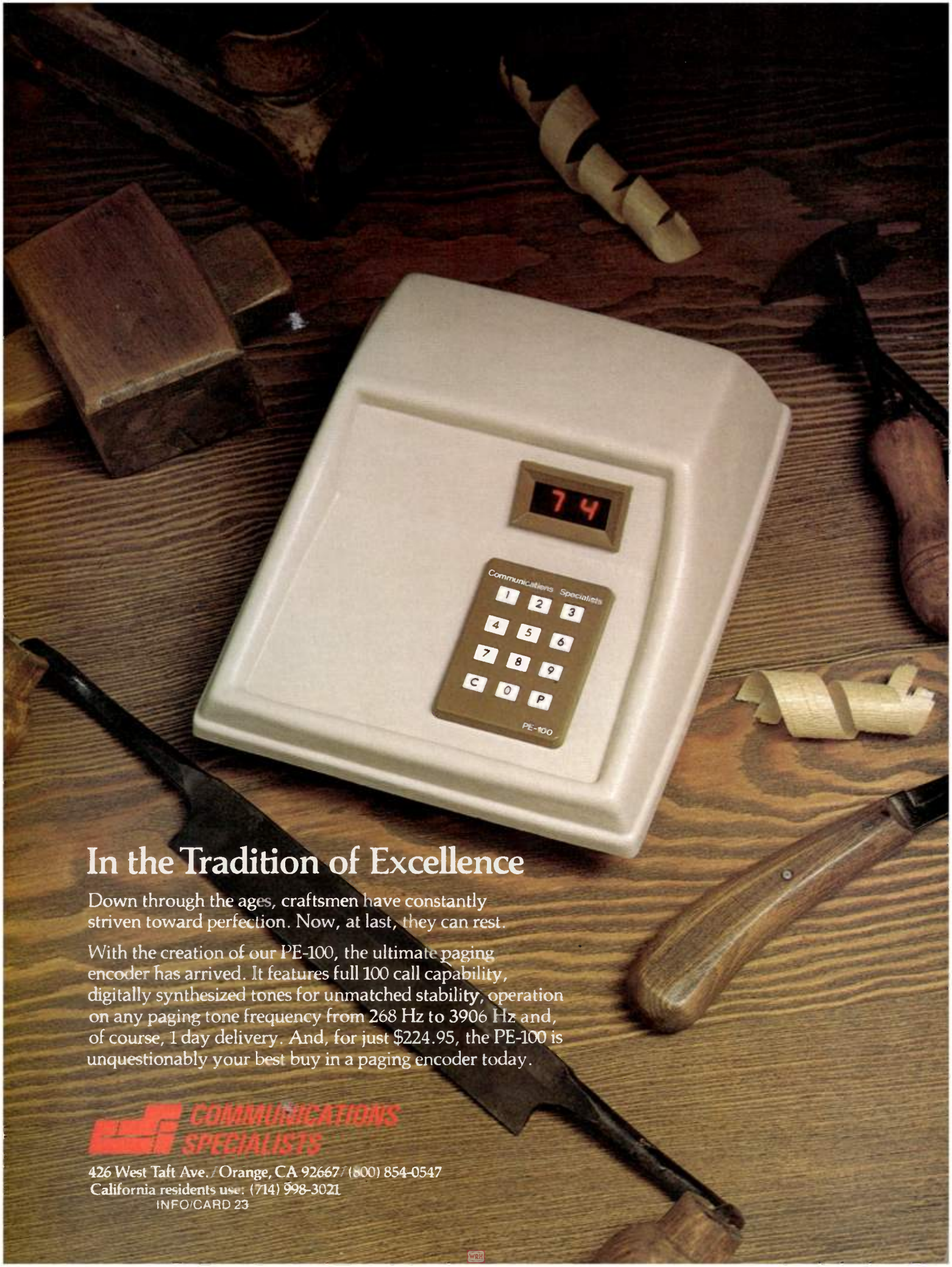
The amount of power, P_A, this switch can handle depends on the power rating of the PIN diode, P_D, and the diode resistance. The equation showing this relationship is as follows for an antenna maximum SWR of σ:

$$P_A = \frac{P_D Z_o}{R_S} \left(\frac{\sigma + 1}{2\sigma}\right)^2 \quad [Watts]$$

In a 50 ohm system where the condition of a totally mismatched antenna must be considered this equation reduces to:

$$P_A = \frac{12.5 \times P_D}{R_S} \quad [Watts]$$

Using these equations it can be shown that using a UM4901D (or equivalent) insulated stud and UM4901C



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stud mounted diode biased at 1 ampere where the R_S value is 0.1Ω and installed in a 50°C heat sink where the UM4901D is rated at 20 watts that a power level of 2.5 KW may be safely controlled even for totally a mismatched antenna. For a perfectly matched antenna, 10 KW may be controlled.

The UM9401 is an axial leaded PIN diode rated at 4.5W dissipation at 1/2" (12.7mm) total length to a 50°C contact. The resistance of this diode is a 1Ω (max) at 50 mA. A quarter-wave switch using 2 UM9401's may then be computed to handle 55 watts with a totall mismatched antenna.

It should be pointed out that the shunt diode of the quarter-wave antenna switch dissipates about as much power as the series diode. This may not be apparent from Figure 17; however, it may be shown that the RF current in both the series and shunt diode is practically identical.

Broadband antenna switches using PIN diodes may be designed using the series connected diode circuit shown in Figure 18. The frequency limitation of this switch results primarily from the capacitance of D_2.

In this case forward bias is applied either to D_1 during transmit or D_2 during receive. In high power application (>50W) it is often necessary to apply reverse voltage on D_2 during transmit. This may be accomplished either by a negative polarity power supply at Bias 2 or by having the forward bias current of D_1 flow through resistor R to apply the required negative voltage.

The selection of diode D_1 is based primarily on its power handling capability. It need not have a high voltage rating since it is always forward biased in its low resistance state when high RF power is applied. Diode D_2 does not pass high RF current but must be able to hold off the RF voltage generated by the transmitter. It is primarily selected on the basis of its capacitance which determines the upper frequency limit and its ability to operate at low distortion.

Using a UM9401 as D_1, and a 1N5767 which is rated at 0.4pf max, as D_2, greater than 25 dB receiver isolation may be achieved up to 400 MHz. The expected transmit and receive insertion loss with the PIN diodes biased at 50 mA are 0.1 dB and 0.3 dB respectively. This switch can handle RF power levels up to 50 watts.

Practical Design Hints

PIN diode circuit performance at RF frequencies is predictable and should conform closely to the design equations. When a switch is not performing satisfactorily, the fault is often not due to the PIN diode but to other circuit limitations such as circuit loss, bias circuit interaction or lead length problems (primarily when shunt PIN diodes are employed).

It is good practice in a new design to first evaluate the circuit loss by substituting alternatively a wire short or open in place of the PIN diode. This will simulate the circuit performance with "ideal

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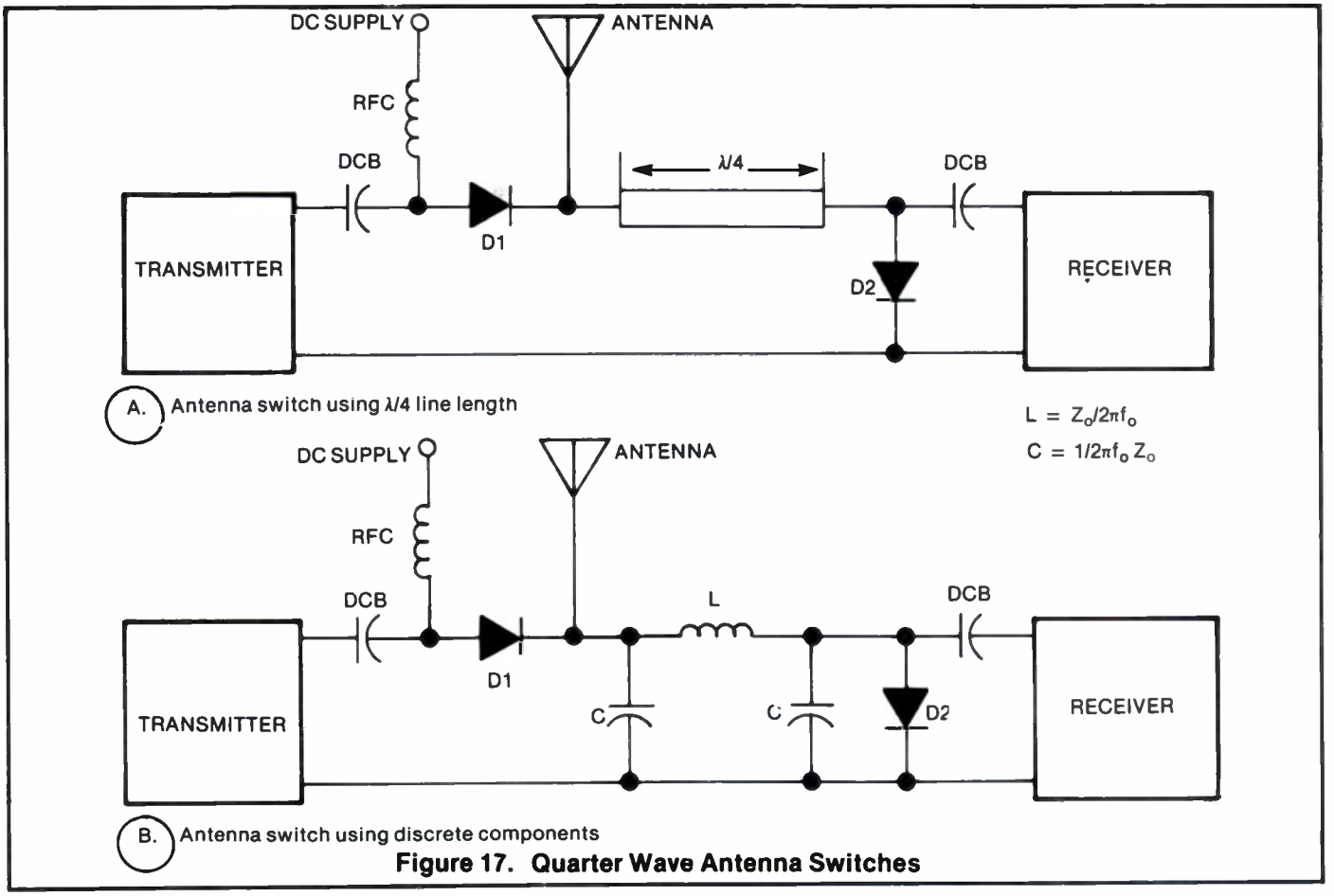

Figure 17. Quarter Wave Antenna Switches

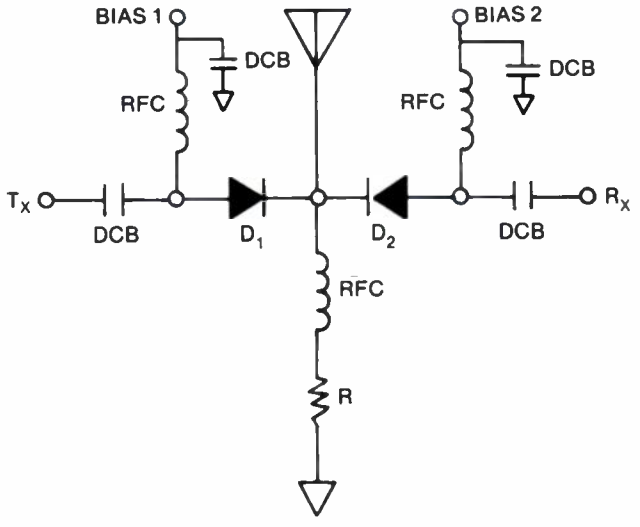

Figure 18.
Broadband Antenna Switch

PIN diodes." Any deficiency in the external circuit may then be corrected before inserting the PIN diodes.

A following article will discuss attenuator and modulator applications and will present a discussion of distortion in PIN diode circuits and describe techniques for reducing distortion. □

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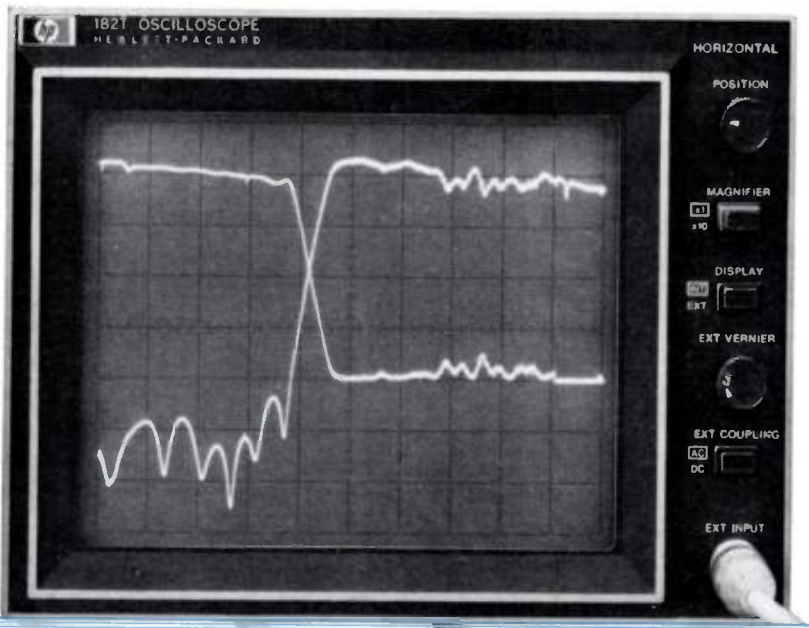

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The HP8750A Storage-Normalizer: It brings additional accuracy and simplicity to swept frequency measurements.

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Here are some examples of the improvements it can bring to your swept frequency measurements:

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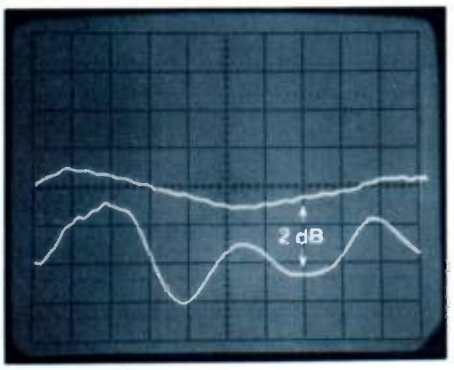
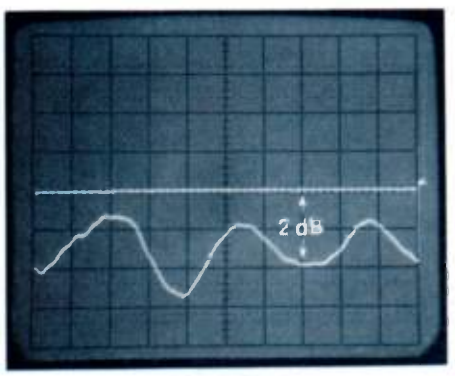


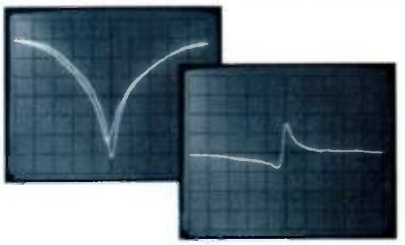
Before Normalization



Normalized

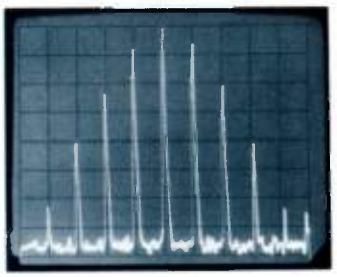
Frequency response or tracking errors in transmission or reflection measurements are eliminated with normalization. You can calibrate the test system's response and store it, then subtract it from the measured data. The resultant difference represents the corrected measurement that's displayed directly in dB.

Comparison Measurements.



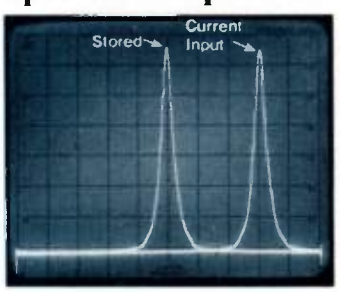
No longer is it necessary to visually scale deviations between two traces. With the HP 8750A, you can now display the *difference* between the two. Deviation between test devices is displayed directly in dB with a single trace.

Slow Sweep Measurements.



Use it for high resolution measurements when slow scan times are needed and get a bright, flicker-free display. Measurement data are displayed from memory with continuous refresh, independent of scan time and scope adjustments.

Spectral Comparisons.



Using the 8750A in spectrum analysis applications, a signal spectrum can be frozen on the CRT and then compared directly with the current input signal.

Because the HP 8750A can "freeze" the display, photography is simplified and hard copies such as X-Y recordings can automatically be plotted, even while new measurements are being made.

Domestic U.S. price of the Storage-Normalizer is $1450.

Call your HP field engineer for more information on how the 8750A enhances measurements made with HP 8755, 8410, 8407 and 8505 Network Analyzers, HP 8557, 8558 and 8565 Spectrum Analyzers, plus other instruments. Or write.

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INFO/CARD 25

How frequency, narrow band-pass characteristics makes mechanical filters very useful in many applications.

Mechanical Filters Find Promising Applications

By Yasukazu Kawamura
Research Group, Watch Development Department,
Daini-Seikosha

In the 30 years since their advent, mechanical filters have found many applications in radio communications, wire telecommunications, telemetering of rivers and dams, and personal radio pagers because of their outstanding selectivity, stability, small size, and low cost. Mechanical filters are conspicuous as narrow-band pass filters for low-frequency ranges. Mechanical filter developments are being accelerated by new applications such as an modulator/demodulators (modems) for data transmission, radio navigation for aircraft and vessels, fish detectors, and multiplex communication.

Construction and Features

Mechanical filters are low-loss stable filters which utilize a mechanical vibrator with a high Q, and are based on mechanical resonance after electric signals are converted into mechanical vibrations. No matter how mechanical filters are constructed, their operating principles are all the same.

Mechanical vibrators may be shaped like forks, bar discs, or cylinders which perform flexure-mode vibration, longitudinal vibration, or torsional vibration according to the frequency band to be used. They are made of a constant elastic alloy which mainly consists of iron, nickel, and chrome. Their frequency-temperature coefficients can be controlled to an accuracy of 1 ppm/°C depending on the raw materials used and heat treatment conditions.

In mechanical filters, the electro mechanical transducer which converts electrical signals into mechanical vibrations is piezo-electric ceramic attached to a mechanical vibrator. The piezo-electric ceramic is lead titanate zirconate with a temperature coefficient of about 20 to 30 ppm/°C and a Q value from 2000 to 3000. Several vibrators connected mechanically or electrically make up a mechanical filter.

Because they are metallic, vibrators are easy to fabricate into any shape. This is an outstanding feature of mechanical filters which makes it possible to broaden the applicable frequency range. This is particularly advantageous over other filters for low-frequency applications. Mechanical filters are composed of resonant elements which serve as band-pass filters. The maximum fractional bandwidth is limited by the electro-mechanical coupling factor of piezo-electric ceramics. The maximum fractional bandwidth is from 1.5 to 2 percent, and can be expanded to 15 or 25 percent by using additional coils and capacitors.

Applicable areas for mechanical filters range from 200Hz to 700kHz with a fractional bandwidth from

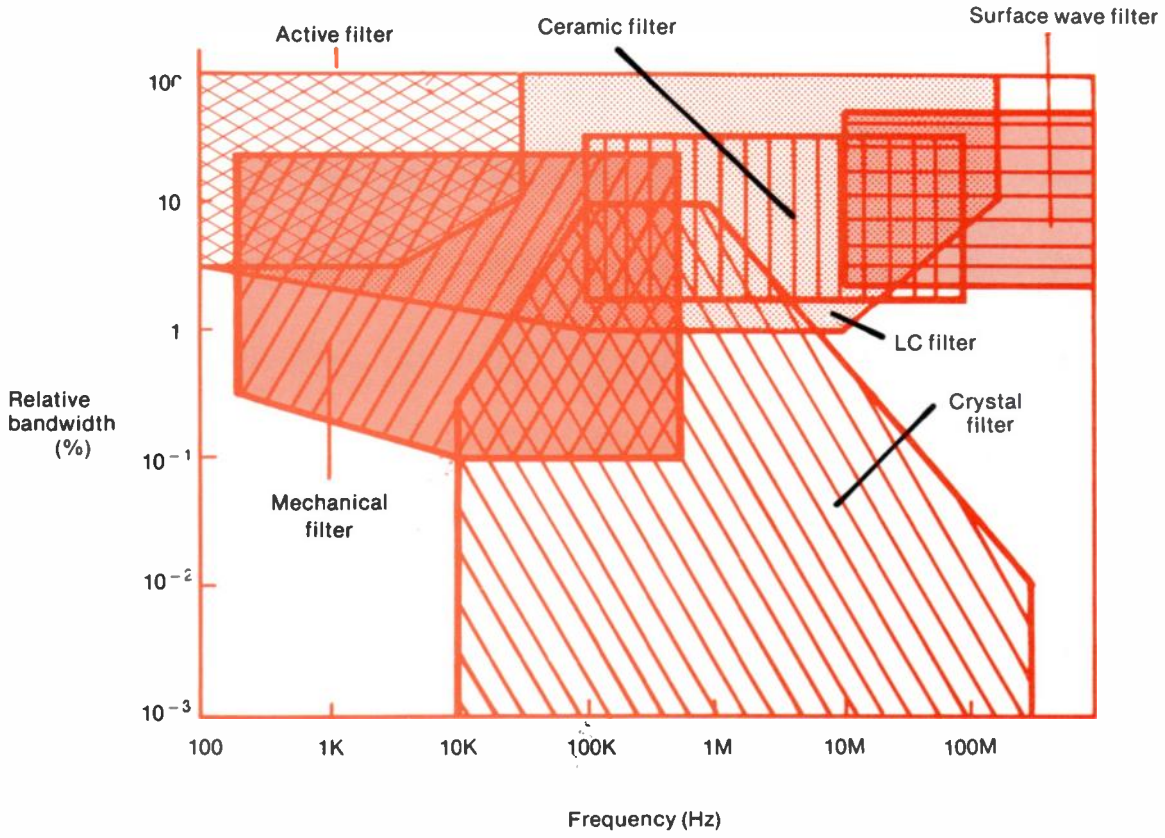


Figure 1. Applicable Areas of Mechanical Filters and Other Filters

0.1 to 25 percent as shown in Figure 1. For the frequency range from 200Hz to 10kHz, tuning forks are used. For the frequency range from 5kHz to 100kHz, the flexure vibration of bars is used. For a higher frequency range, the longitudinal vibration or torsional vibration of discs or cylinders is used. To illustrate the construction of a mechanical filter, a bar filter that employs four vibrators is shown in Figure 2a and

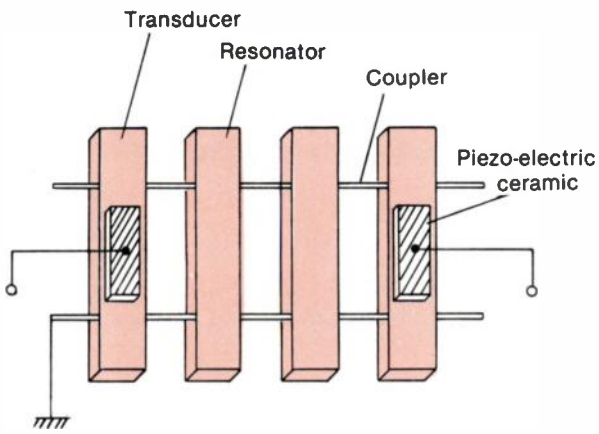


Figure 2a. Structure of Bar Type Mechanical Filter

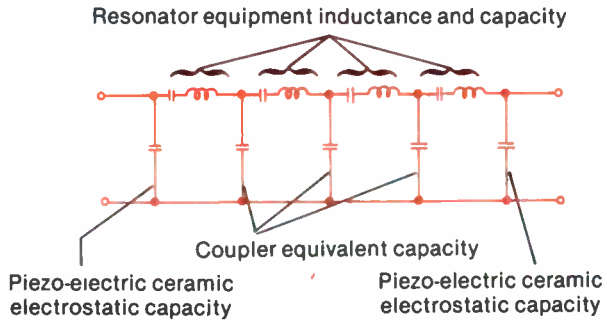
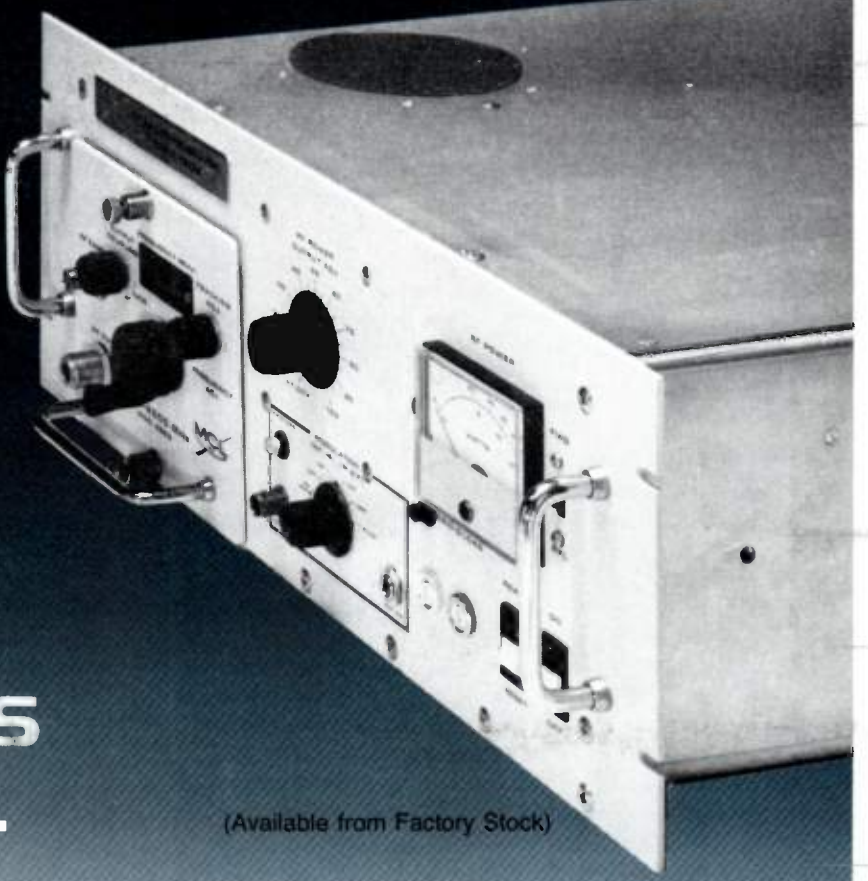


Figure 2b. Equivalent Circuit of Bar Type Four-resonator Mechanical Filter



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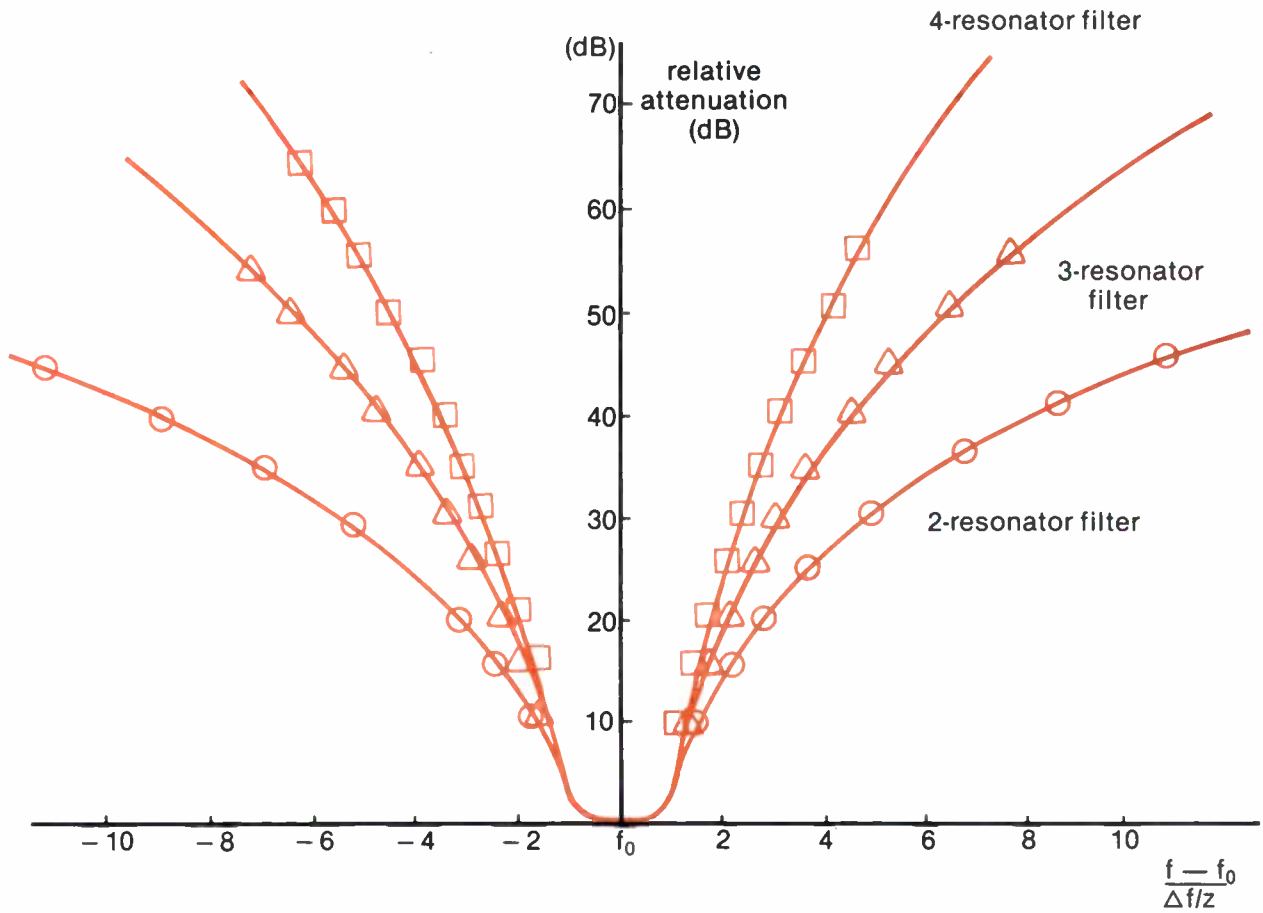

Figure 3. Number of Resonators and Characteristics of Mechanical Filter

its equivalent circuit is shown in Figure 2b. The center frequency is determined by the resonance frequency, and the bandwidth is determined by coupling factors such as the diameter and length of the coupling wire. In this example, four vibrators are used; however, the number of vibrators required is determined by the required selectivity. One example is shown in Figure 3.

Mechanical filters feature high Q values, excellent temperature and aging stability, miniaturization, etc.

Mechanical filters are especially outstanding when used as narrow-band pass filters for frequencies from 300Hz to 200kHz. Because of their excellent performance and low cost, mechanical filters are finding new applications in various areas.

New Applications

Radio Navigation

Hyperbolic navigation systems that use radio waves are used to check the positions of ships or aircraft for safe navigation. The omega navigation system covers the entire world with very low freqency (VLF) radio waves emitted by eight stations. VLF has a long range because it is diffracted along the earth's surface.

Frequencies used for this system are 10.2kHz, 11.333kHz, 13.6kHz, and 11.05kHz. Therefore, one wave length is about 30km.

Each station transmits one second tone bursts at these frequencies consecutively at intervals of one second, with the emission time staggered one second for respective stations.

Ships or airplanes equipped with omega receivers receive radio waves emitted by two stations to measure the phase difference and calculate their positions with an accuracy of two nautical miles using computers. Radio waves received after transmission over a long distance are very weak and contain lots of noise. Therefore, a powerful narrow band selective preamplifier is required, and mechanical filters are best suited for narrow-band pass filters in these preamplifiers.

Figure 5 shows the characteristics of a mechanical filter used for the omega receiver. The center

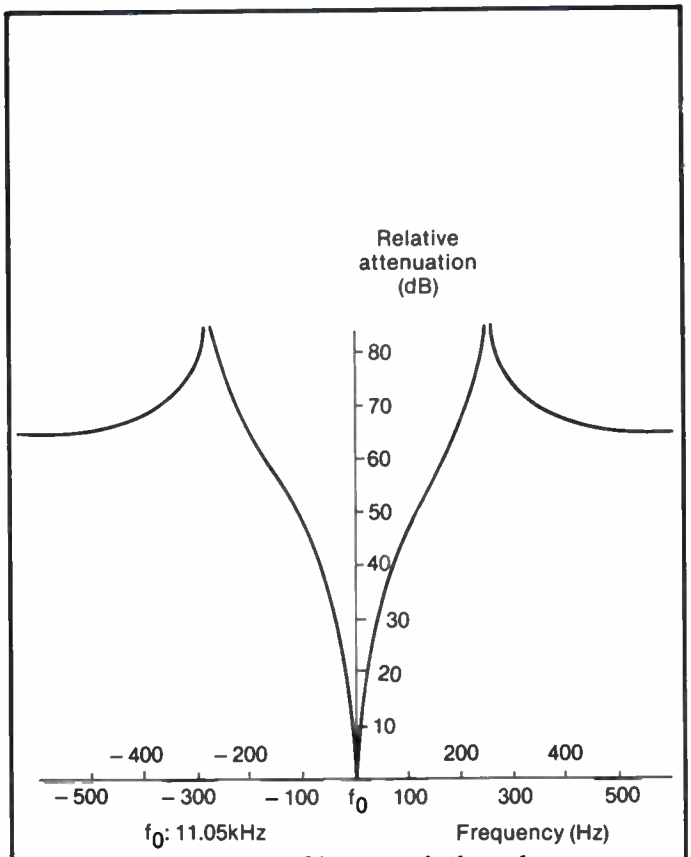

Figure 4a. Characteristics of Mechanical Filter for Omega Receiver

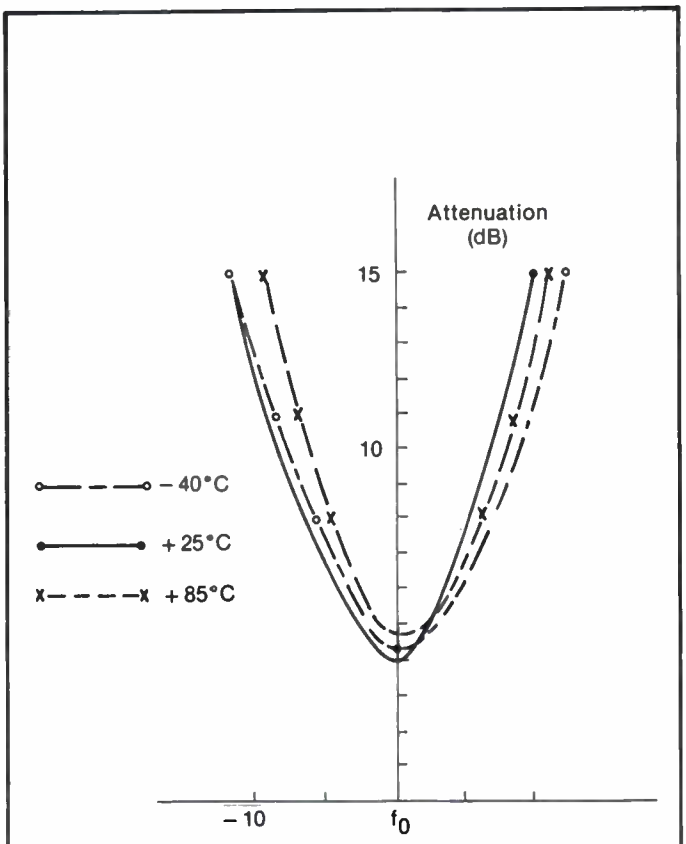

Figure 4b. Characteristics of Mechanical Filter for data Transmission at 200 bit/sec

frequency is 11.05kHz, the 3 dB bandwidth is only 10Hz, and the attenuation is 60dB ± 200Hz from the center frequency. By selecting proper constant elastic alloy and piezo-electric ceramics, a 3Hz frequency deviation and a 2 ppm/°C temperature coefficient from – 40°C to 85°C can be realized.

Since the omega receiver is designed to measure phase differences, excellent phase stability is required for the filter. The magnitude of input signals varies greatly depending on the distance from stations; however, the phase stability is kept within 0.5° by using a mechanical filter.

The long term stability of a mechanical filter depends on many factors such as the vibrator shape, the vibration mode, piezo-electric ceramic and adhesive materials, and the bandwidth. For filters used for omega receivers, the stability is about 200 ppm and the frequency deviation is within 2Hz for 10 years, Also, the filter is so small that it is housed in a 12.3cm^3 enclosure.

Mechanical filters are attracting considerable attention in the loran C system, which is a radio navigation system mainly used for ships. The system frequency is 100kHz. Therefore the service area is smaller than that of the omega system but its accuracy is better by a factor of 1 to 2 when compared with the omega system. The U.S. Coast Guard sees to it that loran C receivers are mounted on large ships such as tankers and all other ships navigating in U.S. territorial waters.

The loran C system is designed so that it detects only surface waves and neglects waves reflected from the ionosphere. In other words, the third cycle of an arriving signal is detected before reflected waves arrive. Therefore the filter used should have a broader bandwidth and faster rise time. Also, the filter should suppress interfering waves which are very strong near 100kHz. Figure 5 shows the characteristics of a mechanical filter with coils designed for a loran C receiver. The center frequency is 100kHz, the 3 dB bandwidth is 24kHz, and the 40 dB bandwidth is 42kHz.

Also, mechanical filters have found applications in the Decca system used for coastal shipping. Mechanical filters with 5, 6, 8 and 9kHz center frequencies are used to discriminate between base stations, which include a master station and three slave stations.

Channel Filters

Channel filters incorporate the most sophisticated technology among filters used for carrier telephone systems.

Throughout the world efforts have been underway to replace conventional LC filters with mechanical or crystal filters in order to miniaturize the required equipment and provide cost reductions. In West Germany, a new speech path convertor has been realized which uses a mechanical filter actuated by flexure-mode vibration at 48kHz. In Japan, NTT, NEC, and Fujitsu, which began early development of mechanical channel filters, selected torsional vibration of a cylinder with a 128kHz frequency because of its

low cost, small size, and stability and recently started practical applications.

The method for making mechanical attenuation poles in the attenuation band has been a technical problem for mechanical filters. This has now been solved by Boerner and Johnson independently who proposed that two finite attenuation poles can be realized by bridging a coupler to resonators which are not adjacent to each other. Therefore, this method has been applied to mechanical channel filters. Figure 6 shows the characteristics of a channel filter developed by Fujitsu. This channel filter incorporates six torsional resonators, two bridging couplers, and two attenuation poles each on both sides of the pass band.

This channel filter measures 10.7cm^3, which is one-sixth the size of the present LC filter.

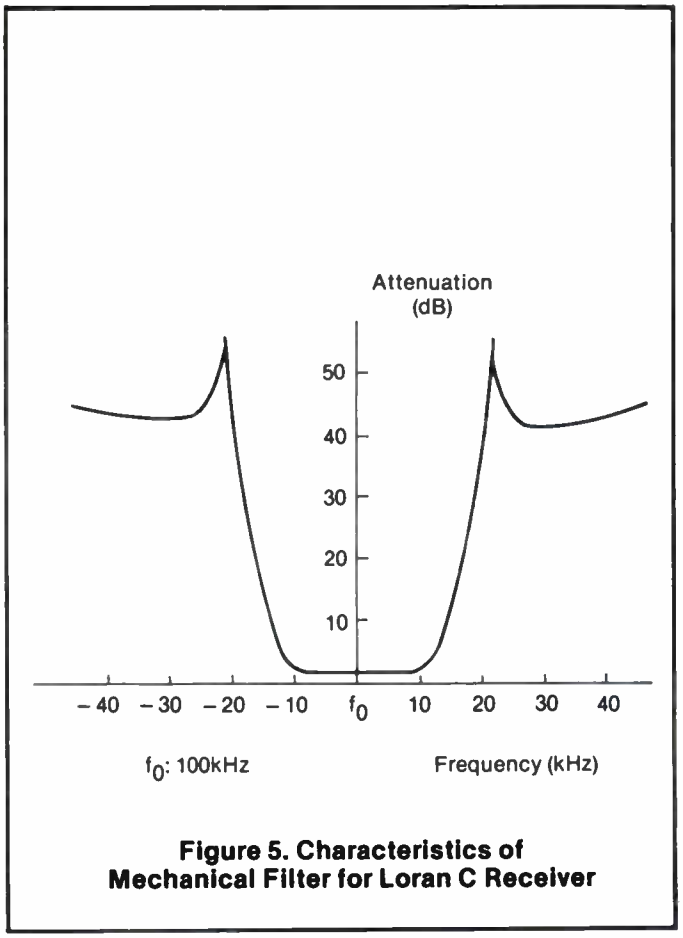

Figure 5. Characteristics of Mechanical Filter for Loran C Receiver

Fish Detectors and Other Applications

Sonar for detecting underwater objects by emitting ultrasonic waves into water and receiving reflected waves from objects was developed for detecting submarines. Later, sonar was applied to fish detectors. The frequencies of ultrasonic waves range from 30kHz to 200kHz, and this frequency band is most suitable for mechanical filters. Also, mechanical filters have been utilized because of their frequency and phase stability, small size, and low cost. Figure 7 shows the characteristics of a filter used for a fish detector. The center frequency is 80kHz, the 3 dB bandwidth is 1.2kHz, and the phase change is almost linear. It measures only 6.3cm^3 in volume.

The simplest mechanical filters, which contain only one tuning fork, are called reed filters. Reed filters have been commonly used as selective elements for personal radio pagers, automatic answering telephone sets, simple remote control equipment, and various other equipment because of their small size and low cost. In one recent application, a reed filter was used for providing data through a telephone line between a doctor and a heart patient with an implanted pacemaker.

Mechanical filters have exploited new possibilities

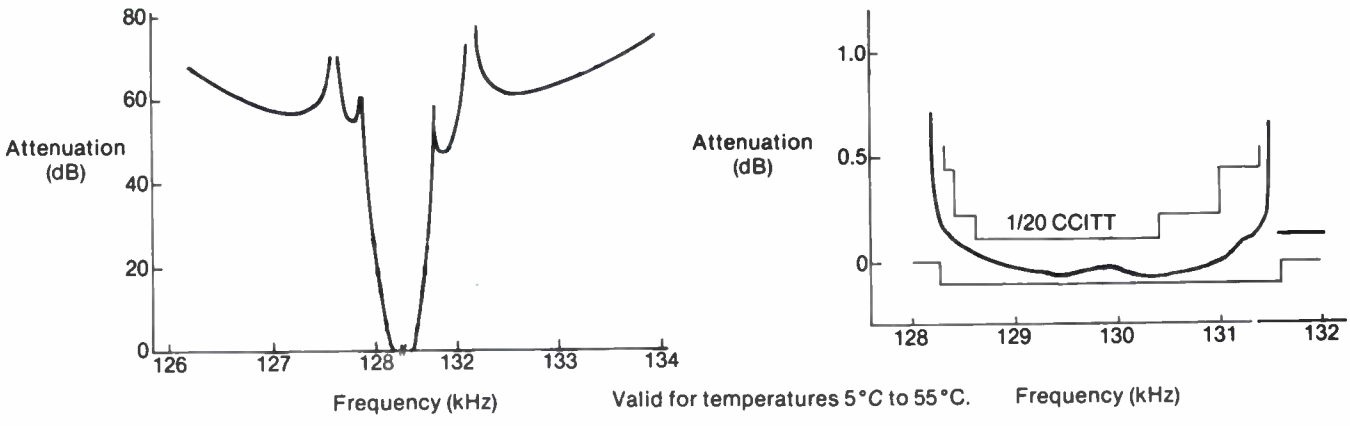

Figure 6. Characteristics of Channel Mechanical Filter (128kHz)

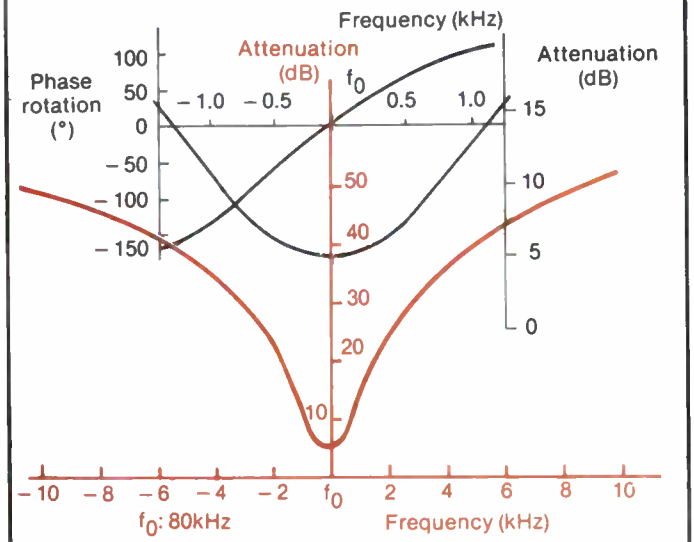

Figure 7. Characteristics of Mechanical Filter for Fish Detector

for meeting selectivity, miniaturization, and cost requirements together with the development of new materials and designs, and now various mechanical filters are available for many applications.

Also, further improvements are anticipated as new requirements appear in the future.

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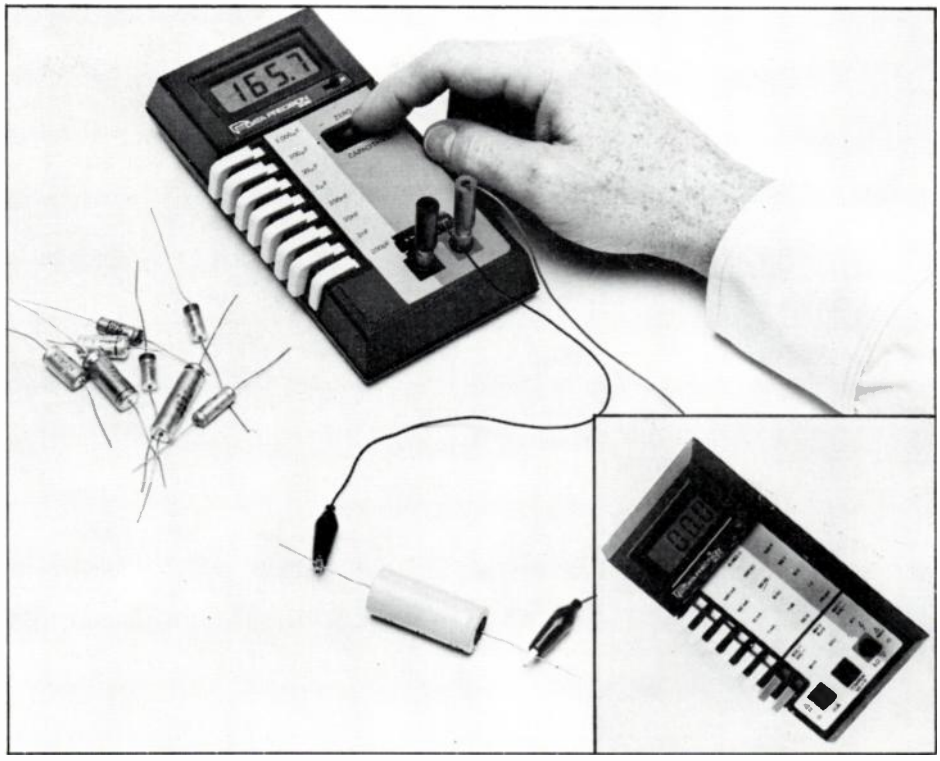
11. "Coming of the Loran C Era," by Kondo, *Dempa Shinbun,* April 27, 1978 □

Capacitance Meter Offers 0.1% Accuracy for $149



A new palm-sized digital capacitance meter selling for only $149 has been introduced by Data Precision. The 3-1/2 digit model 938 measures capacitance from 0.1pf to 1999μf in eight switchable ranges, with an accuracy of ±0.1 percent of reading ±0.5 pf ±1 digit on all but the 2000μf range, where accuracy is ±1 percent of reading ±1 digit. This capacitance meter is a companion instrument to a hand-held multimeter also recently introduced (inset) by Data Precision. The model 935 selling for $149.00, is designed primarily for field use, 3-1/2 digit DMM with 0.1 percent accuracy.

The model 938 uses a newly designed measurement technique (patent pending) to obtain this extremely high accuracy over such a wide range of capacitance. The technique developed for the model 938 works by directly measuring the ratio of change in charge (ΔQ) to the change in voltage (ΔV) of the unknown capacitor. This ratio, ΔQ/ΔV, is, by definition, capacitance. Using this new technique, one can scale the readings easily to make measurements over a wide dynamic range while still maintaining outstanding accuracy, stability, and measurement speed.

Packaged in a rugged plastic case similar to Data Precision's new model

935 digital multimeter, the model 938 features the same small size, light weight and handy pushbutton switch range selection. A zero adjustment is also provided for compensating for the stray capacitance of test leads. Measurements are displayed on a 0.5 inch high liquid crystal display for easy reading in any light conditions, including direct sunlight.

The model 938 is tough enough for field use and well protected electrically. An internal fuse prevents instrument damage from charged capacitors or in case of inadvertent connection to voltage sources. It will operate up to 200 hours off a single 9V alkaline battery. Battery replacement, recalibration by a single potentiometer adjustment or fuse replacement is easily accomplished after removing one coin-operated captive screw.

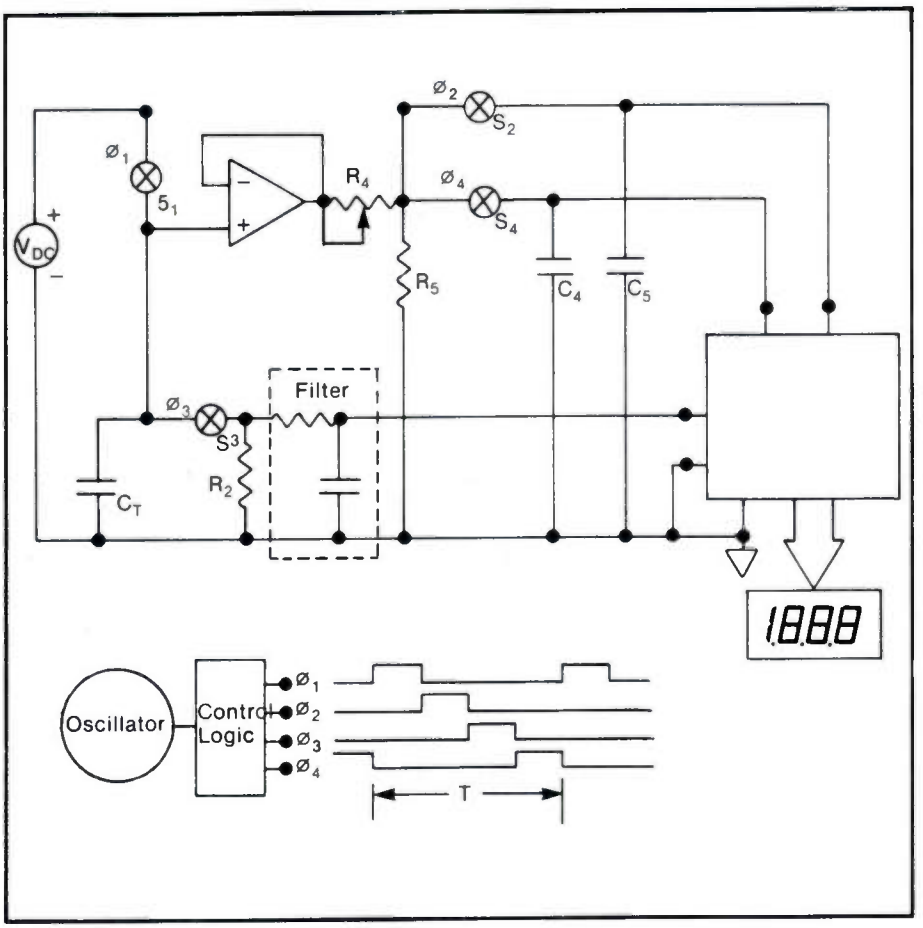
The price of the model 938 is $149 (US delivery), including battery, instruction manual, certificate of conformance to NBS Standards, and final QC test report. It is covered by a full one year warranty. Delivery is from stock at all Data Precision Stocking Representatives.

The model 935 is priced at $149.00 in unit quantities, including test leads, battery, and instruction manual, full one-year warranty, certificate of conformance to NBS Standards and U.S. factory final QC test report.

Theory of Operation

The model 938 Capacitance Meter uses a unique circuit that provides accuracy, stability, and noise immunity. In operation, the meter repeatedly charges and discharges the unknown capacitor at a fixed rate. The voltage difference between charged and discharged states of the unknown capacitance is measured and provided to the reference input of an A/D converter. The current flow created due to the repetitive discharge of the unknown capacitor is filtered and provided to the signal input of the integrating A/D converter. This average discharge current is proportioned to the charge removed from the unknown capacitor during each cycle. Thus, the A/D converter in effect measures the ratio of change in stored charge (△Q) to change in voltage (△V) for the unknown capacitor, which is by definition capacitance.

For further information contact Data Precision Corporation, Electronics Avenue, Danvers, Ma. 01923. (617) 246-1600. Telex: 921819. Please circle INFO/CARD #130.



Sequence of Operation

1. *S_1 closes C_T charges, S_1 Opens.*
2. *S_2 closes, charges voltage of C_T, attenuated by R_4 and R_5 , is stored on C_5 , S_2 opens.*
3. *S_3 closes, discharging capacitor through R_2 . S_3 opens. The voltage across R_2 is low pass filtered to provide an average voltage which is a measure of the average discharge current to the signal input of the A/D converter.*
4. *S_4 closes, and the attenuated discharge voltage of C_T is stored on C_4 . S_4 opens. The difference between the stored voltage on C_5 and C_4 is a measure of the change of voltage on C_T and is provided as the reference for the A/D converter.*

The digitized output signal from the A/D converter is proportional to a ratio of V in and V ref:

$$\frac{\overline{Vin}}{Vref} = \frac{\overline{I}\,in\,R_2}{\Delta V_C}$$

$$\text{Since } \overline{Iin} = \frac{\Delta Q_C}{T},$$

$$f = \frac{1}{T}, \; f = \text{frequency of operation},$$

$$\text{and } \frac{\Delta Q_C}{\Delta V_C} = C_T$$

$$\text{the A/D output} = R_2 f C_T.$$

Thus the output of the converter is proportional to capacitance and can be scaled by R_2 and the frequency of operation, controlled by the internal oscillator. The model 938 uses both f and R_2 scaling to provide 8 decades of capacitance measurements.

Packaging Concept For Implementation of Fiber Optics Technology

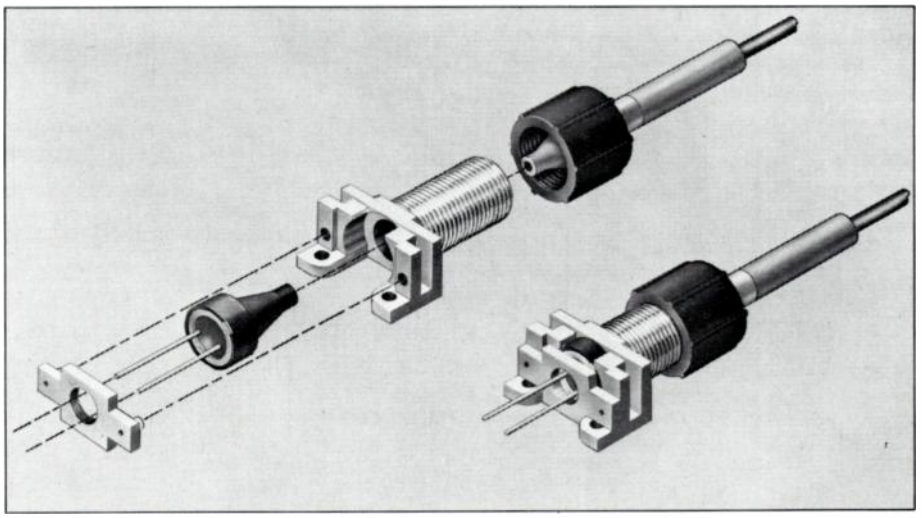
A coordinated development effort by Motorola, of Phoenix, Arizona and AMP Incorporated of Harrisburg, Pa. has yielded a new concept in electro-optics packaging. Results from the program include the imminent introduction of a new line of solid state light sources and detectors (by Motorola) and a new series of connectors (by AMP) — a combination of components matched to hurdle the three main impediments to increased fiber optics use — coupling efficiency, cost and serviceability.

Current methods of coupling active devices to optical fibers fall into two general categories. The inexpensive method of fitting a standard semiconductor package into a connector bushing is rugged and serviceable, but does not produce optimum coupling because of the relatively large spacing between the semiconductor die and the fiber. The other approach of bonding a connectorized fiber directly to the semiconductor die provides excellent optical coupling but is not suited to automation. This "pigtail" approach is still viable when optimizing performance of higher cost sources and detectors. Motorola's semiconductor chips, mounted on a sturdy header, are packaged in a resilient plastic ferrule that is an integral part of the optical interconnecting system. An optical fiber contained in the ferrule package extends directly from the active area of the semiconductor die to the highly polished surface of the ferrule for maximum light transfer. An AMP Optimate fiber optic connector mates directly with the new Motorola semiconductor package and provides efficient coupling to all major commercially available fiber optics.

Motorola, is assembling the active devices, controls all variables that affect the amount of light exiting an emitter or the sensitivity of a detector. All variables that affect connection losses due to concentricity, end spacing, and angular alignment are under the control of AMP who manufactures the resilient plastic ferrule used by Motorola and the corresponding connector. The only remaining variables are the diameter, and NA (numerical aperture) of the fiber optic cables being used. The light-coupling aperture of the new Motorola semiconductors is a 0.008 inch diameter core (204 microns) with an NA of .48 for efficient coupling to small fibers. Connector coupling losses to a similar fiber are typically 2 dB. Coupling losses due to mismatched diameters of NA's are easily calculated, and the engineer can readily determine the amount of light coupled into the fiber optic cable from the emitter, or into the detector from the cable. With conventional dome lens device this is extremely difficult.

Motorola is currently sampling a light-emitting diode (infrared) and a series of detectors, including diodes, transistors, Darlingtons and an integrated monolithic detector with built-in preamplifier. All devices are slated for introduction in production quantities during the second quarter of 1979.

The AMP Optimate connector compatible with these new semiconductors

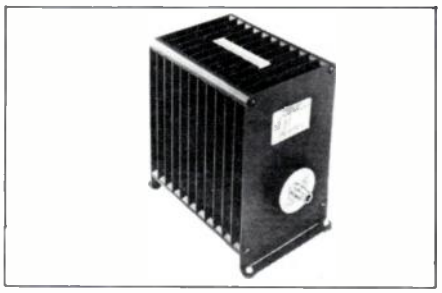


can be bulkhead mounted or PC board mounted and is less than 0.300 inch high for use between PC boards located on 0.500 inch centers typical of computer applications. The connector is metal to provide effective electrical shielding and accepts snap-on shields for further EMI/RFI protection or critical receiver circuitry. Both the standard plastic Optimate cable connector line, and the new high performance metal versions mate with the metal PC board connector. When the metal connector is used, additional shielding is provided by the connector body itself. This new high-performance metal connector accepts all-glass and plastic clad silica filters down to 125 microns diameter. The assembly method provides a strain-relief feature that grips the protective strength members common in high-performance cables.

Further information concerning the new connection system is available from AMP Incorporated of Harrisburg, Pa. 17105. Additional data about the new source and detector semiconductors is available from Motorola Semiconductor Products Inc., P.O. Box 20906, Phoenix, Ariz. 85036. Circle INFO/CARD #120.

300 Watt Dry RF Load Resistor

The new Bird model 8173 Termaline® dry highpower coaxial load is designed for 50 ohm RF line and system termination during design, test and alignment. At 300 watts continuous duty it complements the present Bird



Dry Loads group ranging from 2 watts through 600 watts. The group, with its rugged construction and air dielectric (no liquid coolants), now included 2, 5 and 10 watt loads with fixed input connectors, and 25, 50, 100, 150, 300 and 500/600 watt loads with Quick Change Connectors.

For more information contact Bird Electronic Corporation, 30303 Aurora Road, Cleveland (Solon), Ohio 44139. Circle INFO/CARD #121.

LSI Test System

A production-oriented, large-scale-integration (LSI) test system designed to cut testing costs for high volume semiconductor manufacturers and users, has been introduced by the Test Systems Group of Fairchild Camera and Instrument Corporation.

Called Sentinel™, the system closes

the gap between large, general purpose LSI systems and less expensive, dedicated, benchtop testers.

"Previously, the customer either had to invest in a large, general-purpose test system costing more than $200,000, or buy a $60,000 benchtop tester with limited capability," said James D. Bowen, vice president and general manager, Test Systems Group. "With Sentinel, the user now has a third option — that of purchasing a mid-priced, flexible system that can adapt to changing technology."

Contact Test Systems Group, 1725 Technology Drive, San Jose, Calif. 95110; Martha Sessums: (415) 962-3615. Circle INFO/CARD #87.

Miniature Fixed Attenuators

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

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

3300 series prices are: 0.1 dB thru 20 dB, $15; 30 dB thru 100 dB, $25. Availability is 45 days ARO.

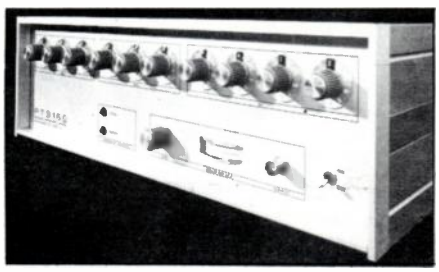
For additional information contact Julian Parker, Product Promotion Coordinator, ext. 241. Gaithersburg, Maryland; (301) 948-3434, TWX: 710-828-9705. Circle INFO/CARD #84.

160 MHz Synthesizer On IEEE-488 BUS

A compact, high performance frequency synthesizer, enhanced with an optional IEEE-488 interface for wider applicability, is available from Programmed Test Sources, Inc.

The Programmed Test Sources' PTS 160 is a 0.1 MHz to 160 MHz frequency synthesizer that has been expanded with an optional IEEE-488 (1978) interface for frequency and amplitude control. Frequency control covers all steps from most significant down to 0.1 Hz. Output level is programmable in 1 dB increments over a 10 dB range, and duplicates manual front panel settings.

The Programmed Test Sources' PTS 160 is priced at $5150 for a typical instrument (rack mount or bench cabinet) with 1 Hz resolution, oven-type stan-

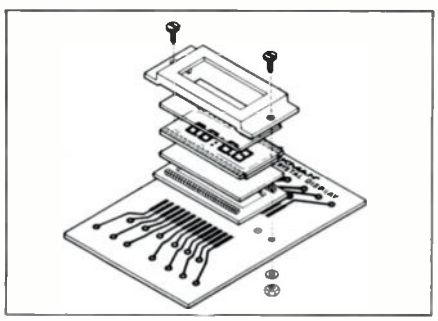


dard, manual control capability, and 488 interface.

For more information contact Programmed Test Sources, Inc., George H. Lohrer, 69 Hayward Road, Acton, MA 01720; (617) 263-6467. Circle INFO/CARD #110.

LCD Designer's Kit

A designer's kit that allows users to experiment with large area liquid crystal displays in various applications is available from Beckman Instruments' distributors. The kit, which



sells for $11.95, includes a Beckman one-half inch, four digit liquid crystal display, an easy-to-mount connector/bezel assembly, printed circuit board, complete specifications and applications information. A list of manufacturers that provide integrated circuits with LCD interfaces is also included.

To order a Beckman LCD designer's kit, contact your local Beckman dis-

tributor or the Display Systems Division, Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. (714) 871-4848. Circle INFO/CARD #111.

12 MHz Single And Dual-Trace Mini-Scope

Now, an accomplishment in perfecting a practical, high-performance three-inch, 12 MHz mini-scope with excellent performance, and unprecedented portability and reliability will give a huge new oscilloscope market a tool as necessary as the 3-1/2-digit DMM.

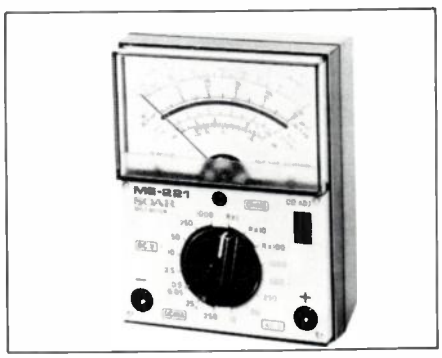
The series 1020 provides sweep rates from 100 ns/division to 100 ms/division, in 12 calibrated steps plus a continuously variable x10 magnifier. Measuring only 8" wide by 7-3/8" deep by 3-1/4" high, and weighing approximately 5 lbs., it operates on 12 VDC at less than 1A, which may be obtained from a battery pack, the cigarette-lighter receptacle or direct battery connection of a vehicle, or any similar 12 VDC source. Plug-in AC power converters permit operation from 120 V or 240 V, 50 to 400 Hz AC line power.

The unique CRT was developed for the series 1020, to maintain a bright, sharp trace. The P31 phosphor screen face is shaped to a radius that assures constant sharp focus, and the integral black graticule minimizes parallex effects. The short tube length provides high immunity to shock and vibration. The screen area is 8 x 10-division (one division equal to 5mm).

Further information may be obtained from Roger Stagnol, Ballantine Laboratories, Inc., 90 Fanny Road, Boonton, NJ 07005; (201) 355-0900. Circle INFO/CARD #113.

Analog Multimeter

The drop-proof battery-operated ME-221 multimeter has a rugged taut band movement that absorbs shocks to 50 G's, and the meter movement is made in the United States. Other features include a wide-scale meter deflection angle of 95 degrees, a mirrored scale for easy reading, four function modes — DCV, ACV, DCmA, and Ohms — and high accuracy and stability.



This accurate and completely portable (11.6 ounces) instrument has a voltage measurement range to 1000 VDC and VAC, a current measurement range to 250 ma, and a resistance measurement range to 500 kilohms. It is powered by two 1.5 volt AA batteries and has an accuracy of ±3 percent DC and ±4 percent AC. Contact Steve Cohen Soar Electronics (U.S.A.) Corp., 813 2nd Street Ronkonkoma, NY 11779; (516) 981-6444, Telex No. 144638. Please circle INFO/CARD #100.

Circular Connectors

Souriau, Inc., manufacturers of an inclusive line of connectors (D subminiature, PC, microminiature, rack & panel, rectangular, underwater, hermetic and aerospace) offers a selection of circular connectors designated as series 851.

Series 851 circular connectors are available in solder, crimp, or PC mount terminations. Their lightweight construction and compact size have contributed to their success in both civil and military applications where reliable electrical connections and

trouble-free operations are a must.

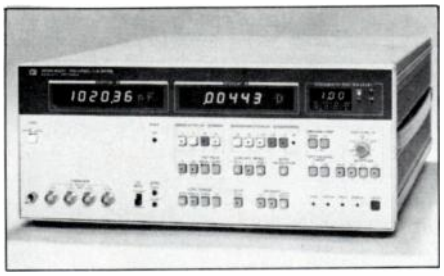
Operating temperatures are – 55°C to + 125°C; this series will be qualified to MIL-C-26482G, series I. They are interchangeable and intermateable with Cannon's KPT, KPTM and KPSE series.

For additional data, contact Souriau, Inc., 7740 Lemona Avenue, Van Nuys, CA 91405; (213) 787-5341, ext. 281. Circle INFO/CARD #99.

Magnetic Circuit Protection

Lambda specifies magnetic circuit protection on all power supplies over 100W. Reason space savings, protector doubles as off-on switch, and most important, delay to operate curves are "tailorable" for individual power supply applications.

Contact Tom Balmer, NAECO, Inc.,



Box 495 F-10 Lincoln Lane, Dayton, NJ 08810; (201) 329-6111. Circle INFO/CARD #98.

AC/DC Power Supplies

These AC/DC regulated power supplies "CM series" provide low cost solutions to the problems of powering analog and digital modules, subsystems, small systems, and instruments. The CM-series is available in 11 low-cost models; single-output +5VDC at 500, 1000 or 2000 mA and dual-output ±12 or ±15 VDC at 60, 100, 200, or 300 mA.

Each supply incorporates exceptionally stable references and high-gain, low-phase-shift, broadband regu-

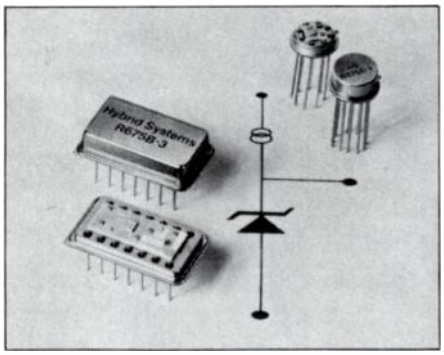
lator circuits to achieve low offset, low drift, and fast response. These supplies are stable even with large capacitive loads. Series pass elements are selected for worst-case conditions of line, load and ambient temperature. All thermal factors are closely controlled. High efficiency circuits reduce internal temperature rise. Low thermal masses and thermal gradients permit minimum delay in reaching equilibrium following any change in operating conditions, from turn-on to full-load swings.

Typical specifications include: 0.02 percent line regulation, 0.02 percent load regulation, temperature coefficient of voltage 0.02 percent/°C, and no derating from 0°C to 70°C.

Contact II intronics, 57 Chapel St., Newton, MA 02158, TWX: 710-335-6835. Circle INFO/CARD #97.

10V References

Hybrid Systems Corporation has announced a full line of precision 10 volt references. The new R675 series offers +10V, −10V and ±10V models. All are available in 14-pin hermetic DIPs. The +10V reference is additionally supplied in hermetic TO-99 package. 14-pin DIP units are



pin-for-pin equivalent of AD2700 models.

MIL-STD-883 processed versions (R675B models) offer low tempco of only ±3ppm/°C for the −55 to +125°C operating range. Commercial/industrial versions (R675C models) have ±5ppm/°C tempco for operating −25 to +70°C and ±8ppm/°C, −55 to +125°C. Output voltages at 25°C. and nominal supplies are within ±5mV. External adjustment is optional.

The R675 series combines precision laser trimmed nichrome resistors with premium grade gain and reference components for ultra-stage performance. Typical of the many applications for precision voltage references are analog-to-digital and digital-to-analog converters, temperature sensors, strain gauges and accelerometers in military, aerospace and medical electronics.

Contact Hybrid Systems Corporation, Crosby Drive, Bedford, MA 01730; (617) 275-1570, TWX: 710-326-7584. Circle INFO/CARD #95.

TV/FM Tuning Components

Motorola has expanded its line of tuning components intended for all-electronic TV and FM tuner applications to compete effectively in price and packaging with European DO-35 glass encapsulated components that have dominated that market until now.

Involved are two varactor tuning diodes and three PIN switching diodes — five components in all, of which three are direct replacements for the most popular European devices and two are Motorola exclusive units that have been available previously in more expensive packages.

The newly-introduced European equivalents are listed below.

The Motorola-exclusive tuning components are all housed in the hermetically-sealed, axial-lead DO-35 glass package, the most highly mechanized package production and test line at Motorola.

The two Motorola-exclusive components are listed below.

The above components are the DO-35 packaged electrical equivalents to the slightly higher priced MV210s and MPN3402s, which are packaged in the plastic TO-92 and Mini-L packages, respectively. Motorola plans to continue manufacture of the plastic-packaged components to serve those customers that have them designed in.

All of the new glass-packaged DO-35 devices are available in quantity from Motorola warehouse stock and authorized distributors.

Contact Motorola Semiconductor Products Inc., Hank Schroeder, P.O. Box 20912, Phoenix, AZ 85036; (602) 244-6900. Circle INFO/CARD #96.

Motorola Type No.	Replaces European Type No.	Description	Prices (100-999)
MV309	BB139	Varactor Tuning Diode for VHF/TV	$ .45
MPN3503	BA243	PIN Bandswitching Diode	.30
MPN3504	BA244	PIN Bandswitching Diode	.35

New Motorola Part No.	Description	Price (100-999)
MV310	FM Tuning Diode	$. 45
MPN3500	PIN Bandswitching Diode	.25

3-Phase Power Outage Simulator

An instrument for simulating and measuring power failures in applications such as computers, radar, and communications has been introduced by Bermar Corporation.

The Bermar model PLM-1033PSC is a solid state, 3-phase outage simulator that permits operator-controlled power interruptions from 1/2 to 999

half cycles on a one shot or repetitive basis. The instrument makes and displays synchronized measurements including true RMS current or voltage, surge current, and crest factor.

Measuring power line carryover in 1/2 cycle increments, the Bermar model PLM-1033PSC simulates failures in 3 phase systems up to 40A per phase, and in single phase systems up to 120A. Any phase or combination of phases can be selected for dropout, and the angle of power return after dropout can be set from 0° to 360° in 1° increments. Control is provided by the model PLM-103, also usable as a standalone with one 15A channel.

Contact Bermar Corporation, Bern-

hard A. Leinfelder, Box 1043, 115 Vine Street, Nashua, NH 03061; (603) 888-1300. Circle INFO/CARD #94.

Recovery Power Rectifiers

Motorola has implemented a change in construction of the popular 6, 12, 20 and 30 amp series of fast recovery rectifiers which is reflected in a substantial price reduction averaging 11.6 percent.

The basic construction change allows the use of fewer and less expensive parts in these rectifiers without affecting quality or reliability. The devices offer soft recovery switching speeds of 200 ns (max) and are used in inverter and switching power supplies.

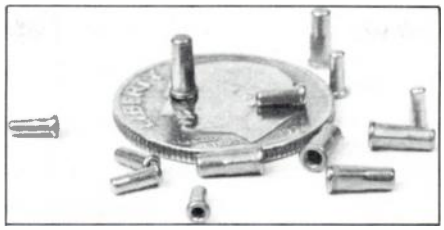
The 6 and 12 amp fast-recovery rectifiers are now packaged in the "new" DO-4 package (Motorola case 245) which is a simplified version of the stud-mounted DO-4 (Motorola case 56B). This now makes possible price reductions.

The 20 and 30 amp fast recovery rectifiers also have soft recovery switching times of less than 200 ns and are used in inverters and switching supplies where RFI may be a problem.

Contact Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036; (602) 244-6900. Circle INFO/CARD #93.

Self-Retaining Cage Jacks

Self-retaining component mounting aids for use in printed circuit boards of all common thickness have been introduced by Cambion® of Cambridge,



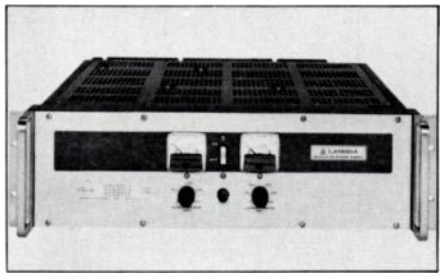
Massachusetts. Cambion® self-retaining ribbed cage jacks are miniature connectors with external ribs to hold them in PC holes of appropriate size throughout handling, storage, and inspection operations. During wavesoldering, they won't float away or rise up. Press fitted manually or by tooling, they are offered for 0.025" pins (P/N 450-3983-01-XX-00) and for 0.030"/0.032" pins (P/N 450-3998-01-XX-00).

Cambion® self-retaining ribbed cage jacks are available completely gold plated, or with gold plated cage spring insert and tin plate housing. According to the manufacturer, the ribbed design permits many thousands of electrically reliable insertions/extractions. These cage jacks join the previously introduced 0.040" diameter version (P/N 450-3729-01-XX-00).

Contact Cambion® , Cambridge Thermionic Corp., William G. Nowlin, General Marketing Manager, 445 Concord Avenue, Cambridge, MA 02138; (617) 491-5400. Circle INFO/CARD #92.

100 Hz to 100 kHz Multifrequency LCR Meter

This new 4-1/2/5-1/2 digit microprocessor based LCR meter from Hewlett-Packard meets requirements for laboratory, production line and quality assurance inspection measurements. Called the Hewlett-Packard model 4274A multifrequency LCR meter, the new instrument can measure inductance from 100.00 nanohenries to



1000.0 henries, capacitance from 1.0000 picofarads to 1.00 farad, R, Z, ESR and X from 100.00 milliohms to 10.000

megohms. D, Q, G & B and Θ are also measured.

Accuracy of the 4274A is typically 0.1 percent of reading. Measurement frequencies are 100, 120, 200, 1k, 2k, 4k, 10k, 20k, and 100 kHz. Optional additional spot frequencies are available within the instrument's 100 Hz to 100 kHz operating range. With this frequency range, measurements on aluminum electrolytic capacitors used in switching power supplies and audio magnetic heads are simplified.

U.S. price of the Hewlett-Packard 4274A multifrequency LCR meter is $7,930. Delivery is 60 days. Contact Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, CA 94304. INFO/CARD #91.

Miniature Programmable Step Attenuator

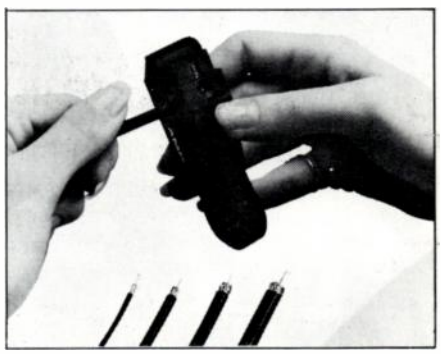
Attenuation control to 127 dB in 1-dB steps from DC to 2 GHz in a miniature package is now available from Weinschel Engineering in the form of the model 3200 programmable step attenuator. Primarily designed for the OEM and cost effectiveness, the 3200 exhibits excellent incremental accuracy: ± 0.2 dB or 1/2 percent up to 5 MHz; ± 0.2 dB or 1 percent up to 1 GHz; and ± 0.3 dB or 2 percent up to 2 GHz. Repeatability is better than 0.001 dB (± 3 σ valve) and switch life has been tested to over (10^7) operations. Having a switching speed of 6 milliseconds and an overall size of approximately 1 x 7/8 x 4 inches makes the 3200 ideally suited for RF level control in programmable signal generators and automatic test equipment.

The model 3200 is optionally available in a hermetically sealed verion which meets all environmental requirements of MIL-A-3933. Also available are interface cards which provide TTL or CMOS compatibility, and a combination IEEE 488 Bus Interface and power supply. Price for the model 3200 is $400 (domestic). Availability is 90 days ARO.

Contact Weinschel Engineering, Gaithersburg, Maryland; (301) 948-3434, TWX: 710-828-9705. Circle INFO/CARD #113.

Coaxial Cable Hand Stripper

Designed to perform two and three step strip configurations, the new coaxial cable stripper from AMP Incorporated can strip coaxial cable in .140" to .300" diameters. The lightweight polyamide tool body houses an interchangeable blade cassette and V-



block. Three different color-coded V-blocks are included with each hand stripper to process RG 58/59, RG 174, and Belden 8281 cable ranges.

Three standard color-coded versions of the blade cassette are available to accommodate commercial BNC, single and dual crimp BNC and UHF coaxial connectors from AMP Incorporated. Four alternate blade sets are provided in each cassette.

Additional information concerning the coaxial cable stripper is available from AMP Incorporated, Harrisburg, PA 17105; (717) 564-0100. Circle INFO/CARD #90.

Automatic Frequency Counter

The EIP model 451 microwave frequency counter provides fully automatic direct measurement of pulsed

RF signals. The counter allows measurement of signals covering the frequency range from 300 MHz to 18 GHz, with pulse widths as narrow as 100 nanoseconds, without external gating or manual tuning.

An eight-page application note providing in-depth information on the model 451 characteristics and theory

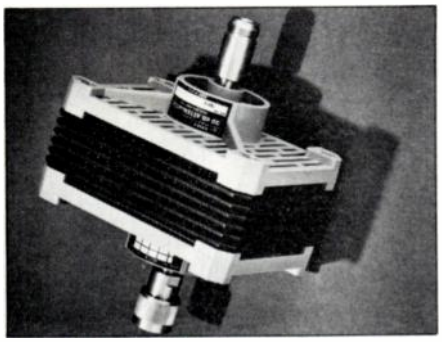
of operation is available from EIP. The application note also describes measurement techniques generally associated with pulsed RF and time-varying CW signals, and discusses the timing and accuracy considerations associated with automatic frequency measurement. Applications involving the automatic pulse and pulse profile capabilities of the model 451 are included.

When making pulsed frequency measurements, the EIP model 451 eliminates the need for cavity wavemeters, transfer oscillators and other auxiliary equipment.

The model 451 is priced at $7200, with delivery in from six to eight weeks after receipt of order. For more information, contact Howard Lurie at EIP, 3230 Scott Blvd., Santa Clara, CA 95051; (408) 244-7975. Circle INFO/CARD #89.

25-Watt Coaxial Attenuator

For broadband coaxial measurements at medium power, Hewlett-Packard now offers a new 30 dB attenuator; the HP 8498A, which covers the DC-18 GHz frequency range. An important feature of the 8498A is its attenuator pad that is designed to be bilateral, with either end able to accept 25 watt input. The standard



connector configuration uses one type N male and one type N female so that adapters are not needed for direct connection to high power. Standing wave ratio is 1.3 at 18 GHz.

The 8498A design provides efficient heat dissipation with cooling fins which remain cool to the touch even during operation at 25 watts. Thus reconnections can be made without waiting for the unit to cool.

Contact Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, CA 94304. Circle INFO/CARD #88.

Miniature 600 MHz Frequency Counter

From Optoelectronics, Inc. is a hand held 600 MHz frequency counter model "OPTO-7000" featuring commercial quality and "large counter" features. Features included are, large

red .4" LED digits, attractive and rugged gold and black aluminum case, Hi-Z input of 1 megohm and 20 pf with sensitivity of less than 10 Mv. from 10 Hz to 50 MHz, 50 ohm input: 10 MHz to 600 MHz — built in pre-amp and prescaler standard TCXO Xtal time base ± .08 PPM/C° over range of 0-60°C (± 1 PPM 20-40°C Typical), extreme stability TCXO < ± 0.1 PPM 17-40°C available as option, selectable 1 sec & .1 sec gate times resolution: 1 Hz to 6 MHz (with S4 option), 10 Hz to 60 MHz, 100 Hz to 600 MHz, automatic decimal placement. Contact Oploelectronics, 5821 N.E. 14th Avenue, Fort Lauderdale, Florida 33334 (305) 771-2050. Circle INFO/CARD #122.

Schottky Devices

Raytheon Company, Semiconductor Division, has received MIL-M-38510, Part I, QPL status on two additional low power Schottky devices. The latest approval reaffirms Raytheon's commitment to the military market. The devices are:

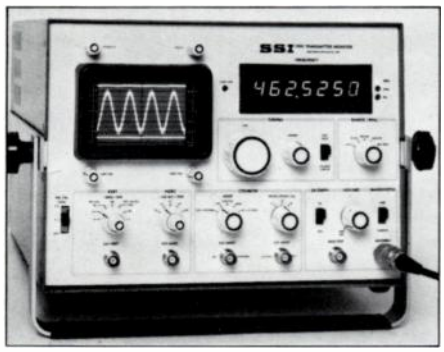
Gov. Designator MIL-M-38510	Industry Equiv.	Package
/30701BEB	54LS138JO6DD	16-Pin Ceramic Dip
/30904BEB	54LS158JO6DD	16-Pin Ceramic Dip

Raytheon's Semiconductor Division has 115 low power Schottky device types available now, including the latest 240 series of octals. Raytheon

offers the full performance range of low power Schottky devices over the military temperature range. Contact D. Andersen, manager Marketing Communications, Raythoen Semiconductor, 350 Ellis Street, Mountain View, CA 94040; (415) 968-9211. Circle INFO/CARD #85.

Transmitter Monitor

A versatile new transmitter monitor that measures carrier frequency plus either AM or FM modulation and 'sub audible tone' frequencies 'off



the air' has been introduced by Spectrum Specialties, Inc. The model SSI-1000 combines a sensitive FM/AM receiver with 1000 MHz counter and a modulation scope.

The FM/AM receiver is tunable from 20 MHz to 1000 MHz and 'phase locks' with a 1 PPM/yr. TCXO to assure stable and accurate transmitter measurements. The counter can be switched 'internally' to measure either carrier or tone frequencies 'off the air', or externally' for audio or RF measurement on the bench.

A modulation scope with wide band circuitry allows viewing of signals from 1 Hz to 200 kHz (digital squelch pulses can be readily observed). The rectangular CRT display provides instantaneous and accurate AM or FM modulation measurements.

A three year warranty with PC board exchange program and telephone trouble shooting provide ease of servicing and continued product support.

Contact Spectrum Specialties, Inc., 3639 Enochs Street, Santa Clara, CA 95051; Richard Walsworth, (408) 737-7374. Cicle INFO/CARD #86.

Sub-Audible Tone Monitor/Counter

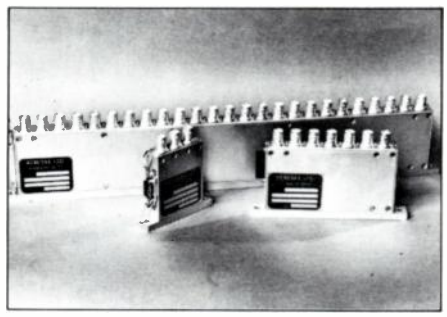
International Tele-Path announces their new model IT—101 sub-audible tone counter. The unit counts all E.I.A. standard tone frequencies from 67 Hz to 203.5 Hz. This includes the half channel slots of 74.4, 79.7, 85.4, 91.5 and 97.4 Hz. The unit needs only a squelched audio input from a receiver or scanner. No extra filters or voltages are required.

A six digit display indicates the tone and count. This information may be viewed at the same time it is received or counts of all tones may be recalled from memory at any time. All tone counts can be reset at once or individually, whichever you desire. 98 counts-per-tone are held in memory with a typical tone lock time of one or two seconds. Price for unit IT-101 is $499.95; Nicad back-up option, $35.95; variable seize time option, $12.95.

Contact International Tele-Path, 3835 Perie Lane, San Jose, CA 95132; (408) 923-2229. Please circle INFO/CARD #81.

Coaxial Stacked Switching Arrays

R.F. Components, the U.K. distributor of Amphenol RF relays and switches, announces crossbar coaxial selector,



with ten inputs and ten outputs. Reed relays, operated by DC signals, select any one point of connection. Customers can select any working voltage from 5 to 50, the number of the cross-points, and also the impedance of the channels: either 50 or 75 ohms.

Contact R.F. Components, Plumpton Rd., Hoddesdon, Hertfordshire, England (telephone Hoddesdon [US code 01144 9924] 63603). Please circle INFO/CARD #117.

Mini-UHF Plug and Jack

A new line of miniature UHF plugs and jacks with five times greater frequency range than standard size connectors and instant-on FCP-type termination feature has been developed by Amphenol North America Division, Bunker Ramo Corporation, Danbury, Connecticut.

The mini-UHF connectors are designed to replace standard size UHF connectors used with RG-58/U coax cable. Typical applications include new miniaturized CB rigs, two-way radio, marine communications, ham radio, related base and mobile equipment/accessories, and instrumentation — virtually anywhere space is at a premium and flexibility of higher frequency performance is required.

Compared to standard size UHF connectors, which have a 500 MHz frequency limit, new Amphenol 81 series mini-UHFs can operate up through 2.5 GHz with VSWR of less than 1.25:1.

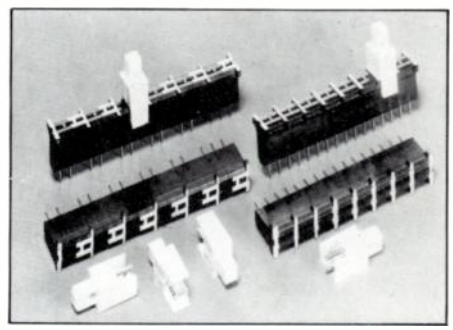
Contact Burson-Marsteller/Chicago, Tele: (312) 329-9292. Please circle INFO/CARD #82.

Socket/Plug Replaces DIP Switch

A new socket/plug series does either programming or on-off switching — and costs 50 percent less than conventional DIP switches.

The programming switch consists of a SWS switch socket and a white SWP switch plug. The plug is simply inserted in the socket where a signal is desired thru the circuit. It can be changed to another circuit by snapping it out of one socket position and placing it in another. The on-off switch works the same way, simply by placing the plug wherever the desired on or off function is required.

In 1000-lot quantities the SWS-36-G (on left) is $.384 each, the SWS-28-G (on right) is $.512 each, and SWP-1-G is $.08 each. Availability six weeks ARO. For information contact: Robinson-Nugent, 800 East Eighth Street, New



Albany, Indiana 47150. Phone: (812) 945-0211. Circle INFO/CARD #118.

Flexible Microwave Absorber

Flexflow™ is available as a two part kit to produce flexible microwave absorber in the shape of gaskets, 0-rings, pyramid loads for high vibration, etc. The 10 lb. kit sells for $86.25 with a one-time setup charge of $50.00. Contact Microwave Filter Company, Inc., 6743 Kinne St., East Syracuse, N.Y. 13057; Emily Bostick, Tele: (315) 437-3953. Please circle INFO/CARD #83. □

How to Understand Frequency Counter Specifications

With the increasing sophistication of frequency counter applications, such as time domain stability measurements, engineers need better defined counter specifications, as well as new specifications.

In a new 34-page application note from Hewlett-Packard, engineers and technicians are able to review basic counter specifications as well as become acquainted with new specs. It contains sections detailing input characteristics of counters including range, sensitivity, signal operating range, dynamic range and trigger level considerations.

Operating mode specifications are covered which include various range specifications and a discussion of least significant digit, resolution and accuracy.

Several appendices cover topics such as time interval averaging, RMS specifications, effects of wideband noise and measurement of counter contributed noise.

The booklet, liberally illustrated, also include many examples. It is available from Hewlett-Packard, 1507 Page Mill Road, Palo Alto, California 94304, free of charge. Ask for AN 200-4, *Understanding Frequency Counter Specifications,* Publication No. 02-5952-7522. Circle INFO/CARD #114.

Connector Catalog

A new 12-page brochure on the environmental KJJ filter connector has been distributed by ITT Cannon Electric, Phoenix, Arizona.

Catalog KJJL/KJJ-2 illustrates in detail "all you want to know" about these MIL-C-38999 type miniature circular filter connectors that offer less space, reduced weight, less wiring, reduced cross-talk and greater reliability. Designed for commercial, industrial and aerospace applications, the KJJ series will accommodate up to 128 contacts and are tested 100 percent (twice) during both in-process and final inspections for capacitance, insulation resistance, and dielectric withstanding voltage.

The catalog contains 49 drawings, 15 photographs and a batch of charts and graphs. ITT Cannon Electric is an international producer of electrical connectors and electronic test accessories for the telecommunications, computer and business machine; military and aerospace; automotive and energy markets.

Contact ITT Cannon Electric, 666 East Dyer Rd., P.O. Box 929, Santa Ana, Calif. 92702. (714) 557-4700. Circle INFO/CARD #119.

Automatic Test Systems Catalog

Automatic test systems today are more flexible in application, lower in cost, and easier to assemble and program than in the past. Some of the reasons are more-powerful operating systems in new, lower-priced minicomputers, and a wide array of instrumentation that is programmable in standard ways. Seven specific examples are described in a new 16-page four-color brochure from Hewlett-Packard, along with straightforward explanations of the variety of choices available to test-system specifiers.

'HP 1000 Automatic Test Applications' is available without charge from Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, Calif. 94304. Circle INFO/CARD #130.

Automatic Frequency Counter And Application Note

The EIP model 451 microwave frequency counter provides fully automatic direct measurement of pulsed RF signals. The counter allows measurement of signals covering the frequency range from 300 MHz to 18 GHz, with pulse widths as narrow as 100 nanoseconds, without external gating or manual tuning.

An eight-page application note providing in-depth information on the model 451 characteristics and theory of operation is available from EIP. The application note also describes measurement techniques generally associated with pulse RF and time-varying CW signals, and discusses the timing and accuracy considerations associated with automatic frequency measurement. Applications involving the automatic pulse and pulse profile capabilities of the model 451 are included.

The model 451 is priced at $7200, with delivery in from six to eight weeks after receipt of order. Contact Howard Lurie at EIP, 3230 Scott Blvd., Santa Clara, CA 95051; (408) 244-7975. Circle INFO/CARD #101.

Potentiometer Catalog

A new 16-page catalog describing Centralab's versatile series 300, 16mm (5/8 inch), industrial grade potentiometer is now available from Centralab. Series 300 Potentiometers offer the electronics designer both single and multiple configurations with a variety of pushbutton and rotary switch combinations.

The new catalog contains a comprehensive listing of the series 300 features and benefits, specifications and dimensional drawings. It also offers potentiometer "Tips", catalog numbers available thru local distrubutors and a handy "How To Order" section. Copies are available by writing Centralab Electronics Division, Globe-Union Inc., 5757 N. Green Bay Avenue, P.O. Box 591, Milwaukee, Wisconsin 53201. Circle INFO/CARD #102.

RF Power Transistor Catalog

Amperex Electronic Corporation, a wholly owned subsidiary of North American Philips Corporation, announces the availability of a new RF Power Transistor Catalog. This catalog outlines the broad spectrum of RF power transistors and RF modules that are available from the Hicksville Division of Amperex.

In general, the transistors outlined in this catalog are designed for use in applications above 1 MHz with RF powers above 1 watt. The catalog divides the transistors into two categories. The first category is for those transistors used at collector voltages of 12.5 to 13.6 volts. These devices are primarily designed for vehicular communications, including 12.5 volts SSB applications. The second category of transistors are those used at collector voltages of 28 volts. These devices are designed for military and base station applications where low current power supplies are used.

The catalog is available without charge from the Hicksville Division of Amperex. To obtain your copy, simply write or call Marty Burden, Product Manager, R.F. Power Transistors, Amperex Electronic Corporation, Hicksville Division, Hicksville, New York, 11802. Telephone (516) 931-6200. Circle INFO/CARD #123.

DIP Switch Catalog

This new catalog describes all the different DIP switches you will need from the different DIP switch company, Grayhill, Inc., La Grange, Illinois.

This catalog is complete — containing the latest information about the bottom seal SPST DIP switch that is impervious to flux and cleaning solutions when a top tape seal is added. The top actuated DIP switch with raised or recessed rockers, as

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well as the side actuated DIP switch, can be sealed in this manner. The side actuated, or Grayhill's Piano-DIP™ can be used for programming functions on closely racked PC boards. The DIP-C™ (SPDT circuitry) and the Double-DIP™ (DPDT circuitry) are also described. The double throw DIP switches are available with toggle actuators and a long life rating that makes them adaptable to front panel applications.

In addition to complete specification information, part numbers and prices are included. Request Catalog No. 3 from Tom Menzenberger, Grayhill, Inc., 561 Hillgrove Avenue, La Grange, IL 60525, or call (312) 354-1040. Circle INFO/CARD #103.

Training Course Includes Take-Home Microcomputer Board

A newly developed F3870 single-board microcomputer is being offered to systems designers who attend a four-day F3870 and F8 training course conducted by Fairchild Camera and Instrument Corporation, Mountain View, Calif.

The single-board microcomputer, designed for prototyping, emulating and programming (387X PEP system) can be used as a design aid for any systems based on standard F3870, F3872, F3874 or F3876 devices. The board provides built-in option for the user to program operating codes into either the F38E70 or into 2716 EPROMS.

Fairchild's microcomputer courses include extensive laboratory sessions which afford attendees an opportunity for hands-on experience in all phases of the systems design cycle. Additional information is available from Microprocessor Training, Fairchild Camera and Instrument Corporation, 464 Ellis Street, Mail Stop 20-1000, Mountain View, CA 94042 or by calling (415) 962-3710. Circle INFO/CARD #104.

Physical Data For Displays

"Displays and Connectors Physical Data," an application note recently published by Beckman Instruments, Inc. supplements the company's short form catalog with information concerning physical data for connectors and displays in series SP-100, SP-200, SP-300 and SP-400 planar gas discharge displays.

The 12-page brochure is filled with drawings and tables for both English and Metric physical dimensions as well as segment designations and pin locations.

In addition, diagrams identify digits and segments and a table lists correspondence between pins and segments, by product type number, as an aid to faster selection.

To receive a copy of the new Displays and Connectors Physical Data Application Note, write: Beckman Instruments, Inc., Display Systems Division, Technical Information Services, 350 North Hayden Rd., P.O. Box 3579, Scottsdale, AZ 85257; (602) 947-8371. Circle INFO/CARD #105.

High Voltage Ceramic Capacitors Catalog

A six-page catalog detailing the characteristics of five new types of KD high voltage ceramic capacitors is available from KD Components of Santa Ana, California.

Complete specifications for the T5, T7, T12, T15 and T20 capacitors, with voltages from 2.5 to 30KV, are given in the catalog. General information on the physical dimensions, design and applications of the high voltage-resistant capacitors is outlined. Specific data on maximum voltage values, dissipation factors, and temperature coefficients is spelled out on easy-to-read charts.

Complete part number and ordering information is included in the catalog 278, which is available from KD Components, 3016 Orange Avenue, Santa Ana, CA 92707. Circle INFO/CARD #106.

Calibrated Data Report For Microwave Attenuators

Fixed and step attenuators have long been used as reference standards in microwave measurements. Step attenuators often find application as signal-level-setting elements in signal generators. Both of these applications require accurate calibration data of attenuation vs. frequency, beyond that offered by the usual data sheet specification. If such calibration reports were done in a microwave standards laboratory, costs could be quite high.

Now an optional test report can be provided from tests performed on an HP 8542B computer-operated automatic network analyzer. Several programming changes and higher accuracy procedures have been made to permit this complete test report to be generated. The test report includes SWR data for both ports and attenuation data at 42 frequencies from 100 MHz to 18 GHz.

Users can program their test system data bank with such step attenuation data to improve accuracy of output test signals. The data is accessed from a look-up table and programmed in as a correction factor at the various frequencies and output levels. Contact Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, CA 93404. Circle INFO/CARD #108.

Connector Catalog

Purchase a new 10-page color Catalog on D & J subminiature rectangular filter connectors from ITT Cannon Electric, Santa Ana, California.

Catalog FDJ-2 provides details on operating temperatures, types of contacts, intermateability with standard product lines, typical filter performance, electrical data, contact arrangements, accessories and shell dimensions.

D*J connectors are intermateable and interchangeable with MIL-C-2438 types and meet applicable portions of that spec. They are designed to filter a great number of circuits in relation to their size and weight.

Contact Richard L. Harmon, (714) 557-4700, ITT Cannon Electric, 2801 Air Lane, Phoenix, AZ 85034. Circle INFO/CARD #110.

10 MHz-26 GHz Broadband Radiation Monitoring Systems

The 8600 series of broadband radiation monitoring systems was specifically developed by Narda to provide flat, accurate near and far field power density measurements over the frequency range of 10 MHz to 26 GHz. This broadband coverage is provided by four isotropic measurement probes, selected by the customer depending on frequency and sensitivity requirements.

All of the available probes are compatible with the two metering instruments; the smaller hand-held model 8611, or the model 8616 metering instrument with MAX-HOLD, AUTO ZERO and ALARM features.

To obtain a copy of Narda's new Broadband Radiation Monitoring Systems Brochure, please write on your letterhead to Robert E. Sowden, Marketing Services Coordinator, The Narda Microwave Corporation, 75 Commercial Street, Plainview, NY 11803 or, for faster service, call (516) 433-9000. Circle INFO/CARD #107.

756-Page Electronic Component Catalog

A new 756-page catalog, No. 104, is now available from Newark Electronics. 24 new lines are included

in the 190 major lines displayed in the new catalog. Among the established lines are the products of Allen-Bradley, Alpha, Amphenol, Belden, Bourns, Bud, Centralab, TRW/Cinch, Cornell-Dubilier, Cutler-Hammer, General Electric, International Rectifier, Mallory, Motorola, Ohmite, Potter & Brumfield, RCA, SPC Technology, Sprague, Switchcraft, Texas Instruments.

Descriptions, electrical and physical specifications and illustrations are provided for semiconductors, resistors, capacitors, potentiometers, controls, switches, relays, fuses, circuit breakers, transformers, connectors, sockets, wire, cable, lamps, lights and other related electronics products.

Detailed product indexing and a separate index of manufacturers are designed to assist in product selection.

Catalog No. 104 is available free on requests sent to Newark Electronics, 500 N. Pulaski Road, Chicago, IL 60624, and on mail or phone requests to any of the 85 Newark locations from coast to coast. Circle INFO/CARD #112.

Quiet Line Filter Handbook

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

The handbook includes information on regulatory agencies and EMI prevention methods including grounding, shielding, balanced lines, twisted pairs, coaxial cables, etc. Ferrite filters are discussed in detail, with emphasis on proper filter testing, installation and application. Considerations for digital circuits are given special attention.

Directed at the application of AMP quiet line low-pass subminiature filters, the booklet also includes a filter selection guide and charts indicating full electrical performance characteristics of AMP Incorporated's EMI filter products.

A copy of the AMP filter handbook and additional information on the Quiet line filter series are available from the AMP Capitron Division, Elizabethtown, PA 17022. Circle INFO/CARD #109.

Sure-Seal™ Catalog

Publication of a new color catalog on Sure-Seal™ environmental connectors has been announced by ITT Cannon Electric, Santa Ana, Calif.

Sure-Seal connectors are tailored for the automotive field, and also fit areas as marine, recreation, household appliance, solar energy and agricultural applications.

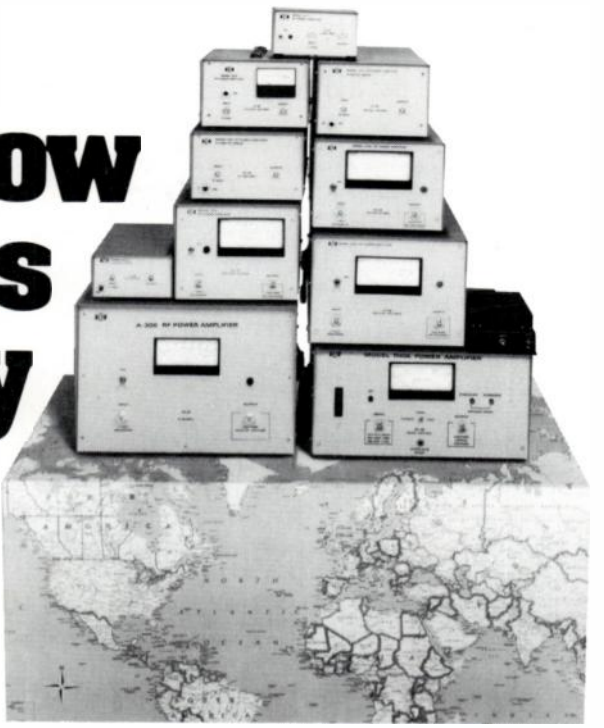
Catalog SS-3 is a 12-page document containing 33 drawings, 21 photographs and 12 charts plus a full page of test data showing such information as contact tensile strength, solvent, weather and ozone resistance. Information includes details on all 10 models of the Sure-Seal connector (fom 1 to 10 contracts) materials and finishes, mechanical and electrical data and basic test criteria.

ITT Cannon Electric is an international producer of electrical connectors and electronic test accessories for the telecommunications; computer and business machine; military and aerospace; automotive and energy markets.

Contact Richard L. Harmon, (714) 557-4700, ITT Cannon Electric, 666 E. Dyer Road, Santa Ana, CA 92702. Circle INFO/CARD #116. □

Advertiser Index

Tomorrow ideas Today



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- 10 kHz to 500 kHz
- Up to 700 Watts Output
- Useful Power up to 1 MHz
- Built-in True Average Power Meter

Primarily designed as a transducer drive source, and for use in high power ultrasonic laboratory applications. Any load impedance may be connected to the output without fear of damage or oscillation.

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A revolutionary development in high power solid state amplifiers, the 1140L is designed for high power RF heating, ultrasonics and laboratory applications. Optional matching transformers will deliver full power to any load impedance from 3 ohms to 800 ohms balanced or unbalanced.

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Extraordinary performance in a wide range of transducer drive applications. The 240L is a high quality laboratory instrument for ultrasonics, biological research and electro-optic modulation.

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Designed to replace bulkier tube amplifiers, the model 3100L provides reliable and maintenance-free operation for NMR, ultrasonics and communications applications.

150 WATT/A150
- 300 kHz to 35 MHz
- Up to 250 Watts Pulse and CW
- No Bandswitching
- Works Into Any Load Impedance

An ultra-linear Class A design, the A150 will "boost" the output of any signal source by a flat 55 dB and provide its full forward power into any load impedance. High quality laboratory unit, for NMR, ultrasonics and biological research.

300 WATT/A300
- 300 kHz to 35 MHz
- Up to 500 Watts Pulse and CW
- 55 dB ± 1 dB Gain
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Highest power in a portable package. Top quality signal transmission in AM, SSB and pulse communication systems. Cannot be damaged by mistuned antenna.

40 WATT/440LA
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- 40 Watts Class A Linear
- State-of-the-Art
- Up to 75 Watts CW and Pulse

The widest band solid-state power amplifier available at its 40 watt power level, the ENI 440LA is truly a state-of-the-art instrument. As a drive source for high resolution acousto-optic modulators and deflectors, the model 440LA is invaluable.

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- 1.3 to 515 MHz Usable Coverage
- 9.5 Watts Linear Output
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An ultra-linear Class A design, the 510L provides faithful reproduction of the input waveform for AM, FM, SSB, CATV, pulse and other complex modulations. The use of microwave transistors on thin film substrates, microstrip circuitry, and plug-in modules make this unit reliable and easy to service.

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- Flat 37 dB Gain
- Up to 5 Watts Saturated

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ENI, 3000 Winton Rd. So., Rochester, New York 14623. Call 716-473-6900. TELEX 97-8283 ENI ROC.

INFO/CARD 7

TO-5 RELAY UPDATE

Still the world's smallest RF relay ...and the stingiest

When we first told you about the inherently low inter-contact capacitance and low contact circuit losses of our TO-5 relays, you agreed that they were ideal for RF switching. And you began designing them in immediately. They provided high isolation and low insertion loss up through UHF (typical performance 45 db isolation and 0.1 db insertion loss at 100 MHz).

Then you discovered another benefit – particularly for hand-held transceivers where battery drain is critical. The TO-5 is very stingy on coil power; the sensitive versions draw only 210mW at rated voltage.

So if you're looking for a subminiature RF switch, don't settle for anything less than TO-5 technology. It's available in commercial/industrial as well as MIL qualified types. Write or call us today for full technical information.

TELEDYNE RELAYS

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