microwave
JOURNAL
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COMMUNICATIONS

• Earth Station TWT • SATCOM Tube Review • The Home TVRO Market
• FET's in Satellite Payloads • Airborne SATCOM Phased Array • MACOMNET

NEW SPECTRUM ANALYZERS

The performance you need... the economy you want.

100 kHz to 40 GHz

Here's what Polarad's new refined 3rd generation, 600 "B" Series Spectrum Analyzers offer you...

- 80 dB on-scale range for 10 dB/div. log scale.
- Improved accuracy for 2 dB/div. and linear scales.
- Greater sensitivity, flatness and noise-free dynamic range.
- Improved dynamic range for harmonics and IM.
- Reduced residual FM and noise sidebands.
- Greater accuracy for Frequency readout and Spans.
- Expanded frequency coverage; 3 MHz to 40 GHz (Models 630B & 640B).
- Cooler operating temperatures increase service life.

NEW ACCESSORIES for the Internal Digital Memory and Programmable Data Processing Interface:

- Model 6488 Adapter for the GPIB, IEEE-488 Bus.
- Model 6700 Digital Cassette Recorder stores and recalls up to 120 displays per cassette.

Model	Freq. Range	U.S.A. Prices (Jan. 81) Without Memory	Including Memory
632B-1	100 kHz to 2 GHz	N/A	$10,175
630B	3 MHz to 40 GHz	$12,460	$14,285
640B	3 MHz to 40 GHz with internal preselector	$16,170	$17,995

Call or write for complete specifications or to request a demonstration.

d polarad polarad **polarad** p

Polarad Electronics. Inc. 5 Delaware Dr. Lake Sucess N.Y. 11042 Tel: 516-328-1100 TWX: 510-223-0414

CIRCLE 1 ON READER SERVICE CARD

Amplifiers

4 GOOD REASONS WHY THE TREND IS TO TRONTECH

	Model Number	Frequency 1dB BW Minimum	Gain (dB) Minimum	Noise Figure (dB) Typ.	Noise Figure (dB) Max.	Pwr. Out @ 1dB Gain Comp. Pt. (dBm) Minimum		Features/ Applications
1.	SPECIAL PURPOSE AMPLIFIERS							
	W110F	1-110 MHz	55	1.0	1.2	+ 15		Low Noise/MR expr.
	W250G	5-250 MHz	43	1.3	1.5	+ 25		Wide Dynamic Range
	P150P	.08-150 MHz	60	1.3	1.5	+ 30		Pulse Amplifier
	P2GS	.05-2 GHz	20	5.5	6.0	+ 23		Increase Sweeper Power
	L215GB	2.15-2.165 GHz	21	3.0	3.5	+ 7		MDS Preamp.
	L13GE-1	1.2-1.4 GHz	25	1.7	2.0	+ 8		Low Noise/Radar
	WV110A	1-110 MHz	60 dB, 70 dB Video	1.0	1.2	+ 15		Video Amp, IF & Video Output
2.	ULTRA LOW NOISE AMPLIFIERS							
	L60E	60 ± 5 MHz	60	1.0	1.1	+ 10		Low Noise IF
	W500E	5-500 MHz	30	1.2	1.4	0		Low Noise Wide Band
	L1GE	.9-1.1 GHz	25	1.6	1.8	+ 6		Low Noise
	W1GE	.01-1 GHz	20	1.6	1.8	− 3		Wide Band Low Noise
	W2G10B	.01-2 GHz	32	3.0	3.5	0		Wide Band Low Noise
	W15GB3	.05-1.5 GHz	30	1.7	2.0	+ 5		Wide Band Low Noise
	W2G2H	1-2 GHz	30	2.2	2.5	+ 5		Wide Band Low Noise
3.	MEDIUM POWER LINEAR AMPLIFIERS					Typ.	Min.	
	P100L	.08-100 MHz	27		5.0	+31	+30	Wide Dynamic Range
	P150H2	.1-150 MHz	27		6.0	+31	+30	Low Distortion
	P500A	2-500 MHz	37		3.0	+31	+30	Wide Dynamic Range
	P1000E	.02-1 GHz	20		6.0	+23	+21	Wide Band Linear
	P1GB	.01-1 GHz	30		6.0	+30.5	+30	Distribution, Driver Amp.
	P10GD	.5-1 GHz	30		9.0	+34	+33	Wideband Linear
	P23GT	2.3 ± .05 GHz	22		8.0	+31	+30	Wide Dynamic Range

4. The devices listed above are just a sample of our state of the art low noise and medium power amplifiers. TRONTECH's unique capability for "FAST ACTION . . . QUICK DELIVERY" on quality, high performance custom designed amplifiers is well known in the industry. Our capability includes: VIDEO & LIMITING, AMPLIFIERS, INTEGRATED ASSEMBLIES, MODULAR AMPLIFIERS, etc. Parameters such as gain, bandwidth, output power, noise figure, form factor, etc. can be tailored to your specs. To satisfy increased customer demand for our products we have moved to larger quarters.

Just give us a call, or write for our new brochure, and you will see why the trend is to TRONTECH.

TRONTECH INC.

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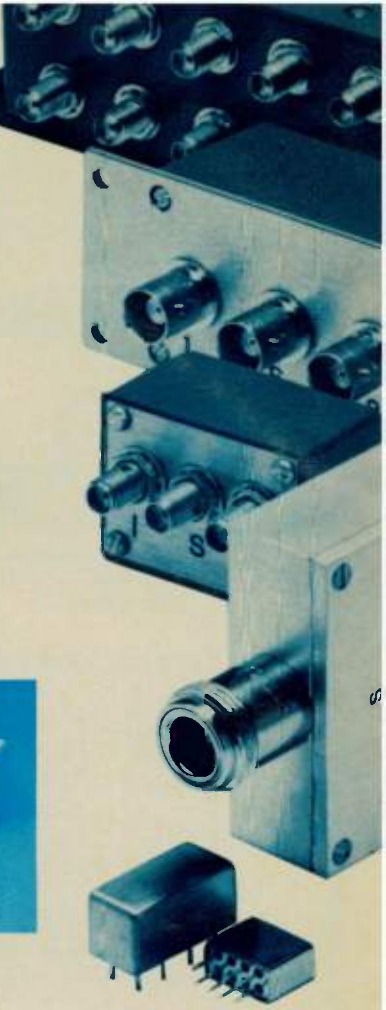
CIRCLE 4 ON READER SERVICE CARD

power splitters



TWO WAY 90°	TWO WAY 180°	TWO WAY 0°	THREE WAY 0°
(1.4-4200 MHz)	(10 KHz-500 MHz)	(2 KHz-4200 MHz)	(0.01-750 MHz)

the world's largest selection... covering 2 KHz to 4.2 GHz

from Mini-Circuits, from $9^{95}

Over 105 standard models 2-way to 24-way, 0°, 90°, 180°, pin or connector models... Mini-Circuits offers a wide variety of Power Splitters/Combiners to choose from, with immediate delivery. But there are always "special" needs for "special applications"... higher isolation, SMA and Type N connectors Intermixed, male connectors or wide bandwidths. Contact us. We can supply them at your request... with rapid turnaround time. Naturally, our one year guarantee applies to these units.

For complete specifications and performance curves refer to the Microwaves Product Data Directory, EEM, or the Gold Book.

Model	Freq. range (MHz)	Min. isol-dB (Mid-band)	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
2-WAY 90°					
PSCQ2-1.5	1.4-1.7	25	0.7*	2	$12.95 (5-49)
PSCQ2-3.4	3.0-3.8	25	0.7*	2	$16.95 (5-49)
PSCQ2-6.4	5.8-7.0	25	0.7*	2	$12.95 (5-49)
PSCQ2-7.5	7.0-8.0	25	0.7*	2	$12.95 (5-49)
PSCQ2-10.5	9.0-11.0	20	0.7*	2	$12.95 (5-49)
PSCQ2-13	12-14	25	0.7*	2	$12.95 (5-49)
PSCQ2-14	12-16	25	0.7*	2	$16.95 (5-49)
PSCQ2-21.4	20-23	25	0.7*	2	$12.95 (5-49)
PSCQ2-50	25-50	20	0.7*	2	$19.95 (5-49)
PSCQ 2-70	40-70	20	0.7*	2	$19.95 (5-49)
PSCQ 2-90	55-90	20	0.7*	2	$19.95 (5-49)
PSCQ 2-120	80-120	18	0.7*	2	$19.95 (5-49)
PSCQ 2-180	120-180	15	0.7*	2	$19.95 (5-49)
PSCQ 2-250	150-250	18	0.8*	2	$19.95 (5-49)
PSCQ 2-400	250-400	16	0.9*	2	$19.95 (5-49)
PSCQ 2-450	350-450	16	0.9*	2	$19.95 (5-49)
ZSCQ 2-50	25-50	20	0.7*	2,3	$39.95 (4-24)
ZSCQ 2-90	55-90	20	0.7*	2,3	$39.95 (4-24)
ZSCQ 2-180	120-180	15	0.7*	2,3	$39.95 (4-24)
ZMSCQ 2-50	25-50	20	0.7*	2,4	$49.95 (4-24)
ZMSCQ 2-90	55-90	20	0.7*	2,4	$49.95 (4-24)
ZMSCQ 2-180	120-180	15	0.7*	2,4	$49.95 (4-24)
ZAPDQ-1	500-1000	20	0.9	2,13	$59.95 (1-9)
ZAPDQ-2	1000-2000	18	0.9	2,13	$59.95 (1-9)
ZAPDQ-4	2000-4200	20	0.9	2,13	$59.95 (1-9)
2-WAY 180°					
PSCJ-2-1	1-200	25	0.8		$19.95 (5-49)
PSCJ-2-2	0.01-20	25	0.5		$29.95 (5-49)
ZSCJ-2-1	1-200	25	0.8	3	$37.95 (4-24)
ZSCJ-2-2	0.01-20	25	0.5	3	$47.95 (4-24)
ZMSCJ-2-1	1-200	25	0.8	4	$47.95 (4-24)
ZMSCJ-2-2	0.01-20	25	0.5	4	$57.95 (4-24)
ZFSCJ-2-1	1-500	25	1.5	5	$49.95 (4-24)
ZFSCJ-2-3	5-300	25	1.5	5	$39.95 (4-24)

1. 75 ohms impedance
*2. Average of coupled outputs less 3 dB
3. BNC connectors standard. TNC available
4. SMA connectors only
5. BNC connectors standard. TNC available. SMA & Type N available at $5 additional cost
6. BNC and TNC connectors. (SMA and Type "N" at $5 additional cost.) (BNC not available on ZAPD-4)

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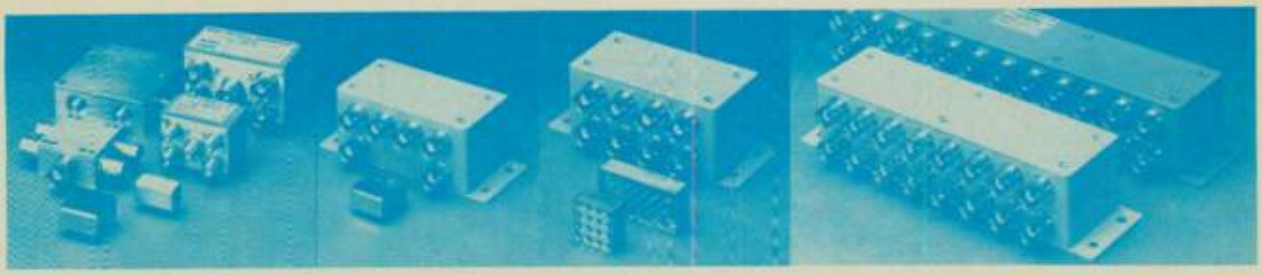
65-1 REV. A

CIRCLE 5 ON READER SERVICE CARD

and combiners



FOUR WAY 0°	SIX WAY 0°	EIGHT WAY 0°	SIXTEEN WAY 0°	TWENTY FOUR WAY 0°
(2 KHz-4200 MHz)	(1-175 MHz)	(0.01-750 MHz)	(0.5-125 MHz)	(0.2-100 MHz)

Model	Freq. range (MHz)	Min. isol-dB (Mid-band)	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
2-WAY 0°					
PSC 2-1	0.1-400	20	0.75		$9.95 (6-49)
PSC 2-1W	1-650	20	0.9		$14.95 (6-49)
PSC 2-2	0.002-60	20	0.6		$19.95 (6-49)
PSC 2-1-75	0.25-300	20	0.75	1	$11.95 (6-49)
PSC 2375	55-85	25	0.5	1	$19.95 (6-24)
PSC 2-4	10-1000	20	1.2		$19.95 (6-49)
MSC 2-1	0.1-450	20	0.75		$16.95 (5-24)
MSC 2-1W	2-650	25	0.8		$17.95 (5-24)
ZSC 2-1	0.1-400	20	0.75	3	$27.95 (4-24)
ZSC 2-1-75	0.25-300	20	0.75	1,3	$29.95 (4-24)
ZSC 2-1W	1-650	20	0.8	3	$32.95 (4-24)
ZSC 2-2	0.002-60	20	0.6	3	$37.95 (4-24)
ZSC 2375	55-85	25	0.5	1,3	$37.95 (4-24)
ZMSC 2-1	0.1-400	20	0.75	4	$37.95 (4-24)
ZMSC 2-1W	1-650	20	0.8	4	$42.95 (4-24)
ZMSC 2-2	0.002-60	20	0.6	4	$47.95 (4-24)
ZFSC 2-1	5-500	20	0.6	5	$31.95 (4-24)
ZFSC 2-1-75	0.25-300	20	0.75	5	$32.95 (4-24)
ZFSC 2-1W	1-750	20	0.8	5	$35.95 (4-24)
ZFSC 2-2	10-1000	20	1.0	5	$39.95 (4-24)
ZFSC 2-4	0.2-1000	20	1.0	5	$44.95 (4-24)
ZFSC 2-5	10-1500	20	1.0	5	$49.95 (4-24)
ZFSC 2-6	0.002-60	20	0.6	5	$36.95 (4-24)
ZFSC 2-6-75	0.004-60	20	0.8	1,5	$38.95 (4-24)
ZAPD-1	500-1000	19	0.6	6	$39.95 (1-9)
ZAPD-2	1000-2000	19	0.6	6	$39.95 (1-9)
ZAPD-21	500-2000	18	0.7	6	$49.95 (1-9)
ZAPD-4	2000-4200	19	0.8	6	$39.95 (1-9)
3-WAY 0°					
PSC 3-1	1-200	25	0.7		$19.95 (5-49)
PSC 3-1W	5-500	15	1.4		$29.95 (5-49)
PSC 3-1-75	1-200	25	0.7	1	$20.95 (5-49)
PSC 3-2	0.01-30	25	0.45		$29.95 (5-49)
PSC 3-13	1-200	35	0.6		$24.95 (5-49)
ZSC 3-1	1-200	25	0.7	3	$37.95 (4-24)
ZSC 3-1-75	1-200	25	0.7	1,3	$38.95 (4-24)
ZSC 3-2	0.01-30	25	0.45	3	$47.95 (4-24)
ZSC 3-2-75	0.02-20	25	0.6	1,3	$48.95 (4-24)
ZMSC 3-1	1-200	25	0.7	4	$47.95 (4-24)
ZMSC 3-2	0.01-30	25	0.45	4	$57.95 (4-24)
ZFSC 3-1	1-500	20	0.9	5	$39.95 (4-24)
ZFSC 3-1W	2-750	20	1.0	5	$41.95 (4-24)
ZFSC 3-13	1-200	35	0.6	5	$39.95 (4-24)

Model	Freq. range (MHz)	Min. isol-dB (Mid-band)	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
4-WAY 0°					
PSC-4-1	0.1-200	20	0.75		$28.95 (6-49)
PSC 4-1-75	1-200	20	0.9	1	$24.95 (6-49)
PSC-4-3	0.25-250	20	0.75		$23.95 (6-49)
PSC-4A-4	10-1000	15	1.1		$49.95 (6-49)
PSC-4-6	0.01-40	25	0.5		$29.95 (6-49)
ZSC-4-1	0.1-200	20	0.75	3	$46.95 (4-24)
ZSC-4-1-75	1-200	20	0.8	1,3	$46.95 (4-24)
ZSC-4-2	0.002-20	25	0.5	3	$69.95 (4-24)
ZSC-4-3	0.25-250	20	0.75	3	$43.95 (4-24)
ZMSC-4-1	0.1-200	20	0.75	4	$56.95 (4-24)
ZMSC-4-2	0.002-20	25	0.5	4	$79.95 (4-24)
ZMSC-4-3	0.25-250	20	0.75	4	$53.95 (4-24)
ZFSC-4-1	1-1000	18	1.5	8	$89.95 (1-4)
ZFSC-4-1W	10-500	20	1.5	8	$74.95 (1-4)
ZFSC 4375	50-90	30	1.2	1,8	$89.95 (1-4)
ZA4PD-2	1000-2000	18	1.0	14	$79.95 (1-9)
ZA4PD-4	2000-4200	18	1.0	14	$79.95 (1-9)
6-WAY 0°					
PSC 6-1	1-175	18	1.0		$68.95 (1-5)
ZFSC-6-1	1-175	20	1.2	9	$89.95 (1-4)
8-WAY 0°					
PSC 8-1	0.5-175	20	1.1		$68.95 (1-5)
PSC 8-1-75	0.5-175	20	0.8	1	$69.95 (1-5)
PSC 8A-4	5-500	18	1.8		$89.95 (1-5)
PSC 8-6	0.01-10	23	1.1		$79.95 (1-5)
ZFSC 8-1	0.5-175	20	1.1	10	$89.95 (1-4)
ZFSC 8-1-75	0.5-175	20	1.0	1,10	$90.95 (1-4)
ZFSC 8375	50-90	25	1.3	1,10	$119.95 (1-4)
ZFSC 8-4	0.5-700	20	1.5	10	$129.95 (1-4)
ZFSC 8-6	0.01-10	23	1.1	10	$109.95 (1-4)
16-WAY 0°					
ZFSC 16-1	0.5-125	18	1.6	11	$174.95 (1-4)
24-WAY 0°					
ZFSC 24-1	0.2-100	20	2.0	12	$264.95 (1-4)

7. TNC, SMA & Type N at $5 additional cost. Please specify connector.
8. SMA connectors standard, BNC on request.
9. BNC connectors standard. TNC available, SMA available at $15 additional cost.
10. BNC connectors standard. TNC available at $10 additional cost. SMA at $25 additional cost.
11. BNC connectors standard. TNC available at $20 additional cost. SMA available at $45 additional cost.
12. BNC connectors standard. TNC available at $35 additional cost. SMA available at $65 additional cost.
13. BNC connectors (not available for ZAPDQ-4). TNC available. (SMA [3MM] and Type N on request. Add $5 per unit.) Please specify connectors.
14. TNC, SMA, Type N please specify connectors.

65-2 REV. A

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Dates: June 15-17, 1982

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1981 MTT-S Exhibitors: 156 organizations exhibited at Los Angeles, June 15-17, 1981.

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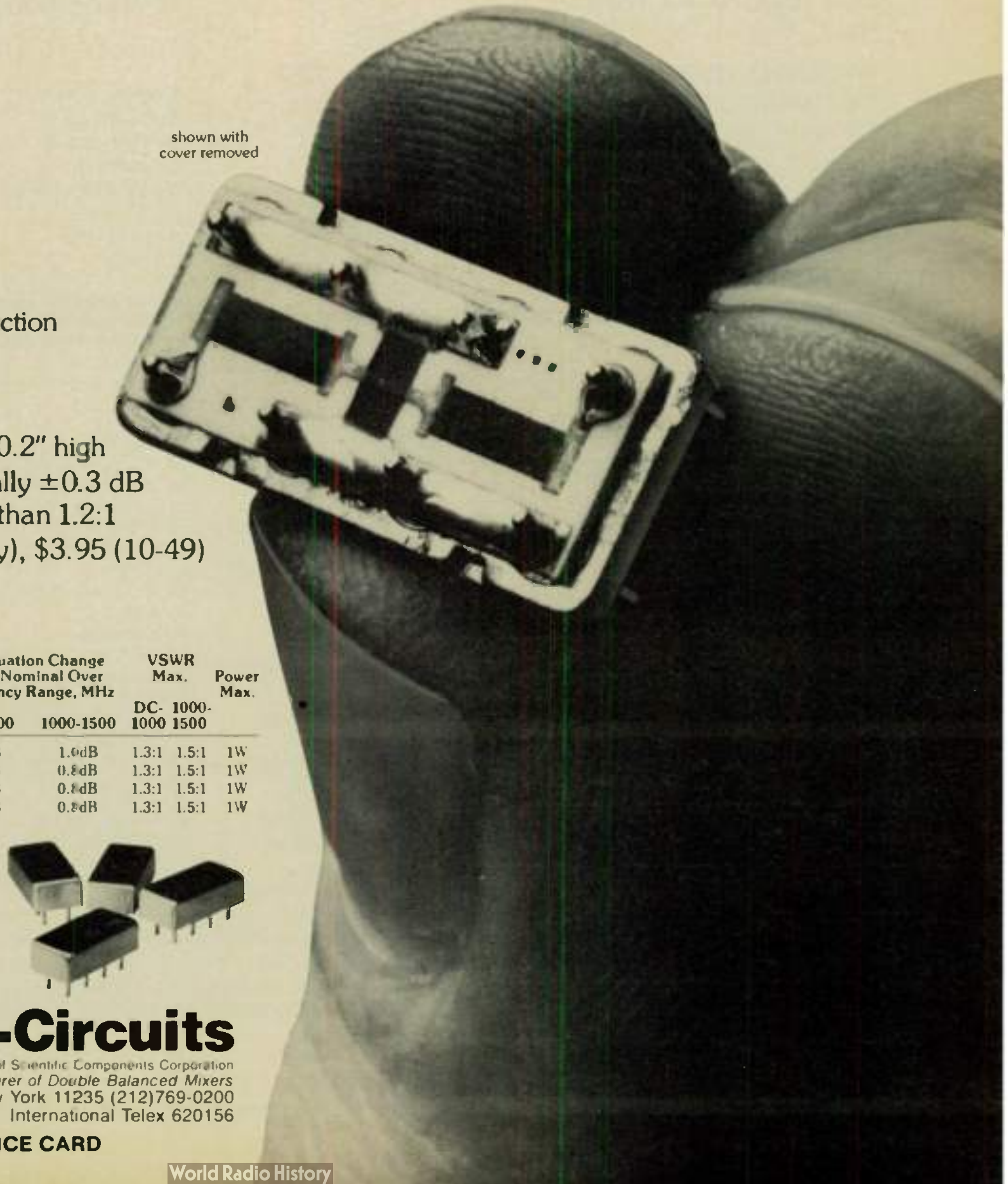

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- √ Low cost: $1.95 (1,000 quantity), $3.95 (10-49)
- √ Delivery: From stock

Model	Attenuation, dB Nominal Value	Attenuation Tolerance from Nominal	Frequency Range MHz	Attenuation Change From Nominal Over Frequency Range, MHz		VSWR Max.		Power Max.
				DC-1000	1000-1500	DC-1000	1000-1500	
AT-3	3	±0.2dB	DC-1500	0.6dB	1.0dB	1.3:1	1.5:1	1W
AT-6	6	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W
AT-10	10	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W
AT-20	20	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W

Mini-Circuits

A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
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CIRCLE 6 ON READER SERVICE CARD

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AUGUST 1981

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ON THE COVER: Teleconferencing and related services available from MACOMNET, a low cost, satellite-linked business communications system, are depicted by Mark Bellerose of Gunn Associates. Art courtesy of MA/COM, Inc. Story begins on p. 86

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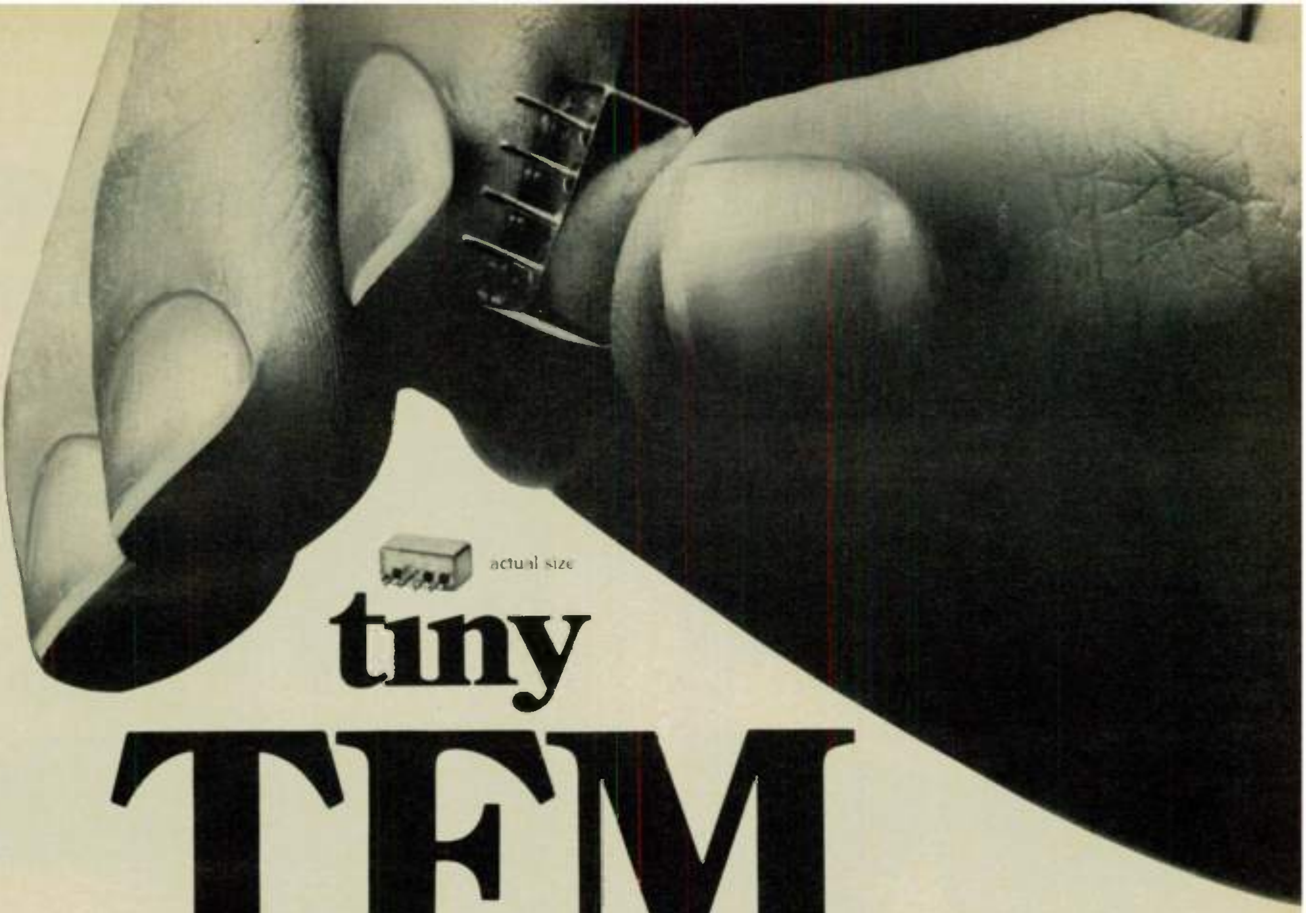
Microwave Journal is issued without charge upon written request to qualified persons working in that portion of the electronics industry including governmental and university installation that deal with VHF through light frequencies. Other subscriptions, domestic, $36 per year, two-year subscriptions $85, back issues (if available) and single copies $5.00. Microfilm copies of Microwave Journal are available from University Microfilms, 300 N. Zeeb Rd., Ann Arbor, MI 48106.

BPA

Horizon House also publishes Telecommunications and Journal of Electronic Defense



tiny TFM

the world's smallest hermetically sealed mixers

40 KHz to 3 GHz MIL-M-28837 performance

The TFM Series from Mini-Circuits from $11[95]

Increase your packaging density, and lower your costs... specify Mini-Circuits miniature TFM Series. These tiny units 0.5" x 0.21" x 0.25" are the smallest, off-the-shelf Double Balanced Mixers available today.

Requiring less PC board area than a flat-pack or TO-5 case, the TFM Series offer greater than 45 dB isolation, and only 6 dB conversion loss.

Manufactured to meet all the requirements of MIL-M-28837, the tiny but rugged TFM units have become the preferred unit in new designs for military equipment.

E-Z Mounting for circuit layouts
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 No.	Frequency Range MHz		Conversion Loss dB, Typical		Isolation dB, Typical						Price	
					Lower Band Edge to One Decade Higher		Mid Range		Upper Band Edge to One Octave Lower			
	LO RF	IF	One Octave from Band Edge	Total Range	LO-RF	LO-IF	LO-RF	LO-IF	LO-RF	LO-IF	$ EA.	QTY.
TFM-2	1-1000	DC-1000	6.0	7.0	50	45	40	35	30	25	11.95	(1-49)
TFM-3	.04-400	DC-400	5.3	6.0	60	55	50	45	35	35	19.95	(5-49)
TFM-4	5-1250	DC-1250	6.0	7.5	50	45	40	35	30	25	21.95	(5-49)
•TFM-11	1-2000	5-600	7.0	7.5	50	45	35	27	25	25	29.95	(1-24)
•TFM-12	800-1250	50-90	—	6.0	35	30	35	30	35	30	39.95	(1-24)
••TFM-15	10-3000	10-800	6.3	6.5	35	30	35	30	35	30	49.95	(1-9)
••TFM-150	10-2000	DC-1000	6.0	6.5	32	33	35	30	35	30	39.95	(1-9)

•If Port is not DC coupled
•• +10 dBm LO, +5 dBm RF at 1dB compression

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

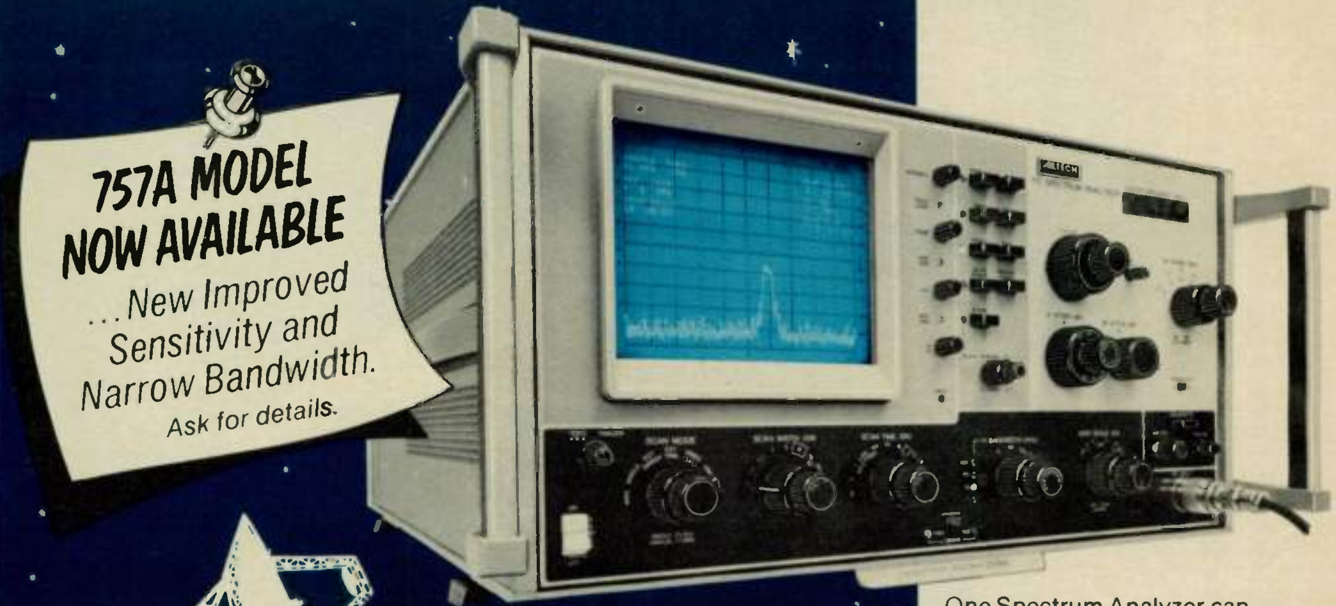
Mini-Circuits
A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
2625 East 14th Street, Brooklyn, New York 11235 (212)769-0200
Domestic and International Telex 125460 International Telex 620156

CIRCLE 7 ON READER SERVICE CARD

68 REV. ORIG

THE AILTECH 757A SPECTRUM ANALYZER

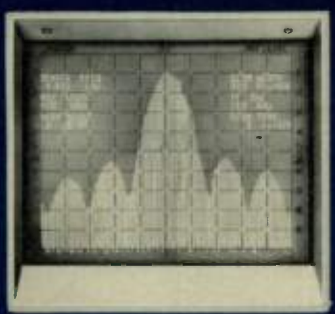
...Reduces Your Time and Cost of Measurement



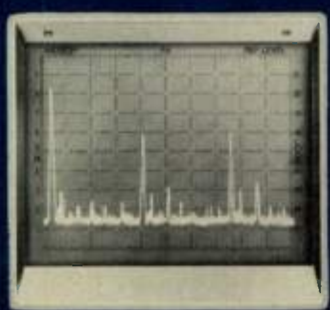
communications

laboratory

production test



radar



rfi/emi

One Spectrum Analyzer can perform the functions of many test instruments and provide utility for a variety of measurements. That's why no laboratory should be without a Spectrum Analyzer.

The AILTECH 757A Spectrum Analyzer, recognized as the easiest and therefore least expensive to use, is the choice throughout the world. The 757A offers many unique advantages.

- Internal Frequency and Amplitude Calibration in ALL Bands
- Built-in Digital Storage Eliminates Blooming Displays
- Digital Memory Does Away With Grease Pencils
- Alphanumeric Readout Provides Calibrated Photographs
- 10 dB Extra Sensitivity Through Preselector By-Pass
- Low Frequency Usage from 10 KHz to 22 GHz

You have to see the AILTECH 757A in operation to really appreciate it... And don't forget to ask about our new Eaton Credit Corporation equipment leasing plan.

For literature and a demonstration at your facility, call or write Eaton Corporation, Electronic Instrumentation Division, 2070 Fifth Avenue, Ronkonkoma, New York 11779, (516) 588-3600.

EATON

Advanced Electronics

Coming Events

14th ANNUAL CONNECTOR SYMPOSIUM NOV. 11-12,1981 Sponsor: Electronic Connector Study Group, Inc. Place: Franklin Plaza, Philadelphia, PA. Sessions: Connectors I & II, Materials I & II & III, Interconnection Techniques, Platings and Finishes I & II, Cabling Techniques and Connectors - Special Applications, plus workshops. Contact: Jim Pletcher, Ex. Dir., ECSG, Inc., P.O. Box 167, Ft. Washington PA 19034. Tel: (215) 279-7084.

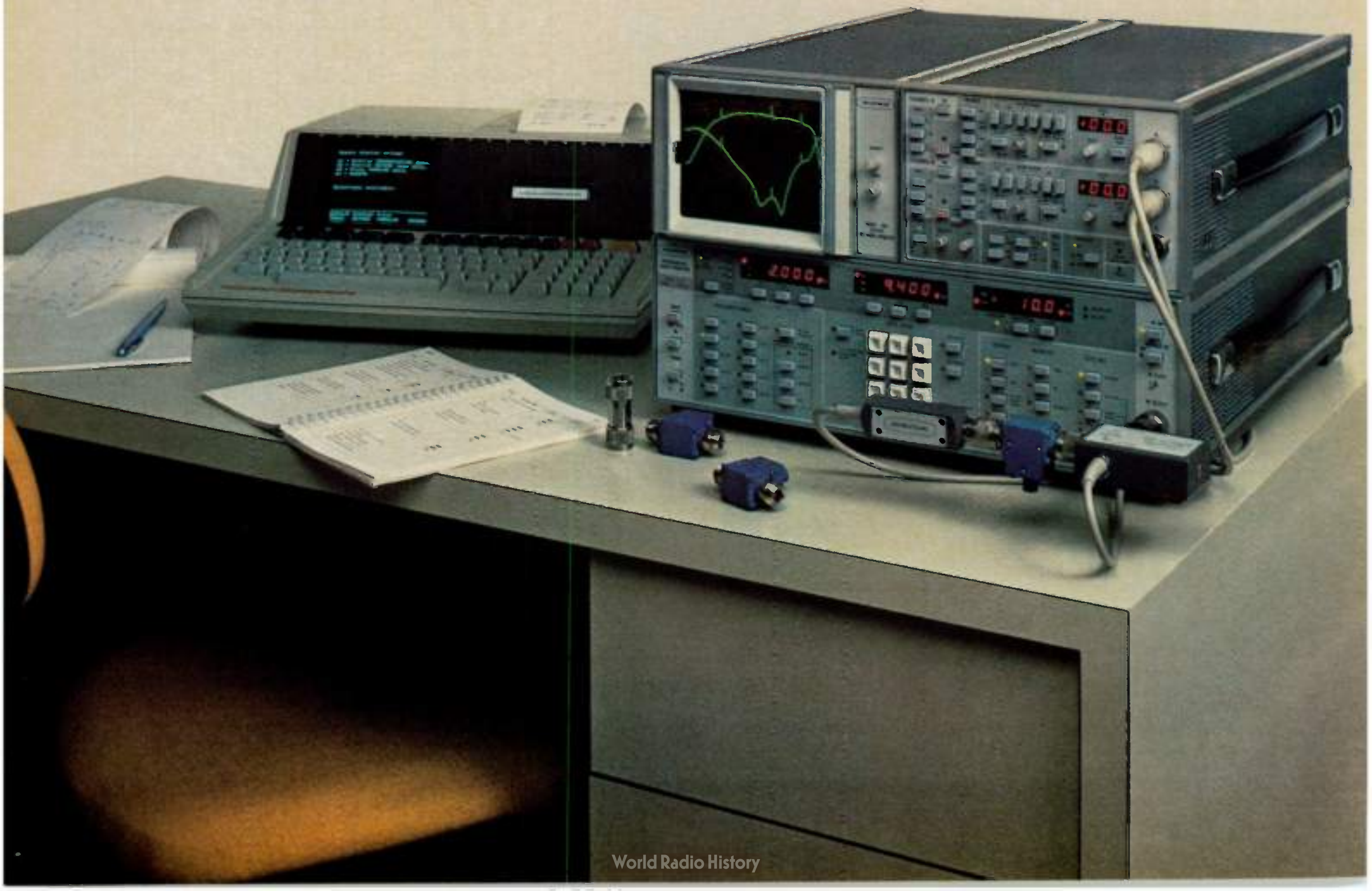
EASCON '81 NOV. 16-19, 1981 Sponsors: IEEE-Washington Sect. and Aerospace & Electronics Society. Place: Washington Hilton Hotel, Washington, DC. Subject: Government-Industry Interchange, including increased federal military budget, new aerospace system developments, and reduced regulations of communication services. Also features exhibition as well as technical classified programs. Contact: Dr. Delbert D. Smith, Chrmn., EASCON '81, COMSAT General Corp., 950 L'Enfant Plaza S.W., Washington, DC 20024. Tel: (202) 863-6822.

NATIONAL TELECOMMUNICATIONS CONFERENCE NOV. 29-DEC.3, 1981 Sponsors: IEEE Communications Society Conference Board and New Orleans Sect. of IEEE Place: Marriott Hotel, New Orleans, LA. Theme: "Innovative Telecommunications - Key to the Future." Contact: James W. Joyner, Gen. Chrmn., South Central Bell, 365 Canal St., Rm. 1790, New Orleans, LA 70140. Tel: (504) 528-7990.

29th SOLID-STATE CONFERENCE FEB. 10-12, 1981 **Call for papers** Sponsors: IEEE Solid-State Circuits Council, IEEE San Francisco Section and Bay Area Council, U. of Penn. Place: San Francisco Hilton, San Francisco, CA. Topics: Design, performance, fabrication, testing and application of new solid-state circuits, device structures, phenomena and systems in the digital, analog, microwave and other areas. Submit 30 copies of a 35-word abstract and 300- to 500-word summary by Sept. 18, 1981 to: Lewis Winner, 301 Almeria/Box 343788, Coral Gables, FL 33134. Tel: (305) 446-8193.

The New Microprocessor-Based Scalar Network Analyzer System.

Running it is as simple as A, B, C, D, E, F!



It's a Wiltron.

You're going to make accurate automated microwave measurements far easier with Wiltron's new Series 5600 Automated Scalar Network Analyzer System over the 10 MHz to 40 GHz range. And you're going to make them for less.

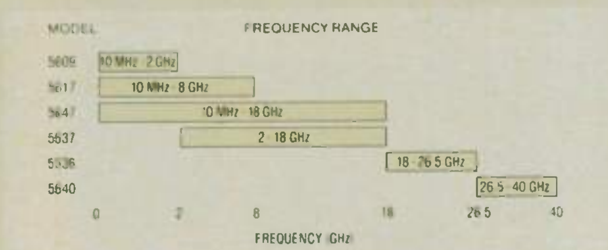
In truth, you're going to discover the most accurate and easiest way ever offered to measure return loss, transmission loss or gain and power automatically. You're going to use a powerful new system featuring distributed microprocessor technology and state-of-the-art microwave design.

Only Three Elements to the System

Each system consists of the Model 560 Scalar Network Analyzer, a 6600 Series Programmable Sweep Generator and the Model 85 Controller. Connect the SWR Autotester and Detector supplied, plug-in the factory preprogrammed cartridge and the system is ready to go.

40 dB Directivity

Wiltron's 5600 Series offers 40 dB directivity over a 10 MHz to 18 GHz continuous sweep range. Dynamic range is 66 dB with −50 dBm sensitivity. The system offers 82 dB programmable attenuation in 0.1 dB steps. ROM-corrected frequencies are accurate to ±10 MHz from 10 MHz to 18 GHz. Six models span the 10 MHz to 40 GHz range.



A key part of the system is the new Series 6600 Programmable Sweep Generator. This sweeper uses fundamental oscillators to avoid substantial errors generated by the harmonic products of multiplier type oscillators. The result, broadband coverage with the lowest harmonic content (−40 dBc, 2-18.6 GHz), low residual FM and greater stability.

A pre-processor chip separately scans front panel controls and interfaces directly with the main processor. Response speed is never a problem. All interfaces with the bus are internal, eliminating the need for an external interface box. For user convenience, up to 99 test set-ups can be stored in the control cartridge for future use.

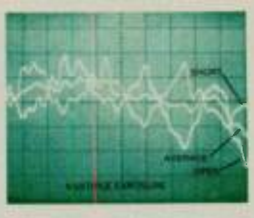
On The Air Moments After You Get It.

Simply plug-in the preprogrammed cartridge and enter a few simple inputs.

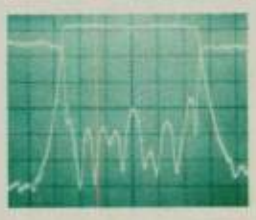
It's as Simple as A, B, C, D, E, F!

A. System Setup
Enter 1) Date
2) Type of measurement to be made

B. Frequency Selection
Enter 1) Frequency range limits
2) Frequency step size or number of test points

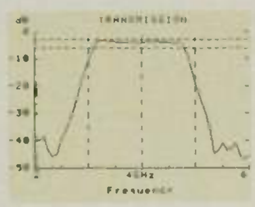


C. Calibration
Enter 1) DUT identification
Select 1) Averaging of open/short residuals.
2) Storing of normalized residuals.



D. CRT display of DUT characteristics
1) Select marker frequencies and amplitude limits.
2) If necessary, adjust DUT
3) If not, continue.

E. Measurement
1) Press key to start automatic measurement sequence



F. Hard-copy output
Select 1) Plotted curves.
2) Tabular data.

Make Your Own Comparison Soon

For a demonstration and/or our new brochure, phone Walt Baxter, (415) 969-6500 or write Wiltron, 825 E. Middlefield Road, Mountain View, CA 94043.

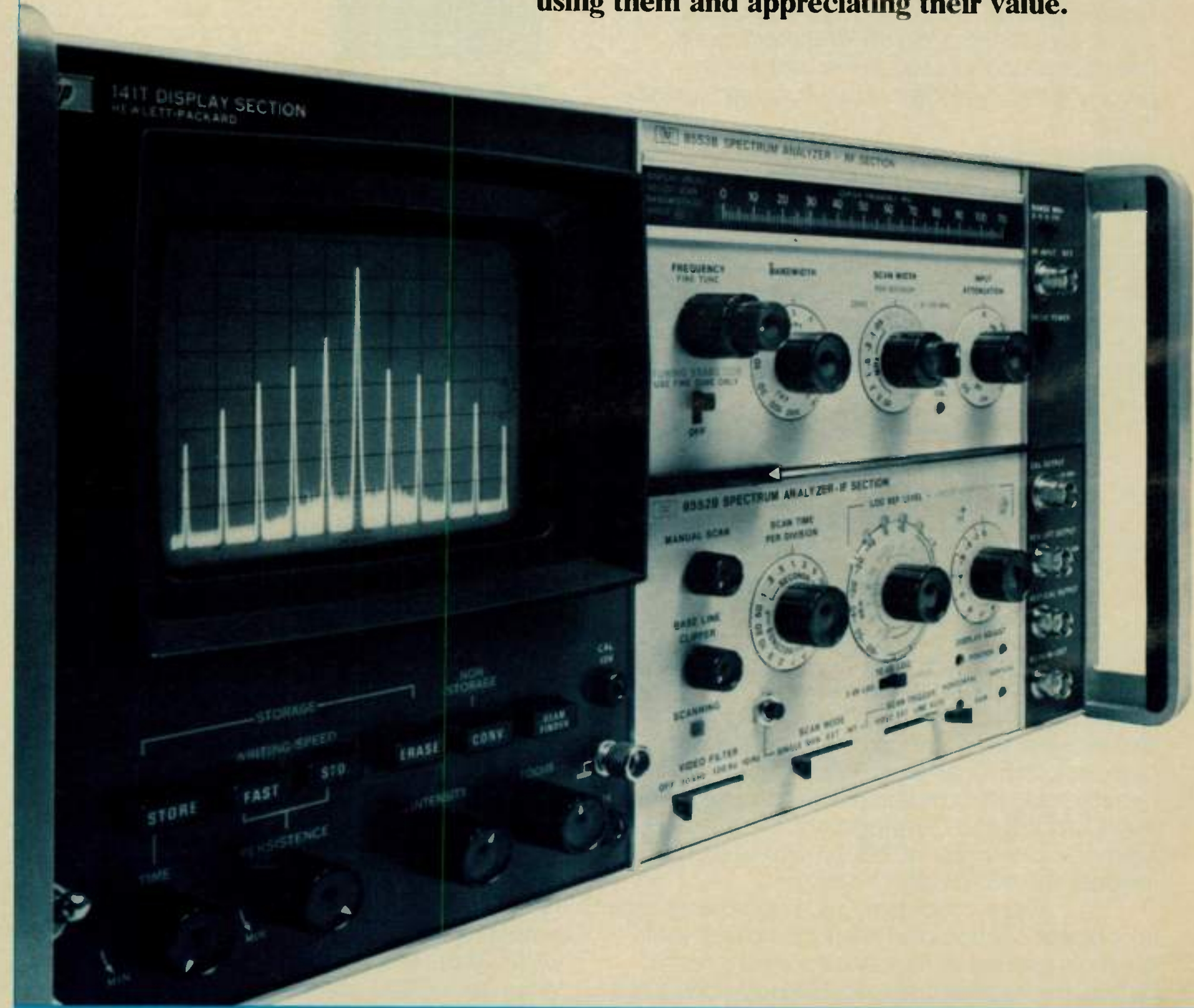
WILTRON

CIRCLE 10 ON READER SERVICE CARD

Looking for value in

Consider the measurement accuracy you get with the HP 140 series Spectrum Analyzers.
Consider how you can extend your frequency coverage with just a small incremental investment.
Consider the useful companion instruments that add to your measurement capabilities.

You'll see why so many engineers around the world not only considered the HP 140 series but are now using them and appreciating their value.



Spectrum Analysis?

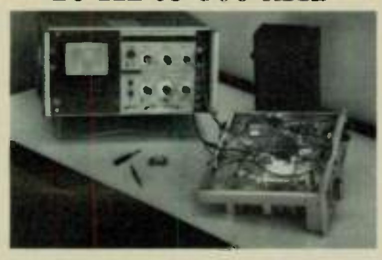
Select either normal or variable persistence display, choose economy or high-resolution IF module. Then pick or change your frequency range by simply plugging in the appropriate tuning module.

No matter what range you're working in, you need reliable unambiguous answers. HP's spectrum analyzers give you accurate measurements over wide, distortion-free dynamic ranges, time after time.

For the full story on value in spectrum analyzers, call your nearby HP field engineer or write 1507 Page Mill Road, Palo Alto, CA 94304.

MODEL #	DESCRIPTION	DOMESTIC US PRICE
140T	Normal Persistence Display	$2700
141T	Variable Persistence/Storage Display	$3510
8552A	Economy IF Section	$3950
8552B	High Resolution IF Section	$5300
8556A	20 Hz-300 kHz RF Section	$3375
8553B	1 kHz-110 MHz RF Section	$3650
8443A	Companion Tracking Generator/Counter	$6300
8554B	100 kHz-1250 MHz RF Section	$6300
8444A	Companion Tracking Generator	$3950
8555A	10 MHz-40 GHz RF Section	$9600
8445B	10 MHz-18 GHz Automatic Preselector	$5450

20 Hz to 300 kHz



The 8556A tuner covers 20 Hz to 300 kHz and comes with a built-in tracking generator. It's calibrated for measurements in both 50 and 600 ohm systems, with accuracies better than ±1 dB. Highest resolution is 10 Hz.

CIRCLE 11 ON READER SERVICE CARD

100 kHz to 1250 MHz

Use the 8554B tuning section to cover the 100 kHz to 1250 MHz range. Maximum resolution is 100 Hz. Measure with ±1¾ dB accuracy. The HP 8444A Tracking Generator (500 kHz to 1300 MHz) also works with the 8555A tuning section.

CIRCLE 12 ON READER SERVICE CARD

1 kHz to 110 MHz

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

CIRCLE 13 ON READER SERVICE CARD

10 MHz to 40 GHz

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

CIRCLE 14 ON READER SERVICE CARD

53103A

HEWLETT PACKARD

HOME TVRO

The market which is developing for home and small commercial TVRO earth stations has every promise of developing into the largest consumer application for microwave products in history. A completely new distribution system has emerged during the past two years to service the demand for TVRO's in the rural areas of the US. These companies have experienced explosive growth since 1979 and there are reasons to believe that the high growth rates will be sustained well into the 80s. Those reasons, together with concerns about the business voiced by some suppliers, are discussed. in detail.

Sum Up

ON PLENARY SESSIONS

In a departure from the design orientation of the main program, the four invited papers of the Plenary Session of this year's MTT-S Symposium covered such diverse topics as a large array radio telescope, biological effects, noise in communications systems and the Voyager satellite. Consulting Editor Joe White found the session to be among the most interesting of the week and reviews the papers in a Special Report.

COMMUNICATIONS SATELLITE TUBES

In this Special Report, the author reviews the microwave tubes which have been used in the power amplifier stages of all of the communications satellites launched by the Western World from 1963 through 1980. It also projects the demands for tubes between 1981 and 1986. The increasing capabilities of the tubes is illustrated and the rate at which the demand for these devices is growing is also described.

FET'S IN SATELLITE PAY LOADS

Using the German Television Broadcasting Satellite, TV-SAT, as an example, the author describes the potential applications for FET's in satellite designs. Their potential to replace diode parametric amplifiers in the up-link front end or to replace Schottky diodes in mixer applications and the trade offs involved are discussed. Finally, the low noise and power amplifier applications which they will serve in TV-SAT are covered in detail.

PHASED ARRAY FOR AIRCRAFT TO SATELLITE COMMUNICATION

A conformal lightweight microstrip phased array is considered as a possible solution to the need for high gain full hemisphere coverage for aircraft to satellite communications. Alternatives including a parabolic dish and the hybrid scan array both suffer from heavy weight and the fact that they protrude far beyond the aircraft skin. The design and fabrication of a 7.5 GHz receive-only microstrip phased array is described. A microprocessor-based beam steering controller and 3-bit digital PIN diode phase shifters provide beam steering. Designs for the radiating element, the digital phase shifter and the corporate feed are described. Operating characteristics of a 64-element array, which achieved an overall efficiency of 46% and gains ranging from 19.6 dB to 14.4 dB as a function of steering angle, are shown.

6 GHz TWT'S FOR LOW-COST EARTH STATIONS

The design of two traveling-wave tubes with output powers of 75 and 150 watts, respectively, is described. Intended for use in unattended earth stations, reliability, ease of operation and of tube changing are of paramount importance. The tubes use many common parts to minimize cost and both offer performance and efficiencies appropriate to the application.

Howard Ellowitz

Workshops & Courses

Sponsor: Compact Engineering
Sites and: U. of Maryland, College Park, MD
Dates: Aug. 31-Sept.4, 1981 Palo Alto, CA Oct. 5-9, 1981 UCLA, Los Angeles, CA October 26-30, 1981
Topic: Modern Microwave Circuit Design — 5-day course.
Fee: $800
Contacts: Les Besser, Pres., Compact Engrg., 1131 San Antonio Rd., Palo Alto, CA 94303 Tel: (415) 966-8440

FROST & SULLIVAN SEMINAR

Sponsor: Frost & Sullivan, Inc.
Site: Key Bridge Marriott, Arlington., VA.
Date: September 21-22, 1981
Fee: $495 1 attendee; $396 or more attendees
Theme: "Winning Strategies for Getting and Keeping Federal Service Contracts."
Leader: Jack Robertson, DC Ed., *Electronic News*.
Contact: Cornelia Yelin, Mgr. PR, F & S, 106 Fulton Street, NY 10038 Tel: (212) 233-1080.

SCEEE SHORT COURSE

Sponsor: Southeastern Center for Electrical Engineering Education (SCEEE)
Site: Syracuse U. Conf. Cent., Blue Mt. Lake, NY
Date: Sept. 28-Oct. 2, 1981
Fee: $500
Topic: Computational Methods in Electromagnetics.
Contact: June Diaz de Arce, Course Coord., SCEEE, 1101 Mass. Ave. St. Cloud, FL 32769 Tel: (305) 892-6146

Watkins-Johnson MIXERS

. . . Now Qualified to MIL-M-28837!

DoD's Defense Electronics Supply Center has approved the listing of certain Watkins-Johnson mixers on its Qualified Products List (QPL).

The advantages to you, the customer, in specifying MIL-qualified mixers are many. They include:

- No need to prepare purchase documentation (RFQ's) or request nonstandard parts approval from DESC.
- W-J qualified mixers can be used in any application requiring screened parts.
- The manufacture of W-J qualified mixers is continuously monitored by the U.S. Government.
- Price is attractive compared to ordering nonstandard screened parts.
- Deliveries will be short because qualified parts will be maintained in stock.

Summarized below are the W-J mixers qualified to MIL-M-28837:

MIL-M-28837	W-J Model	Package Style	Operating Range	Price* "N"	Price* "S"	Delivery "N"	Delivery "S"
/1-01	M6D-100	Relay Header	DC-200MHz	$47	$84	Stock to 4 wks.	Stock to 8 wks.
/1-02	M6E-100	Relay Header	DC-500MHz	$47	$84	Stock to 4 wks.	Stock to 8 wks.
/2-02	M4A-100	Flatpack	10-1500MHz	$111	221	Stock to 4 wks.	Stock to 8 wks.
/7-01	M6T-100	TO-5	10-500MHz	$55	108	Stock to 4 wks.	Stock to 8 wks.
/7-03	M6V-100	TO-5	.4-500MHz	$73	141	Stock to 4 wks.	Stock to 8 wks.

*Qty 25-99 (domestic U.S. prices only)

For further information on these MIL-qualified mixers (and other models currently undergoing qualification) contact the Watkins-Johnson Sales Office in your area or phone Mixer Applications Engineering in Palo Alto, California, at (415) 493-4141, ext. 2637.

WATKINS-JOHNSON

Watkins-Johnson—U.S.A.: • **California.** San Jose (408) 262-1411, El Segundo (213) 640-1980 • **Florida.** Fort Walton Beach (904) 863-4191 • **Georgia.** Atlanta (404) 458-9907 • **Illinois.** Palatine (312) 991-0291 • **District of Columbia.** Gaithersburg, MD (301) 948-7550 • **Massachusetts.** Lexington (617) 861-1580 • **Missouri.** Bridgeton (314) 291-6532 • **Ohio.** Fairborn (513) 426-8303 • **Texas.** Dallas (214) 234-5396 • **United Kingdom:** Dedworth Rd., Oakley Green, Windsor, Berkshire SL4 4LH • **Tel: Windsor 69241** • Cable: WJUKW-WINDSOR • Telex: 847578 • **Germany,** Federal Republic of: Manzingerweg 7, 8000 Muenchen 60 • Tel: (089) 836011 • Cable: WJDBM-MUENCHEN • Telex: 529401 • **Italy:** Piazza G. Marconi, 25 00144 Roma-EUR • Tel: 59 45 54 • Cable: WJROM-I • Telex: 612278

CIRCLE 15 ON READER SERVICE CARD

Guest Editorial

The Sky's Not the Limit

ROBERT D. BRISKMAN
COMSAT General Corp.,
Washington, DC.

Robert D. Briskman *received a B.S.E. Degree from Princeton University and a M.S.E. degree in electrical engineering from the University of Maryland. He joined the International Business Machines Corporation in 1954 and worked on the development of asynchronous buffer systems. After two years of military service as an Electronic Countermeasures Analyst Officer, for which he was awarded the Army Commendation Medal, Mr. Briskman was employed by the Army Security Agency.*

In 1959, he joined the National Aeronautics and Space Administration. At NASA, Mr. Briskman was Chief of Program Support for such programs as APOLLO, GEMINI, RANGER, MARINER and ECHO. Mr. Briskman received the APOLLO achievement Award from NASA. In January 1964, Mr. Briskman was employed by the Communications Satellite Corporation [CSC] responsible initially for satellite command and control activities including those involved with the launching of INTELSAT I [Early Bird].

Mr. Briskman joined COMSAT General Corporation on its founding in 1973 and was Assistant Vice President, Space and Information Systems. He was responsible for the COMSTAR satellite system, the development of earth resource and information systems, and the implementation of a remote data collection system in conjunction with the United States Geological Survey [USGS] and Telesat Canada. Mr. Briskman joined Satellite Business Systems [SBS] in mid-1977 where he was responsible for the Pre-Operational Program which provided voice and data communications services to various IBM facilities in the United States using the first demand-assigned, time division multiple access system ever placed commercial operations. He returned to the CSC in 1980 and is currently Assistant Vice President, Systems Implementation of COMSAT General Corporation.

Mr Briskman is a Fellow and past Secretary-Treasurer, Vice President for Technical Activities and Director of the Institute of Electrical and Electronics Engineers [IEEE]. He has been President of the Aerospace and Electronic Systems Society, Director of the National Telecommunications Conference, Chairman of the EASCON Board of Directors, and Chairman of the IEEE Standards Board.

The success of commercial communications satellites and the development of microwave technology have always been synonomous and will continue to be so. After accepting the gracious invitation to write a Guest Editorial, I quickly re-read my last article in *Microwave Journal* "Trends in Design of Communications Satellite Earth Stations" which was coauthored with my associate Dr. Robert C. Barthle in October of 1967. It is with considerable relief that I can report our predictions in that article have been successfully implemented. Let's hope that the expectations expressed herein for further expansion of satellite communications systems also come into being in the near future.

One observes that much of the microwave industry demonstrates only mild interest in the development of equipment for communications satellites. The reasons generally given are that the stringent requirements for lifetime, performance and weight of satellite microwave equipment, coupled with difficult environmental specifications, make development economically unattractive, particularly in light of the limited number of production units required. On the other hand, the microwave industry has always shown great interest in development of earth stations for communications through such satellites. It is important to recognize that these two areas must go hand-in-hand. Without reliable, well-performing and economical satellites, there would not be the burgeoning earth station business that has developed over the past four years.

It seems pertinent, therefore, to consider the satellites first, since they will pace new communications system development. There are actually too many developmental activities currently underway to report here so only key areas have been selected for discussion, and the area of mobile satellite services will not be covered.

One very significant spur to commercial communications satellite development has been the creation by NASA of the Space Transportation System, commonly known as the Shuttle. The Shuttle is projected to bring satellite launch costs (expressed in dollars per kilogram in geosynchronous orbit) during 1984 down to the $20,000-$25,000 level from the $40,000-$60,000 level of current expendable launch vehicles.

A second stimulus has been the approval of additional frequency bands both for satellite fixed and broadcast satellite services by the 1979 World Administrative Radio Conference of the International Telecommunications Union. The frequency bands originally allocated for satellite communications are now insufficient, and the new additional frequency bands will both alleviate this problem and relieve geosynchronous orbital congestion. The more important bands are Ku for fixed and broadcast services and Ka for fixed services. Most previous commercial communications satellites operated in C band but, recently, fixed service satellites (ANIK B, INTELSAT V and SBS) have been emplaced which use the Ku band. Demonstration broadcast service

[continued on page 20]

NEC microwave semiconductors

Presents an Unbeatable Combination...

Low noise and high gain thru 20 GHz.

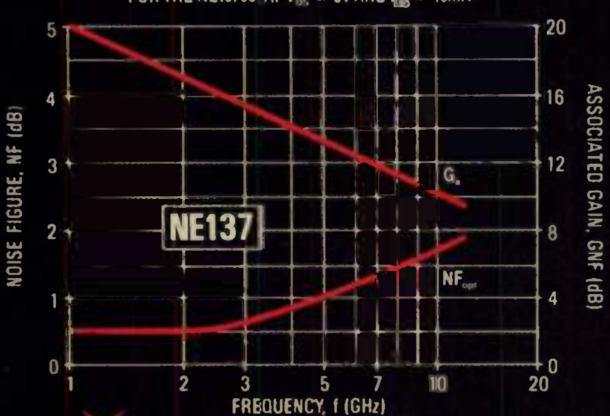
The NE21800 chip has a 1.0μm recessed gate and gold bonding pads. It's ideal for MIC and pulsed applications where fast recovery time is a requirement. The NE21889 is hermetically sealed in a ceramic-metal stripline package for hi-rel applications from IF to 8 GHz. This low noise GaAs FET (1.0 dB at 4 GHz) offers high associated gain and proven reliability and stability.

The NE137 is a 0.5μm recessed gate Ku-band GaAs FET intended for military and hi-rel applications to 20 GHz. The NE137 is available as a chip (NE13700), or in a hermetically sealed stripline package (NE13783). The NE137 represents the ultimate in commercially available GaAs FETs, 0.7 dB at 4 GHz and 1.6 dB at 12 GHz.

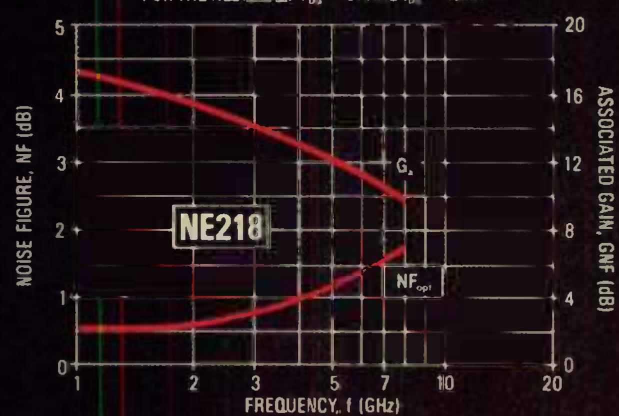
NEC also offers a complete line of general-purpose GaAs FETs. The popular NE244 offers a 3.0 dB NF_{opt} and G_a of 7.0 dB at 12 GHz. The NE388 has a 2.6 dB NF_{opt} and G_a of 9.5 dB at 12 GHz. The NE694 offers a 2.5 dB NF_{opt}, G_a of 8.5 dB, and $P_{1\,dB}$ of 20 dBm at 8 GHz. NE695 has a 2.7 dB NF_{opt}, G_a of 9.0 dB, and $P_{1\,dB}$ of 23 dBm at 8 GHz. The NE463 is a dual gate 1.0μm FET for modulators, AGC, switch and mixer circuits.

Long-term performance and reliability are assured with NEC's proprietary wafer selection and processing procedure. Contact California Eastern Laboratories for the CEL representative nearest you.

TYPICAL NOISE FIGURE AND ASSOCIATED GAIN VS FREQUENCY FOR THE NE13783 AT V_{DS} = 3V AND I_{DS} = 10mA



TYPICAL NOISE FIGURE AND ASSOCIATED GAIN VS FREQUENCY FOR THE NE218 AT V_{DS} = 3V AND I_{DS} = 10mA



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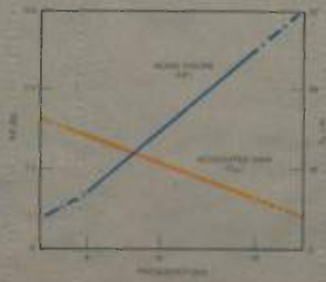

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CIRCLE 19 ON READER SERVICE CARD

The Home TVRO Market

HOWARD ELLOWITZ, *Publisher*

The 1979 FCC decision deregulating receive-only earth stations — freeing them from licensing and frequency coordination requirements — opened the door to an unprecedented commericial and consumer market for TVRO's and the microwave products which they incorporate.

While established earth station suppliers are doing an outstanding job marketing to multistation receive and transmit networks and cable TV receive-only station prospects, they were not in a position to service the demand for low-cost TVRO's which arose after deregulation. That demand is concentrated in rural areas, among motel operators, condominium developers and private home owners and it is driven by the fact that the only usable TV signals in those areas are those being distributed by satellite nationally to commercial users.

To meet that demand, an entirely new distribution system has emerged. It has been created by enterprising small companies whose principals have had little, if any, previous experience in the microwave industry. It is located largely in the rural areas which it serves and, reflecting its consumer orientation, it is a multi-tiered system.

The primary suppliers began organizing in the spring of 1980. The typical new venture would buy earth station components — antennas, LNA's and receivers — from established suppliers and assemble and install systems for the end user. Growth soon made it impractical to operate in this manner, however, and the primary suppliers quickly developed networks of distributors who would buy in lots of ten or more systems and dealers who would buy up to ten systems at a time from distributors and deal with end users.

In addition, some primary suppliers have begun to manufacture antennas and/or receivers and other manufacturers who have concentrated on the cable TV equipment market are beginning to offer receivers designed specifically for this new market. The LNA is the only system component which is being supplied solely by well-known amplifier houses. At this date, those suppliers appear immune to competition from the systems houses themselves.

On the basis of a number of reports, the largest primary system supplier appears to be National Microtech, headquartered in Grenada, MS. Organized in 1980 with a total investment of $6,000, its President, Horton Townes, indicated monthly sales approaching 400 systems with a value of $1,000,000 in May 1981. He ex-

MICRODESIGN TVRO receiver and remote control unit.

month beginning in September. In addition to its TV-receive functions, the Merrimac unit accesses the audio sub-carriers in the satellite transmissions — which are designed to carry such material as stereo music and news.

Dexcel's commitment to the market is evidenced further by plans to begin delivery of separate downconverters and receivers in September of this year. The Dexcel-designed receivers will be assembled in Japan. In addition, a full electronics package consisting of an LNA/downconverter, receiver and cabling will be offered at retail for $2,200. Modulators for channels 3 and 4, audio subcarrier service and direct video output features will be included.

Merrimac Industries TVRO receiver includes speaker for audio subcarrier material.

In a market that is growing so explosively, there are inevitably causes for concern. First, there are the opportunists who will install poor-quality systems whose unhappy customers could have a dampening effect on the growth rate. Secondly, overseas competition for the LNA and receiver business must also be anticipated. If the market indeed fulfills its own promise, its attractiveness will rank with other US consumer electronic markets in which Japan has competed so successfully.

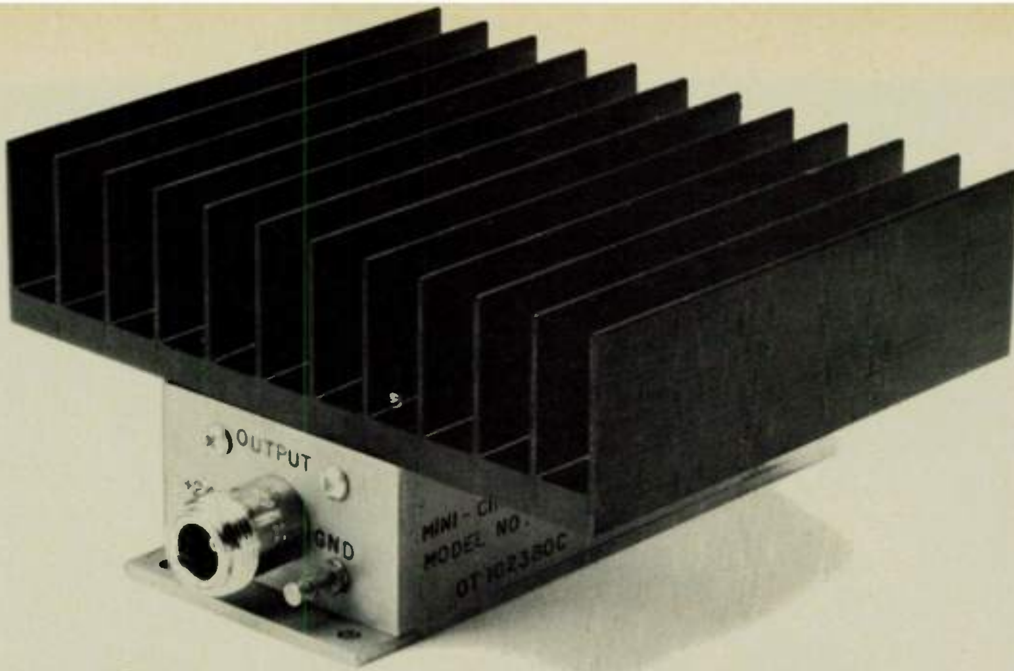
Next, the question of charges to individual TVRO owners for programming which is distributed primarily for resale by commercial operators is still an open one. As shown in the Table, many SATCOM I channels are offered without charge to such users, while others carry fee schedules. When and if scrambling is employed, collection from individual users may become more uniform. In any event, system suppliers are confident that their residential customers will not be deterred by nominal monthly charges for their services.

Finally, there is concern that the rapidly expanding distribution system is absorbing disproportionate quantities of the components being shipped. Since the primary system users have little information about actual installation rates, it is difficult to make an informed judgment on that question. The next twelve months may reveal the answer and it is a critical one. In the meantime, contrary to conventional wisdom, the pessimist will consider the pipeline half full, the optimist, half empty.

Ultimately, the US consumer will be the beneficiary. The rural area home owner, apartment dweller and motel guest will see his world transformed from one without TV to one with a variety and quality of programming equal to that available in any metropolitan area. The services available from SATCOM I should be more than enough to satisfy a dedicated TV watcher. For the complete addict, there are ten more birds to be sampled.

SATCOM I SERVICES

Transponder	Channel	Programming	Home TVRO Fee
1	Nickelodeon/ Arts	Playground for children & adolescents	$.10/month
2	PTL	24-Hr Christian entertainment	No charge
3	WGN	Variety-movies sports, specials	No charge
5	Movie	Non-stop movies from early a.m. to early a.m.	No charge
6	WTBS	Family directed programming — sports, movies, news	$.10/month
7	ESPN	Sports, featuring 1400 NCAA events	$.04/month
8	CBN	24-hr Christian programming	No charge
9	USA Net	Sporting events, children's films, cultural	No charge
9	BET	Entertainment featuring black performers	No charge
9	C-Span	Daily live coverage of House of Representatives	No charge
10	Showtime (West)	Entertainment specials	No charge
12	Showtime (East)	Same as transponder 10	No charge
14	Cable News Network	24-hour news	$.15/month
16	ACSN	Educational & cultural including college-level credit courses	$25/year
17	WOR	Sports, movies, TV show re-runs	No charge
18	Galavision	Spanish language films, sport, special	No charge
20	Cinemax (East)	All-movie service	Not published
22	Modern Satellite Network	Programs, series, opinion for general consumer	No Charge
22	Home Box Office (West)	Movies, sports, entertainment specials	Not published
23	Cinemax (West)	Same as transponder 20	Not published
24	Home Box Office (East)	Same as transponder 22	Not published



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Of course, our one-year guarantee applies to each amplifier.

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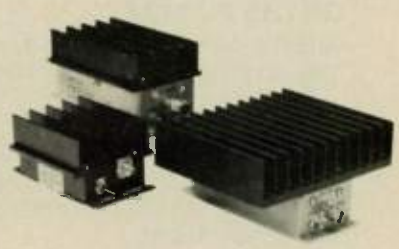

* Model No.	Freq. MHz	Gain dB	Gain Flatness dB	Max. Power Output dBm 1-dB Compression	Noise Figure dB	Intercept Point 3rd Order dBm	DC Power Voltage	DC Power Current	Price $ Ea.	Price Qty.
ZHL-32A	0.05-130	25 Min	±1.0 Max	+29 Min	10 Typ	+38 Typ	+24V	0.6A	199.00	(1-9)
ZHL-3A	0.4-150	24 Min	±1.0 Max	+29.5 Min	11 Typ	+38 Typ	+24V	0.6A	199.00	(1-9)
ZHL-1A	2-500	16 Min	±1.0 Max	+28 Min	11 Typ	+38 Typ	+24V	0.6A	199.00	(1-9)
ZHL-2	10-1000	15 Min	±1.0 Max	+29 Min	18 Typ	+38 Typ	+24V	0.6A	349.00	(1-9)
ZHL-2-8	10-1000	27 Min	±1.0 Max	+29 Min	10 Typ	+38 Typ	+24V	0.65A	449.00	(1-9)
ZHL-2-12	10-1200	24 Min	±1.0 Max	+29 Min*	10 Typ	+38 Typ	+24V	0.75A	524.00	(1-9)
ZHL-1-2W	5-500	29 Min	±1.0 Max	+33 Min	12 Typ	+44 Typ	+24V	0.9A	495.00	(1-9)

Total safe input power +20 dBm, operating temperature 0° C to +60° C, storage temperature −55° C to +100° C, 50 ohm impedance, input and output VSWR 2:1 max

+28.5 dBm from 1000-1200 MHZ

For detailed specs and curves, refer to 1980-81 MicroWaves Product Data Directory, Gold Book or EEM

* BNC connectors are supplied, however, SMA, TNC and Type N connectors are also available

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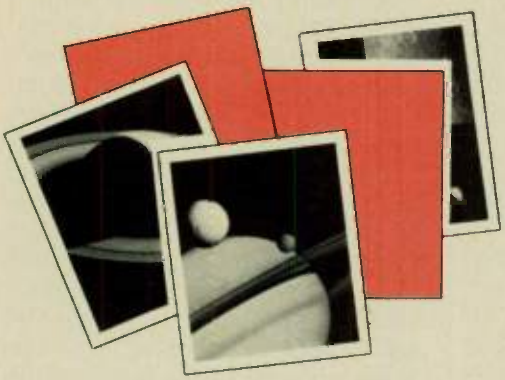


I Love Plenary Papers

From the '81 MTT-S Symposium

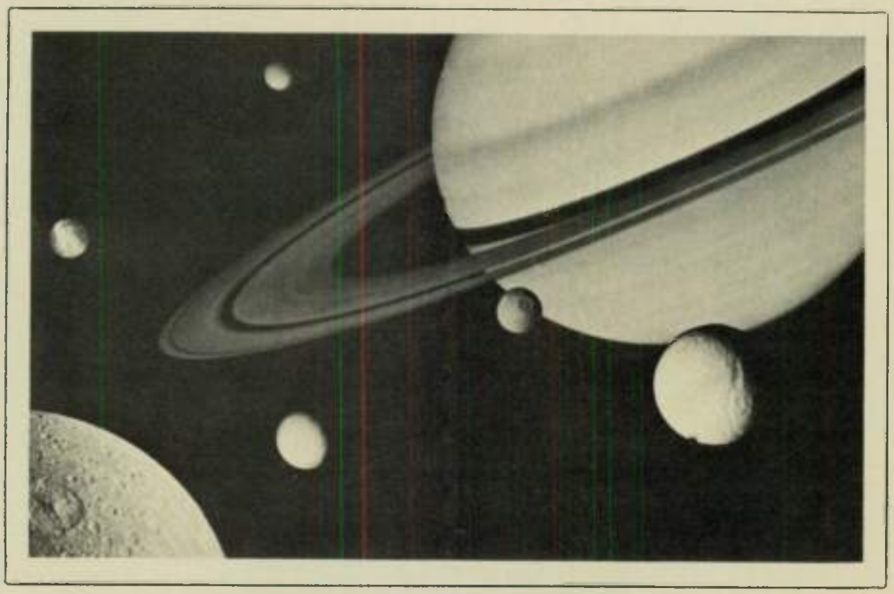
JOSEPH F. WHITE, *Consulting Editor*

This year's MTT Symposium featured a whole morning dedicated to what is referred to as a plenary session. Plenary is derived from the Latin word *Plenus* which means full. There are many interpretations as to why such a title would be applied to this session. In the case of the 1981 MTT Symposium, the event was jointly sponsored by the MTT, AP-S and the URSI Groups, with the Wednesday meeting time for the Plenary session at the juncture in the week that divided the groups regular paper sessions. Thus, the term plenary could be interpreted to mean that the session would be full of both microwave and antenna specialists. Another interpretation for the use of the word might be that the talks themselves were sufficiently full of interest that they would appeal to all the delegates of all three symposia. In my opinion both interpretations can be applied accurately; the session was attended by members of all three symposia and the talks indeed were of considerable interest to everyone.

I think the reason that I like plenary talks is that I can understand them. Normally when I attend a technical paper session at the MTT I'm already pretty harried from having had the problem of selecting which of four simultaneous competing sessions I'd like to attend, how I'd find the room on time in which it would be held and whether the speaker I want to hear will give his talk on schedule or whether his talk is moved off till later — at which time it will conflict with still another talk I wanted to hear in another of the competing sessions. Finally, to be honest, unless the talk is in my narrow technical niche, I fear that the author will start out by saying "... and as we all know, the problem is best addressed using the Jacobian function to evaluate the electric field distribution in the resonator. . . " at which point I won't understand it, since I don't know what Jacobian functions are.

None of these problems, however, affects the joyful attendee at a properly run Plenary session. There are no competing talks during a Plenary session. Enough time is scheduled, 30 to 45 minutes per talk, to allow the author to develop his ideas fully. The speaker knows he will have a large audience, consequently he prepares his ideas carefully, his vugraphs are legible, even downright interesting and most are in color. He knows some of the audience won't know about Jacobians and so he introduces his specialty as if he were speaking to a group of laymen (this is the part I like best). With this setting, it's practically an anticlimax to tell you readers who weren't there at the MTT Plenary Session this year just how good the talks were, but I'll try anyway (publishers take a dim view of consulting editors who think something is so beyond words that no editorial column should even be attempted for the magazine).

Chairman Seymour Cohn introduced the four talks. The first talk was presented by Dr. Peter Napier of the National Radio Astronomy Observatory in Socorro, NM. Entitled "The Very Large Array Telescope," the paper describes the first results obtained with this radio listening device that operates at the 6 and 20 centimeter wavelengths (1.5 and 5 Ghz) with resolutions of 10ths of an arc



A montage prepared from images taken by NASA's Voyager 1. (courtesy of Jet Propulsion Lab)

[*continued on page 30*]

[*from page 29*]

seconds and sensitivities of approximately 100 microjanskies. I didn't catch what a microjanski was (probably an astronomer's Jacobian) but the talk was fascinating by any standards. Using large antennas and integration methods, radio signals are used to map intergalactic areas at distances as far away as 40 million light years. Astronomers often talk about such distances, you and I have heard them, but when the equipment being used is microwave, not optical, the reality of the idea moves closer. One field of view shown in a "color" (wavelength) enhances map made at this distance clearly illustrated the explosion of a star system with a resulting plume of material that jetted out at right angles to the direction of observation, and occupied a field of view that was approximately 50,000 light years across!

The second paper by Sy Okwit of LNR Communications, Hauppage, NY, was entitled: "Noise in Analog and Digital Microwave Communication." Sy had gone a long way in this talk to making the complex mumbo-jumbo of noise figure, receiver sensitivity, and sky temperature manageable concepts. In fact, it will be a pity if he doesn't reduce this to a formal paper so that it can be retained in the literature for its tutorial value. I failed to point out earlier that, regrettably, there seems to be a practice at all symposia at which such invited papers are presented to avoid publishing a complete summary of the paper in the Symposium Digest. Notwithstanding this minor fault, the talk proceeded through step-by-step examples of how practical systems for point-to-point terrestrial and earth-to-satellite applications can benefit from a system trade-off analysis involving the cost and performance characteristics of antennas, receivers, and special amplifiers.

The third talk, by O. M. Ghandi of the University of Utah in Salt Lake City, was entitled: "Biological Effects and Medical Applications of Electromagnetic Fields." All of us have been mystified by the attention given the 10 milliwatt per square centimeter US *radiation* standards (referred to

[*continued on page 32*]

[from page 32] **PLENARY PAPERS**

never be satisfied with anything short of direct experimental results conducted under controlled conditions on humans; but that, of course, could be the subject of another plenary paper. Dr. Ghandhi noted that mammals have a peak absorption frequency for which the long dimension of the body is about 0.4 wavelengths, for example, for a six-foot, 170-pound male this occurs not in the microwave spectrum but rather (in the television and UHF communication bands) at about 70 MHz. He also went on to point out that heating tissue selectively with microwaves may prove to be an important adjunct to radiation and chemotherapy treatment of cancer. Cells heated very much above 41° C (body temperature is 37° C) causes cell death, at 45° C almost immediate destruction takes place.

The fourth and final talk entitled: "Voyager Encounter with Saturn" by Dr. E. C. Stone of the Physics Department of Cal Tech and Chief Scientist of the Jet Propulsion Laboratory provided a unique review of the marvelous accomplishments of the Voyager satellite. Fittingly, the same satellite, as it passed Jupiter, was the subject of another plenary talk, this one given at the European Microwave Conference (see *MJ* front cover, November 1979 and feature article *MJ*, January 1980). So numerous and interesting have been the discoveries of the Saturn fly-by, that Dr. Stone literally raced through his talk, happily this was at a rate which the audience could follow.

Highlighted by a 16mm movie, showing computer composites of the approach to Saturn, he described what are now recognized as six individual sets of rings and related them to the earliest discovery of Saturn's rings in 1666. At that time, only two solid rings separated by what was then thought to be empty, "Cassini," space were known. The Voyager showed that the space between the major rings is not actually empty. One of the proposed Voyager courses would have passed through the Cassini space, and no doubt this would have been disastrous, since the Voyager photos show "particles" as large as 3-meter diameter boulders roaring through it.

[continued on page 36]

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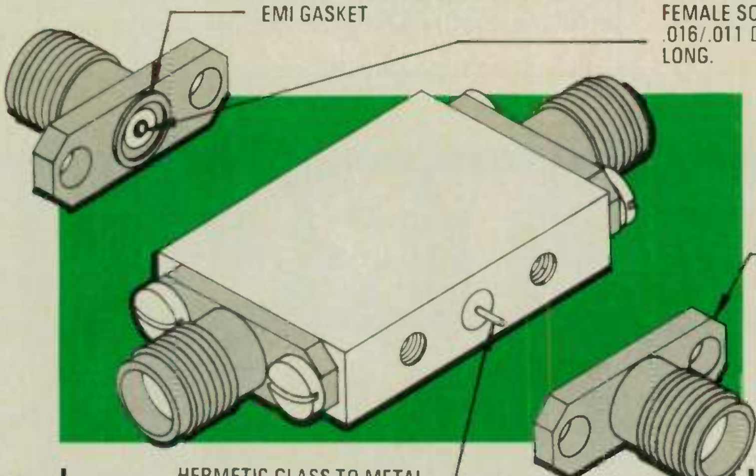

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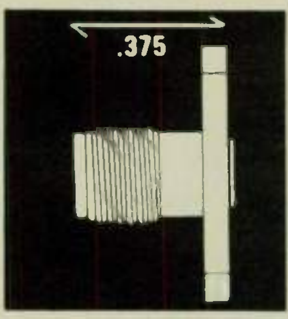

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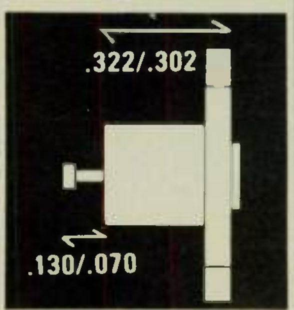

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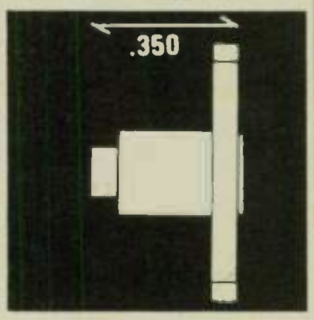

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The marvelous images Voyager radioed back came via S and X band traveling-wave tube transmitters each having only 20 watts of power. The transmission path, by any standard a record, of 1 billion miles produced a signal power level at the terrestrial receiver of less than 10^{-20} watts! The scientific crew, numbering 120, have been busily reducing the Voyager telemetry data for the last two years.

Saturn has a mass five times that of the earth but with a density of only 0.7 times that of water. It consists principally of hydrogen. Ammonia clouds encircle it in jet streams reaching speeds of between 200-1000 miles per hour. The Cassini division is actually filled with 5 separate rings and is 500 miles across, but so thinly populated are the rings that they appear to be transparent. The F ring (the sixth and most recent to be discovered) contains dust and particles that would have disappeared, i.e. been gravitationally absorbed by the other rings or lost into space, were it not for the fact that its particles are "shepherded" into a ring by tow orbiting satellites. These two satellites' existence was predicted, but they had never been seen before the Voyager mission.

Many surprises, including radial dark spokes (in Saturn's rings) which emanate out from the dark side of Saturn and then disperse as the particles encircle the sunny

[*continued on page 91*]

CIRCLE 31 ON READER SERVICE CARD

Increasingly, designers and engineers are including protective radomes in their plans for new radar systems. With good reason.

They've found that radome-enclosed radar systems provide better performance over considerably longer periods of time than exposed radar systems.

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And radomes prove to be a cost-effective investment that pays for itself quickly. Radar system maintenance and repair costs are cut considerably. Severe damage from heavy snow, strong winds, and massive ice build-ups is eliminated. As are the corrosive effects of sand, salt, dust, and chemical pollutants.

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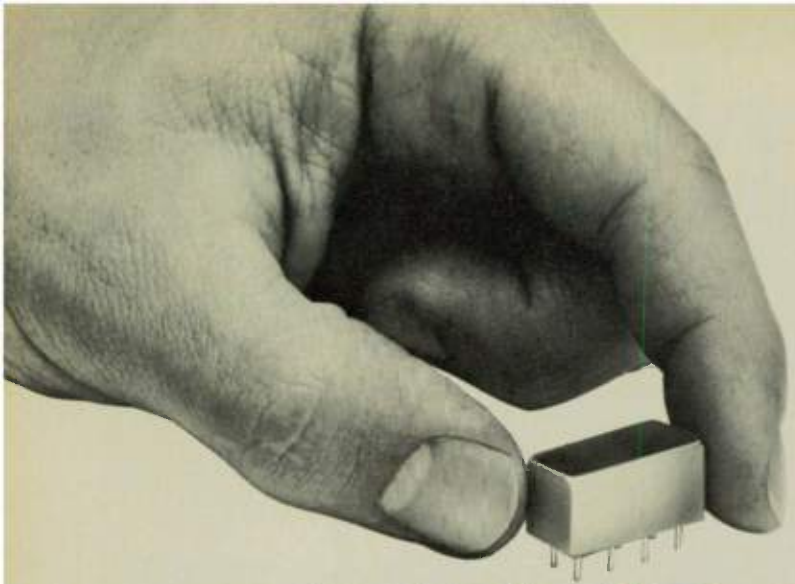

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LO	0.5-500
RF	0.5-500
IF	DC-500

CONVERSION LOSS (dB)		TYP	MAX
1-250 MHz		5.5	7.0
0.5-500 MHz		6.5	8.5
ISOLATION (dB)		TYP	MIN
0.5-5 MHz	LO-RF	50	45
	LO-IF	45	35
5-250 MHz	LO-RF	45	30
	LO-IF	40	25
250-500 MHz	LO-RF	35	25
	LO-IF	30	20

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55 REV. A

News from ★ Washington

GERALD GREEN, *Washington Editor*

STEADY GROWTH PREDICTED FOR PRODUCTION OF MICROWAVE EQUIPMENT

The total free world production of microwave equipment will expand steadily, from $22.2 billion in 1980 to $56.4 billion in 1986, for an average annual growth rate of 16.8 percent in current dollars, according to the Microwave Equipment and Component Forecast prepared by Gnostic Concepts, Inc.

Commercial communications is the largest consumer of microwave equipment in a worldwide basis, with government/military microwave second, although government/military microwave holds the largest share of US production.

This worldwide equipment production growth, driven by continually increasing needs for long-distance communication and for improved weapons systems, will create an impressive market for microwave components. The free world production of microwave components will increase from $5.25 billion in 1980 to $14.18 billion in 1986, representing an average growth rate of 18.0 percent per year. This component production, in turn, will create major demand for microwave semiconductors and parts for microwave integrated circuits.

The United States led in production of microwave components, with a 55 percent share, $2.89 billion in 1980, according to the report. This share will decline slightly to 51 percent in 1986, while the US production value climbs at 16.4 percent per year to reach $7.18 billion. The Japanese share will expand from 10 percent to 12 percent, or $1.7 billion, over the forecast period — supported by substantial exports of advanced performance devices.

THE WAR IN SPACE

The war in space has begun. Not the more heralded competition between the superpowers involving particle beams and lasers but an increasingly competitive battle to provide Americans with direct satellite-to-home television broadcasting service.

The most recent combatant is CBS, Inc. who recently announced plans to provide a service that would include a"revolutionary"new type of picture that would enable viewers to receive large screen pictures and stereophonic sound.

The CBS proposal uses a high-resolution transmission that could project twice as many lines on a screen, providing clear large-screen projections.

The CBS proposal is bound to heat up the already competitive battle that includes RCA, COMSAT, and a host of smaller companies. It also broadens and increases the market potential for electronic manufacturing companies who would provide components to the emerging direct satellite-to-home broadcast industry.

R&D INCENTIVES INCLUDED IN NEW CONGRESSIONAL BILLS

Legislation recently has been introduced in the Senate designed to encourage research and experimental activities in the United States. The proposed legislation would enable deductions for R&D conducted in the US.

The new legislation, S. 1410, similar to a companion House bill, H.R. 2473, would remove an existing disincentive that encourages US corporations to transfer part of their R&D activities from the US to foreign countries.

News from Washington

USAF JAM-RESISTANT COMMUNICATIONS TESTS SUCCESSFUL

USAF crews flying aircraft equipped with jam-resistant radios were able to conduct uninterrupted communications during a recent Tactical Air Command large-scale exercise.

"The radio equipment was installed in A-10, O-2 and EC-130 aircraft participating in the exercise,"said David Carstairs, Electronic Systems Division's HAVE QUICK Chief Engineer. "Results of the six-week operation show that despite attempts by a simulated enemy to disrupt conversations by jamming, the radios performed well, insuring uninterrupted communications among the participating pilots and air and ground controllers."

HAVE QUICK equipment is being manufactured by Magnavox Government and Electronic Company of Ft. Wayne, IN. The equipment is being installed in Tactical Air force aircraft and communications jeeps that control close air support stations.

SCIENCE AND ENGINEERING EMPLOYMENT STABLE BETWEEN 1970-1980

Science and engineering (S/E) employment in US private industry remained virtually unchanged between 1970-1980 — 2.1 million according to the latest survey conducted by the National Science Foundation. A long-term decline in S/E employment in manufacturing industries was countered by a steady growth of S/E employment in non-manufacturing industries. Between 1978 and 1980, however, employment in manufacturing increased slightly.

Results of the study are considered worrisome for the US, since S/E employment figures in industrial countries throughout the world have been steadily rising.

USAF TESTING JAM-RESISTANT COMMUNICATIONS SYSTEMS

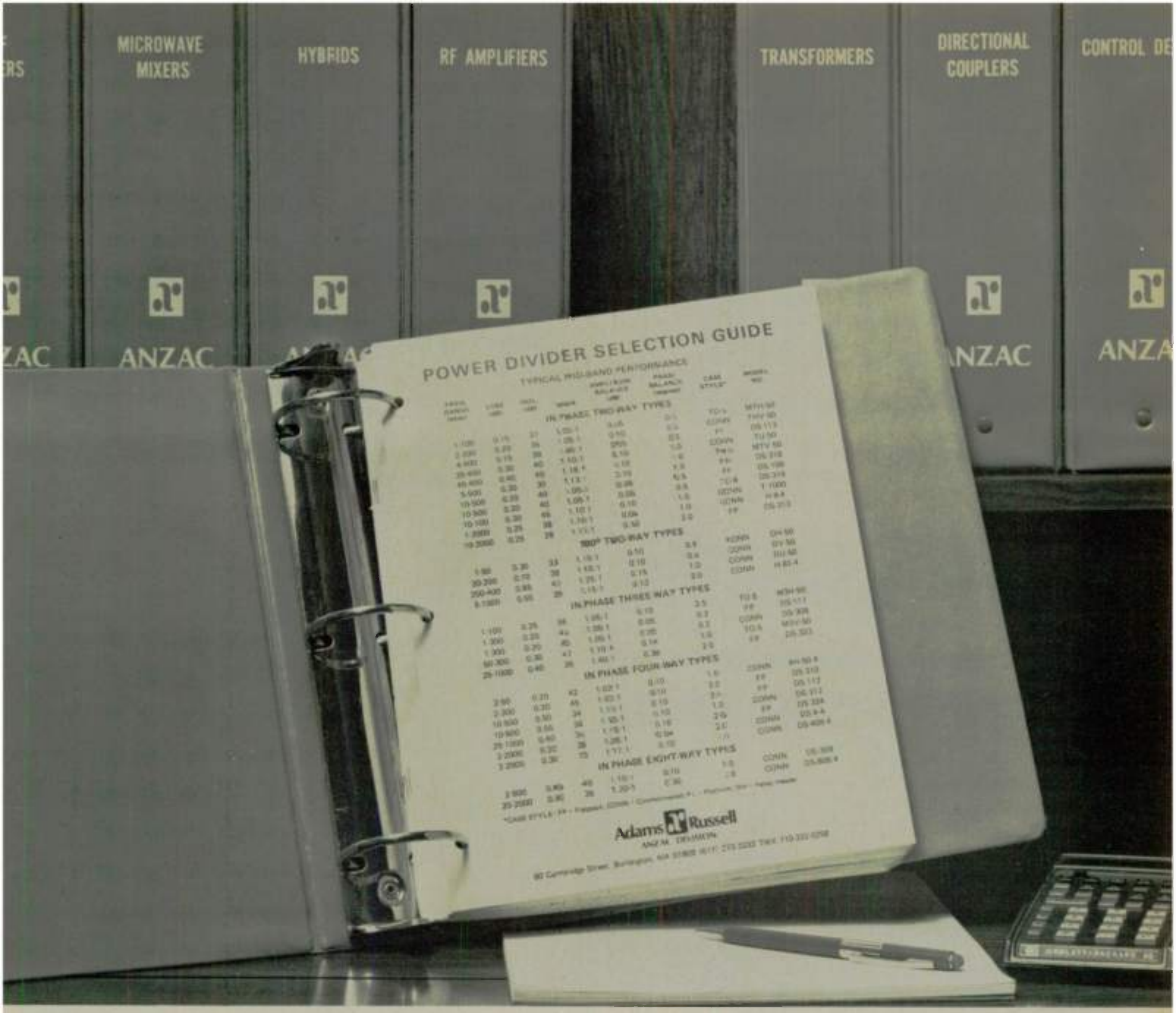
The Air Force is conducting flight tests of two competing jam-resistant voice-communications systems for its SEEK TALK program that will provide protection against jamming for pilots and ground communications units in combat areas.

The equipment was developed by Air Force Systems Command's Rome Air Development Center (RADC) in New York under the overall management of the parent organization — the ELectronics Systems Division (ESD).

The tests, which are being conducted by RADC engineers at the Elgin Air Force Base in FL, will help the Air Force decide which contractor, or contractors, will be awarded follow-on development and production efforts, according to Major Richard Swanson, SEEK TALK's engineering test director at ESD.

Results of the tests will also be considered by the system's contractors - Hazeltine Corporation of Greenlawn, NY and General Electric company of Utica, NY — while building full-scale engineering models of the airborne and ground terminals presently contracted for by ESD under a three-phase program. The new models will be functionally similar to those currently being tested, but are being designed to fit in about one cubic foot.

A production decision is expected in early 1984.



POWER DIVIDERS OFF THE SHELF

At Anzac, it's not just data that's off the shelf. Our million-dollar-plus inventory of RF and microwave components allows us to literally ship off the shelf within 48 hours of your order! All the selection data is packaged in an easy-to-use 272-page catalog which is yours for the asking. So, ask. Please.

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The Building-Block Approach to Customized Synthesizer Systems.

We start with the WJ-1250. From this excellent basis, we custom-build a microwave signal generation system to satisfy your exact application needs.

Because the WJ-1250A/1291 mainframe utilizes modular RF sources, the RF section can be tailored to meet specific requirements. This makes your customized system highly cost efficient as it is only necessary to modify or redesign the RF source with no changes to the frequency synthesizer mainframe.

We can easily customize such parameters as frequency range, power, pulse modulation, and dual RF outputs (with frequency offset). For those systems which require a completely new design, Watkins-Johnson Company has over twelve years of leadership in the microwave signal generation field. Even a new design will build upon the RF techniques tested and proven in the standard units.

The benefits from your customized system will include easier-to-perform tests, more complete test results, guaranteed proper system operation, and your engineers will be free to perform other duties.

For more information on how we can quickly customize your synthesizer system to your exact specifications, contact your local Watkins-Johnson Sales Office or telephone the SSE Division, Applications Engineering, in Palo Alto, California at (415) 493-4141, ext. 2218.

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CIRCLE 36 ON READER SERVICE CARD

Around the Circuit

PERSONNEL

Precision Tuning, Inc. announced the appointment of **J. Lautermilch** as President and **George Pereira,** the company's principal owner, becomes V.P. of Operations . . . **Thomas Goodell** assumed the position of international Sales Manager at Weinschel Engineering . . **Jack H. Liberman** was named General Manager of Hewlett-Packard Co.'s Santa Clara Division . . . Anaren Microwave, Inc. announced the promotion of **John G. Stratakos** from Sales Manager to Manager of Marketing and the appointment of **Robert Worden** to the newly created position of V.P. of business Resources and Planning . . . **David Kirchner** was promoted from Manager and Programs to Technical Director of the Yig Tek Plant of Eaton Corp's Communications Products Division . . . **Scott E. Elkins** was appointed V.P., Marketing and Planning of Booton Electronics Corp., a recently created post . . . **Burt Widener** was appointed Division Manager of Omni Spectra, Inc.'s Connector Division, the M/A-COM Co. based in Waltham . . . US Instrument Rentals, Inc. appointed **Herb Lambrechts** to the position of V.P., Sales and Marketing . . . California Microwave, Inc. announced the promotion of **H. Gary Vandemark** from Manager-Programs to the post of Director-Programs for the company's Satellite Communications Division . . . Alpha Industries, Inc. promoted **Allan L. Coon,** Treasurer to the position of V.P. and Treasurer and **Martin J. Reid** was promoted from V.P., Semiconductor Div. to Senior V.P. . . **George Caryotakis** assumes the position of President of Varian Associates Electron Device Group.

CONTRACTS

American Satellite Comany received a $2.7M contract award from a San Francisco-based bank for the installation and operation of a coast-to-coast high-speed data communications pilot network. . . . **Scientific-Atlanta, Inc.** received an order to supply 5-meter earth station antennas and video receivers to Lembaga Elektroteknika Nasional (LEN), Bandung, Indonesia. The contract is valued at over $800K and is part of a multi-year expansion of the Indonesian domestic satellite communications network . . . **Northrop Corporation** awarded the **General Electric Aerospace Electronics Systems Dept.** a contract of more than $200M for application and testing of an advanced multi-mode radar system . . . **Hazeltine Corporation** announced receipt of a $1.5M award from ERADCOM for AN/TPX-46 (V) 7 IFF Interrogator Systems and ancillary items . . . **M/A-COM Inc.'s** operating company, **Prodelin, Inc.,** signed a $1.4M contract with **Kentron Int'l** for fiberglass microwave antennas, waveguide and coaxial transmission lines to be used on the Pakistan Railways microwave communications network . . . **E-Systems, Inc.** was awarded a $2M contract from the US Navy to incorporate a jam-resistant capability into the AN/WSC-3 UHF radio terminal.

INDUSTRY NEWS

Microwave International Corp., has moved to 200 W. Glades Road, Boca Raton, FL 33431 . . . **M/A-COM,** Inc., announced the formation of a new company, **MACOMNET, Inc.,** which will sell, install and service low-cost private corporate satellite communications networks to the US business community for the interactive transmission of voice, video and data. **Alpha Industries, Inc.,** has completed its acquisition of **Central Microwave Co.** Transaction was effected as a pooling of interest by exchanging 90K shares of Alpha stock for all the outstanding shares of Central Microwave.

NEW MARKET ENTRIES

MATCOM, INC. has been formed to market and distribute microwave components from Europe and Japan. Brian L. Jones heads the company, which will carry an initial line of Toshiba TWT's and microwave semiconductors including GaAs FET's, R & K Laboratories mixers and RF components and Flann Microwave Instruments' hybrids and mm-wave components. Address is 450 San Antonio Road, Palo Alto CA 94306; Tel: (415) 493-6127 . . . **Cuming Corporation** has entered the microwave reflector field with a line of spherical lens type reflectors. Specialized collapsible corner reflector line will be added later. William R. Cuming is President and Paul E. Rowe is Chief Scientist. Location is 135 Old Post Rd., Sharon MA 02067; Tel: (617) 784-6204.

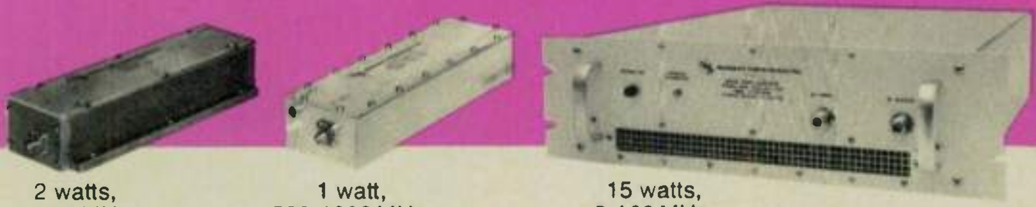
FINANCIAL NEWS

Raymond Industries Inc.'s Board of Directors declared a quarterly dividend of 6.5¢ per share, payable on July 7, 1981 to shareholders of record June 29, 1981 . . . **Sanders Associates, Inc.'s** Board of Directors voted the regular quarterly dividend of 14.5¢ per share payable July 21, 1981 to stockholders of record July 10, 1981 . . . **Alpha Industries, Inc.'s** Board of Directors declared a semiannual cash dividend of 5¢ payable on August 14, 1981 to shareholders of record on July 17, 1981 . . . **Microdyne Corporation** reported second quarter results for the period ended May 3, 1981 of net sales of $7.4M, net income of $940.1K or 232¢ per share. This compares with 1980 quarterly net sales of $5.7M, net income of $863.5K or 21¢ per share . . . **AEL Industries, Inc.** reported a net loss of $1.98M, or $1.01 per share, on sales of $12.41M for the first quarter ended May 29, 1981. This compares with 1980 quarterly net loss of $2.78M, or $1.47 per share, on sales of $12.17M.

Solid state Class A linear power amplifiers.

Unmatched quality. Proven reliability. Competitive price.

The total value/engineering package from MPD.



2 watts, 1-500 MHz:	1 watt, 500-1000 MHz:	15 watts, 2-100 MHz:
$495	**$825**	**$1895**

Other power ratings up to 200 watts, frequency ranges from 1-1000 MHz to 4-8 GHz instantaneous bandwidth.

As the original pioneer and world leader in Solid State RF/Microwave Power Amplifiers, we have noted with interest the recent price and performance claims being made by some competitive companies in the field. When all is said and done, however, there emerges one inescapable fact: there is no other company—*repeat, no other company*—that can match MPD's technical design expertise, manufacturing know-how and proven track record of product reliability under actual field operating conditions!

One of our strongest product areas is Class A linear power amplifiers. Here are just a few design and performance facts that have made our Series LWA the world-wide standard of quality:

- PURE CLASS A
  Exceptional linearity characteristics combined with wide dynamic range performance
- MINIMUM DISTORTION
  Low noise figure plus high power output.
- UNCONDITIONALLY STABLE
  For any source/load VSWR.
- FULLY PROTECTED
  Against DC input reversal, thermal overload, RF input overdrive, infinite load VSWR.
- GRACEFUL DEGRADATION
  Isolated circuit design.
- THERMAL DESIGN
  Exclusive heat dissipation techniques assure reliability.

Our Series LWA offers more than 70 standard models, in module packages and rack-mount cabinets, including ultra-broadband frequency ranges from 1-1000 MHz up to 7900-8400 MHz, and saturated power ratings up to 200 watts.

The next time you're looking at Class A amplifiers, compare the product specifications and reliability record at the same time you're comparing the prices—we think you'll quickly learn the full meaning and importance of MPD value/engineering!

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CIRCLE 37 ON READER SERVICE CARD

In High Power Attenuators and WEINSCHEL Offers Standards Still Trying to Match.

Weinschel high power attenuators and terminations are just another result of our innovative engineering, state-of-the-art manufacturing and quality control standards. For example: resistive films deposited on high thermal conductivity substrates eliminate the need for heat conducting liquids, thus reducing size and improving reliability. The substrates also withstand high-levels of shock and vibration. A proprietary film process produces resistive elements with outstanding qualities like: low temperature coefficients, very low aging rates and immunity to momentary overloads. Our design also offers good thermal isolation to connector center conductors, avoiding damage to mating connectors and cables. Conservatively rated, they handle at least 24% more power than specified. At Weinschel Engineering we make no compromise with quality and performance, why should you?

Model 40 High Power Fixed Coaxial Attenuator
Frequency Range — dc — 1.5 GHz
Average Power — **150 W**
Peak Power — **10 kW**
Standard Attenuation Values — 3, 6, 10, 20, 30, 40 dB Deviation — ± 0.5 dB Max
Connectors — Stainless Steel Type N — Mate with N per MIL-C-39012

Model 1428 High Power Termination NEW
Frequency Range — dc — 1.5 GHz
Average Power — **150 W**
Peak Power — **10 kW**
VSWR — 1.10 Max
Connectors — Stainless Steel Type N — Mate with N per MIL-C-39012

Circle Reader Service 100

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Medium Power Coaxial Fixed Attenuators
Models 22 & 23

10 WATTS
- dc — 12.4 GHz — Model 22
- dc — 18.0 GHz — Model 23
- Power Ratings — 10 to 20 W Avg., 1 to 2 kW Peak
- Standard Values — 3 and 6 dB and 10 thru 60 dB/10 dB increments
- Stainless Steel Type N Connectors — Mate with N per MIL-C-39012

Circle Reader Service 101

Medium Power Fixed Coaxial Attenuator
Model 41

10 WATTS
- dc — 18.0 GHz
- Power Rating: 10 W Avg., 1 kW Peak
- Standard Values — 3, 6, 10 and 20 dB
- Calibrated at Five Frequencies thru 18 GHz
- Stainless Steel WPM Connectors — Mate with SMA per MIL-C-39012

Circle Reader Service 102

High Power Fixed Coaxial Attenuators
Models 33, 34 & 35

25 WATTS
- dc — 8.0 GHz — Model 33
- dc — 4.0 GHz — Model 34
- dc — 1.5 GHz — Model 35
- High Power — 25 W Avg., 5 kW Peak
- Standard Values — 3, 6, 10, 20 and 30 dB
- Stainless Steel Type N Connectors — Mate with N per MIL-C-39012

Circle Reader Service 103

Terminations...
Others are

C 2

High Power Coaxial Fixed Attenuators
Models 24, 25 & 26

50 WATTS
- dc — 8.0 GHz — Model 24
- dc — 4.0 GHz — Model 25
- dc — 1.5 GHz — Model 26
- High Power — 50 W Avg., 5 kW Peak
- Standard Values — 3, 6, 10, 20 and 30 dB
- Stainless Steel Type N Connectors — Mate with N per MIL-C-39012

Circle Reader Service 104

High Power Coaxial Terminations
Models 1426 & 1427

50 WATTS
- dc — 8 GHz
- High Power — 50 W Avg., 5 kW Peak — Model 1426 25 W Avg., 5 kW Peak — Model 1427
- Low VSWR — 1.30:1 Maximum
- Calibration Data — dc Resistance and VSWR Supplied
- Stainless Steel Type N Connectors — Mate with N per MIL-C-39012

Circle Reader Service 105

Miniature Medium Power Termination
Model 1419

10 WATTS
- dc — 18.0 GHz
- Power Rating — 10 W, 1 kW Peak
- Low VSWR — 1.35:1 Maximum
- Stainless Steel WPM Connectors — Mate with SMA per MIL-C-39012

Circle Reader Service 106

EHF Device and Component Contracts at NOSC

NAVAL OCEAN SYSTEMS CENTER
San Diego, CA

The Naval Ocean Systems Center (NOSC) currently has a number of contracts for developing EHF devices and components in support of ongoing and projected Navy systems in ESM, satellite communications, and radar. Summaries of these contractual efforts are given below; NOSC technical contracts for further information on these contracts and associated Navy programs are listed at the end of each summary.

EHF SURVEILLANCE RECEIVERS

Wideband Mixers

As part of a project at NOSC to reduce the complexity of channelled EHF ESM receivers, several contractors are developing EHF mixers and SHF IF amplifiers with very wide bandwidths. The objective is to implement a recently demonstrated technique at NOSC in which one mixer can downconvert a whole band to a high IF, thus eliminating the need for EHF multiplexers and numerous mixers EHF ESM channelized receivers. Hughes Electron Dynamics Division is developing mixers (Contract N66001-80-C-0565) with E-plane circuit techniques that will have unusually wide RF and IF bandwidths. A Ka band mixer will cover the 26-40 GHz band with an LO at 24 GHz and the IF band from 2 to 16 GHz. A W band mixer will span the 78-94 GHz RF band with an IF extending to 42 GHz. The split waveguide block will house a Duroid printed circuit with a balanced mixer and LO and IF diplexing filters. Alpha Industries is developing wideband mixers on contract N6601-80-C-0440 with similar frequency characteristics. The conversion loss is expected to be less than 8 dB over the 26.5-40 GHz band by use of low-loss substrates and careful matching to high quality GaAs beam lead diodes. Narda Microwave Corporation is developing low noise IF amplifiers (contract N66001-81-C-0126) with a frequency band of 2 to 18 GHz and a gain of 20 dB. Two low-noise GaAs FET amplifiers covering the 2-8 and 8-18 GHz bands will be diplexed and combined after amplification by means of MIC filters. The design goal for amplifier noise figure is 9 dB. The size is expected to be less than 1.0 x 2.0 x 6.0 inches. (J. Reindel, Code 9262).

Indium Phosphide Low-Noise Gunn Amplifiers

Varian Associates has a two-year contract with NOSC (contract NOO123-79-C-0692) that calls for a 26.5-40 GHz InP TWT replacement amplifier with 30 dB gain and 9 dB noise figure. Small bandwidth amplifiers will also be built in the 40-60 GHz band with 20 dB gain. The basis for the optimistic noise figure is the fabrication of "P notch" ion-implanted diodes. A small (0.5 micron) doping notch at the Gunn cathode allows a fast buildup of field to above threshold, resulting in a significantly reduced "dead space" as compared to the recently developed "N notch" diodes formed with low-doped epitaxy. The best ion-implanted diodes fabricated to date use Beryllium (P) and Sulfur (N) implants, resulting in 10 dB noise figures and 10 dB gain over several GHz in the upper Ka band. (D. Rubin, Code 9262)

SATELLITE COMMUNICATIONS

The Electron Dynamics Division of Hughes Aircraft Company has two contracts for high power devices, one a tube and the other solid state. On contract NOO123-80-C-1498, Hughes is continuing the design of the Hughes 915H TWT to meet a Navy requirement for a TWT having 50 dB of gain at 43-45 GHz with a 250 W CW output. A total of eight tubes will be built, the first ones with conventionally machined cavity parts and later ones with diamond-turned machined parts. Both air- and water-cooled designs will be fabricated and tests. Measurements at Hughes on the first tubes are scheduled for the last half of 1981. The solid state contract, NOO-123-79-C-1528, is concerned with the investigation and development of silicon double-drift IMPATT diodes and circuits for use at 44 GHz in a CW space-combining antenna. Goals include reproducible one- and two-diode amplifier modules with a minimum bandwidth of 2 GHz. Single diodes have been demonstrated that are near a goal of 2 watts at 12 percent efficiency. Work is under way on two-diode Kurokawa combiner circuits. (R. Casey, Code 8143)

The space-combining antenna, mentioned as the application for the Hughes solid state combiner circuits, is being handled by Motorola on contract N66001-81-C-0019. The end objective of the antenna project is a dual-band system having a receive mode in K band and a transmit mode in Q band. During the design study phase, Motorola has investigated a) system heat transfer and individual diode thermal characteristics, b) dual-band antenna technques, and c) methods of adapting the Hughes solid-state devices to the Motorola antenna approach. Motorola and Hughes are coordinating their respective efforts on these contracts. (R. Casey, Code 8143)

LNR Communications has been developing an S to Q band upconverter with a self-contained phase-locked Q band pump source on contract NOO123-79-C-1529. The main specifications include 2-4 GHz input, Q band output, 2 GHz instantaneous input and output bandwidth, 100 mW upper sideband output, 100 mW S-band input power, 300 mW (nominal) Q band pump power and 40 dB power sideband rejection. The upper sideband upconverter has been fabricated and tested, and most of the work on the phase-locked pump source has been completed. (R. Casey, Code 8143)

Scientific Atlanta is building a dual-frequency radome on contract N66001-81-R-0082. The radome, a hemisphere over cylinderin configuration, is specified to have transmission losses less than 0.3 dB over a specified 1.5 GHz region in Q band and less than 0.15 dB over a 1 GHz region in K band. The radome material selected by the contractor must be able to handle 2 watts per square inch, and the radome must be sealed with a coating resistant to sun and weather effects. Delivery of this radome is expected by mid-1981. (M. Devan, Code 8124)

EHF RADAR TUBE TECHNOLOGY

Development of an axial gain millimeter-wave crossed field amplifier (CFA) has begun at Raytheon, Power Tube Division (contract N-66001-80-0278). During their initial phase of the effort, Raytheon developed a manufacturable slow-wave structure with characteristics suitable for a CFA. This structure will be used to develop a device capable of more than 200 kW peak power and with a bandwidth greater than 10 percent. (R. Wills, Code 9261). **Contact: John Carson, (714) 225-6763.**

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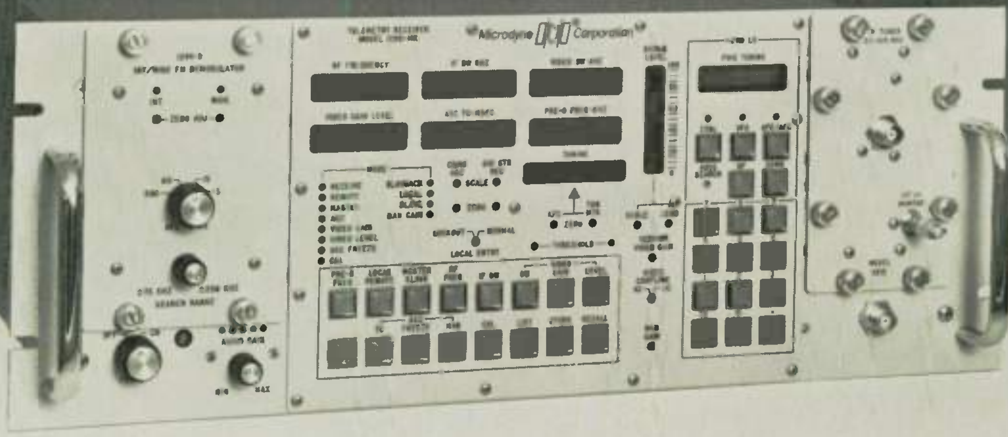
the telemetry receiver your computer really understands



Microdyne's New 1200-MR

Both remotely and manually controllable, the 1200-MR double conversion receiver is the first to anticipate and meet the many telemetry requirements of the 1980's. Consider just some of the features:

- IEEE-488 or optional RS-232 interface
- Keyboard entry for manual control
- Discrete tuning ranges, voltage controlled from 215 MHz to 4.2 GHz
- AM, FM, PM and Bi-Phase Demodulation Modes
- DC to 5 MHz video Baseband response
- Synthesized LO's, phase locked to a common 5 MHz reference, with 1×10^{-7} stability
- Up to seven internal 2nd IF filters, switch selectable with BW's up to 10 MHz
- Ruggedized design allows installation on aircraft, land vehicles, ships and submarines

For free technical brochures describing the 1200-MR receiver, and/or the 3200-PC and 3200-PC(10) Diversity Combiners call or write: Microdyne Corporation, 627 Lofstrand Lane, Rockville, Maryland 20850. Telephone (301) 762-8500.

Microdyne Corporation

Now - Extremely fast fade rate combiners for dramatic BER and SNR improvements

The new 3200-PC and 3200-PC(10) are the first and only commercial Pre/Post-D Diversity Combiners offering the following unique features:

Fast Fade Rates —Optimal Ratio Combining maintained with two randomly phased RF signals that vary up to 20 dB in relative amplitude at fade rates up to 20,000 c.p.s.!

AM/AGC Combining — AM Function insures Optimal Ratio Combining when fade rates exceed limited receiver AGC response times.

BER and SNR Improvements — Dramatic BER reductions and SNR improvements under severe multipath, flame attenuation and pseudo-random noise conditions.

Receivers Required — Two 1200-MR receivers are used with the 3200-PC Combiner. Two 1100-AR or similar type receivers, with 10 MHz and appropriate logic outputs are used with the 3200-PC(10) Combiner.

Replaces Other Combiners — The 3200-PC(10) replaces Microdyne 3300-C or similar type 10 MHz input combiners with BER and SNR limitations.

Ruggedized Design — Both combiners are ideally suited for ground stations and installation on aircraft, mobile vehicles, surface ships and submarines.

CIRCLE 39 ON READER SERVICE CARD

Microwave Tubes for Communications Satellites of the Western World

BERND.K. KNORR
AEG-TELEFUNKEN, Tube Division
Ulm, West Germany

INTRODUCTION

There are many publications on satellites, their design and application. This paper attempts to evaluate these publications[1-8] in respect to microwave devices being used in the power amplifier stages of communications satellites in the Western World. The following Tables (I and II) show communications satellites for commercial, military and developmental applications. Emphasis is on traveling-wave tubes (TWT's) as the main microwave device in satellite power amplifiers. For the TWT's manufacturers' designations, characteristics like frequency range and output power as well as the number of tubes per satellite are presented. All tubes are traveling-wave tubes. Only Russian communications satellites use other microwave tube types such as klystrons. Solid state amplifiers have their domain in the UHF and L band. In the near future they may find application in the C band.

The basic circuit functions of a satellite transponder are shown in Figure 1. The up link signal arriving at the antenna in one frequency band (f_1) is amplified in the low noise receiver of the transponder. In the next step, the signal is converted to a second frequency (f_2) which is the down link frequency if no further frequency conversion is applied. Before the down link frequency can be applied to the power amplifier, it is adjusted to the input characteristics of the power stage.

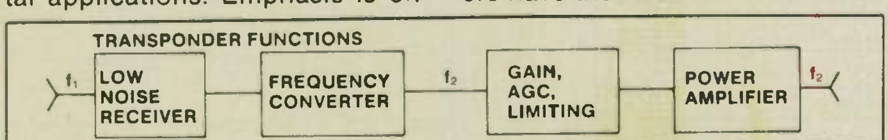


Fig. 1 Schematic circuit diagram of a satellite transponder.

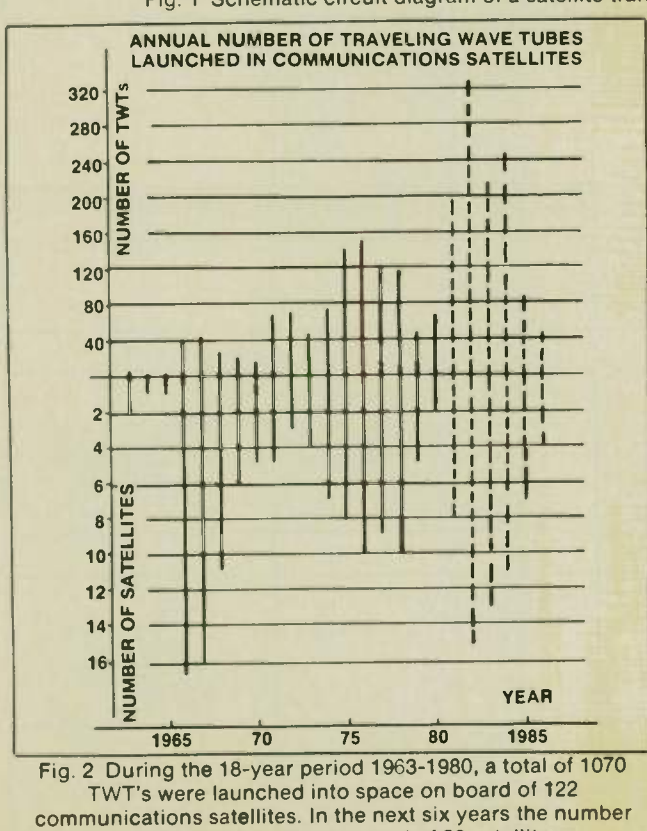


Fig. 2 During the 18-year period 1963-1980, a total of 1070 TWT's were launched into space on board of 122 communications satellites. In the next six years the number of TWT's will be 1117 on board of 58 satellites.

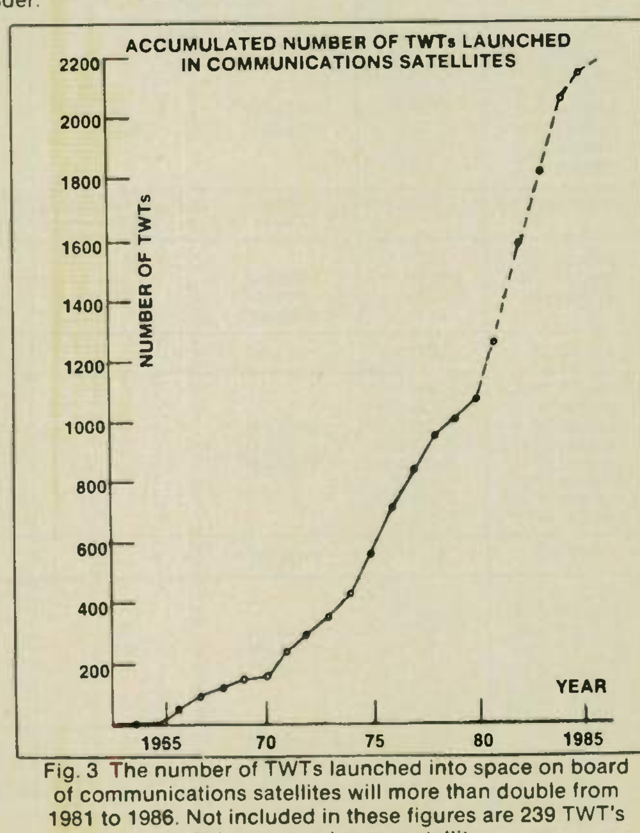
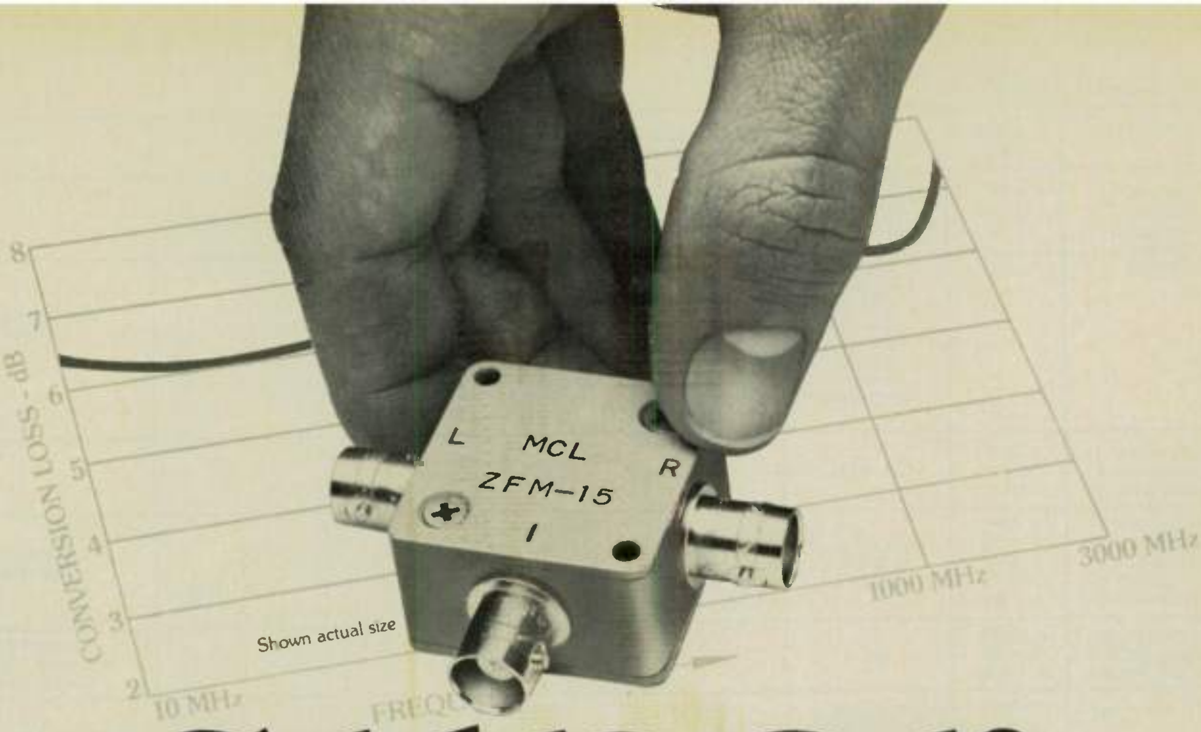


Fig. 3 The number of TWTs launched into space on board of communications satellites will more than double from 1981 to 1986. Not included in these figures are 239 TWT's built into ground spare satellites.

TABLE I

Project	Launch Date	Device Characteristic: TWT Type or Solid State Amp. Cat.	Device Characteristic: Output Power (W)	Device Characteristic: Frequency (GHz)	Number of TWTs: per Satellite	Number of TWTs: per Project	Notes
Syncom 1 Syncom 1 Syncom 3	F 2/63 F 7/63 F 8/64	314 H	2.5	1.8	2 2 2	9	
LES — 1	2/65	Solid state amplifier, details unknown		UHF	—	—	
Intelsat I (Early Bird)	4/65	215 H	6	4	2	2	
LES — 3 LES — 4	12/65 12/65	Solid state amplifier, details unknown		UHF	—	—	
DSCS I 1-7 (IDCSP) 8-15 16-18 19-26	6/66 1/67 7/67 /68	WJ — 251 X — 1066	3.5	7.25	1 1	34 34 68	In addition, 8 satellites launched which failed — also one of 7/67 launch.
Intelsat II 1 Intelsat II 2 Intelsat II 3 Intelsat II 4	F 10/66 F 1/67 F 3/67 F 9/67	a) 215 H b) 226 H	6 0.06	4 4	4 2	16 8 24	
ATS-1 (+ B)	12/66	384 HA solid state amplifier, details unknown	4.5	4 0.135	4	4	
ATS-2 (+ C)	F /67	384 HA solid state amplifier, details unknown	4.5	4 0.135	4	4 —	
LES-5	7/67	solid state amplifier, details unknown		UHF	—	—	
ATS-3 (+ D)	11/67	243 H	12	4	2	2	
ATS-4 (+ A)	7/68	384 HA solid state amplifier, details unknown	4.5	4 0.135	4 —	4 —	
LES-6	9/68	solid state amplifier, details unknown		UHF	—	—	
Intelsat III 1 Intelsat III 2 Intelsat III 3 Intelsat III 4 Intelsat III 5 Intelsat III 6 Intelsat III 7 Intelsat III 8	F 9/68 F 12/68 F 2/69 F 5/69 F 7/69 F 1/70 F 4/70 F 7/70	a)235 H b) 233 H	12 0.15	4 4	2 2	16 16 32	
Tacsat	2/69	239 H 240 H	4.5 20	2.3 7.85	2 3	5 5	
Skynet 1A Skynet 1B ATS-5 (+ E)	11/69 8/70 8/69	Hughes* 414 H Hughes*	13	7 1.55 15	4* 2 2*	8 4	
NATO 1A	3/70	Hughes*		7	4*	4	
Intelsat IV 2 Intelsat IV 3 Intelsat IV 4 Intelsat IV 5 Intelsat IV 7 Intelsat IV 8 Intelsat IV 6 Intelsat IV 1	F 1/71 F 12/71 F 1/72 F 6/72 F 8/73 F 11/74 F 2/75 F 5/75	a) 261 H b) 262 H c) 272 H	6 1.5 1.5	4 4 4	24 4 2	192 30 2 224	Two 272 H replacing two 262 H on F8. Four driver TWTs per satellite
NATO 2	2/71	Hughes*		7	4*	4	
DSCS II 1+2 DSCS II 3+4 DSCS II 5+6 DSCS II 7+8 DSCS II 9+10 DSCS II 11+12 DSCS II 13+14	F 11/71 F 12/73 F 5/75 F 5/77 F 3/78 F 12/78 F /79	a) 265 H b) 263 H c) 293 H	20 0.5 40	7 7 7	2 2 2	see Table II	No. 15 and 16 in production From No. 13 or with 40 W TWT.
Anik A 1 Anik A 2 Anik A 3	11/72 4/73 5/75	a) 275 H b) 276 H	5 0.4	4 4	12 2	36 6 42	
Skynet 2A Skynet 2B	F 1/74 F 11/74	Hughes*		7	4*	8	

[continued on page 56]



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LO Power + 10 dBm

CONVERSION LOSS, dB	Typ	Max.
20-1500 MHz	6.3	7.5
10-3000 MHz	6.5	8.5

ISOLATION, dB (10-3000 MHz)	Typ	Min
LO-RF	30	20
LO-IF	30	20

SIGNAL 1 dB Compression Level +5 dBm

IMPEDANCE all ports 50 ohms

VSWR (at ports)	Typ
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RF	2.1
IF	1.8

CONNECTORS BNC STD, TNC on request
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MOUNTING Thru hole, Threaded insert, Flange

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CIRCLE 40 ON READER SERVICE CARD

[from page 54] TUBES

TABLE I

Project	Launch Date	Device Characteristic			Number of TWTs		Notes
Westar 1 Westar 2 Westar 3	4/74 10/74 8/79	a) 275 H b) 276 H	5 0.4	4 4	12 2	see Table II	
ATS-6	5/74	235 HD 233 H 268 H 254 H Multistage bipolar transistor amplifiers	12 0.2 2.5 2.5 110 40 20 20 17	4 4 17 30 0.860 1.550 2.075 2.570 2.670	2 2 2 2	8	Parallel operation of TWTs.
Symphonie 1 Symphonie 2 Symphonie 3	12/74 8/75 Spare	TL 4003	13	4	2 2 2	6	
Intelsat IVA 1 Intelsat IVA 2 Intelsat IVA 4 Intelsat IVA 5 Intelsat IVA 3	F 9/75 F 1/76 F 5/77 F 9/77 F 1/78	a) 271 H b) 275 HA c) 276 H	6 5 0.4	4 4 4	22 10 6	110 50 30 190	Six driver TWTs per satellite
Satcom (RCA)1 Satcom (RCA)2 Satcom (RCA)3	F 12/75 F 3/76 F 12/79	296 H	5	4	24	72	See also Table II. Satcom 4 & 5 have design changes.
CTS (Hermes)	1/76	TH 3536 L-5394 FET amplifier	20 200 0,1	12 12 12	2 2	4	Coupled-cavity TWT Experimental transmitter
Marisat 1 Marisat 2 Marisat 3	2/76 6/76 10/76	a) 275 H b) 291 H	5 7/29/64	4 1.5	2 2	6 6 12	L-band transmitter Power anode voltage controlled.
LES-8 LES-9	3/76 3/76	c) solid state amplifier for Navy use, details unknown Impatt amplifier 0.5 solid state amplifier.		UHF 36 UHF	—	—	Gapfiller leased US Navy service
NATO 3 A NATO 3 B NATO 3 C	5/76 1/77 12/78	265 H	22	7	4 4 4	12	

TABLE I

Project	Launch Date	Device Characteristic			Number of TWTs		Notes
Comstar 1 Comstar 2 Comstar 3	5/76 7/76 6/78	a) 275 H b) 277 H c) 272 H	5 5.5 1.5	4 4 4	12 12 4	see Table II	For Comstar 4 see Table 1b. Comstar 2 with IMPATT amplifier equipped for Bell Lab. tests at 19/29 GHz
Palapa 1 Palapa 2	7/76 3/77	275 H	5	4	12	24	
ETS (Kiku) 2	2/77	low power ss amplifiers		1.7; 11.5; 34			beacon experiments only.
Sirio 1	8/77	280 H	10	12	2	2	
CS (Sakura)	12/77	292 H NEC	4 4.5	20 4	6 2	8	
Fleetsatcom 1 Fleetsatcom 2 Fleetsatcom 3 Fleetsatcom 4	2/78 5/79 1/80 10/80	solid state amplifiers, details unknown		UHF	—	—	For No. 5 see Table II
BSE (Yuri)	4/78	837 HD 294 H	1 100	12 12	3 3	6 6	
OTS 1 OTS 2 ANIK B	F 9/77 F 5/78 12/78	a) TL 12022 b) TH 3525 TL 4010 TL 12025	20 20 10 20	12 12 4 12	4 4 12 4	8 8 16 16	MAROTS program was not completed.
ECS (Ayame) 1 SBS 1	F 2/79 11/80	a) 251 H b) Hughes* TL 12026	3 20	32 4 12	2 2 16	4 see Table II	ECS 2 in production
Intelsat V 1	12/80	a) TH 3559 b) 244 H c) 249 H	10.5 4.5 8.5	12 4 4	a) 10 b) 33 c) 6	see Table II	6 TWTs for telemetry.
Satellite Data System	NN	837 H			no information available	no information available	US Air Force polar communications system.

[continued on page 58]

Solid state devices are used today in these low-power amplifiers. A few low-power TWT's in the range of 0.5-1.5 W which were used in the past for this purpose are included in Tables I and II. The output of the power amplifier produces sufficient effective radiated power in the down link antenna to be received by the earth terminals. In the power amplifiers of communications satellites, microwave devices for power ranges up to 20 W are used; in the power amplifiers of TV-distribution satellites TWT's are used in the power range of 30 to 270 W as helix and up to 450 W as coupled-cavity TWT's. Some satellites built for experimental and military applications use solid state amplifiers. The bipolar transistor challenged the TWT in the UHF, L and S band frequency range. At higher frequencies, IMPATT amplifiers are implemented. In future they will be augmented by power FET amplifiers. With the advent of power combining techniques they become feasible in the 10 to 20 W power range at C band.

WESTERN WORLD COMMUNICATIONS SATELLITES

In Table I, all communications satellites of the Western World are listed in order of their launch date of the first satellite of a project. This corresponds roughly to the order the contracts were executed. Except for military satellites, the number of power amplifiers in a satellite is listed. One military project was omitted due to a lack of information. This is the US Air Force Satellite Data System which became operational 1979. Satellites of this system will also be launched in the future.

In addition, there are other projects in the planning phase like Intelsat VI, Nato IV, Arabsat, Brazilsat and the NASA experimental satellite for 20/30 GHz. The quantity of microwave devices in Table II, therefore, represents a minimum of demand for the future, especially after 1984.

Concerning the order volume for the microwave devices, it should be mentioned that in addition to the number of flight models shown in Table I also engineering models, spares and life test models were ordered. Satellites launched until the end of 1980 are shown in Table I. The satellites of Table II are presently under construction or their contract awards will be given to the industry in the course of 1981.

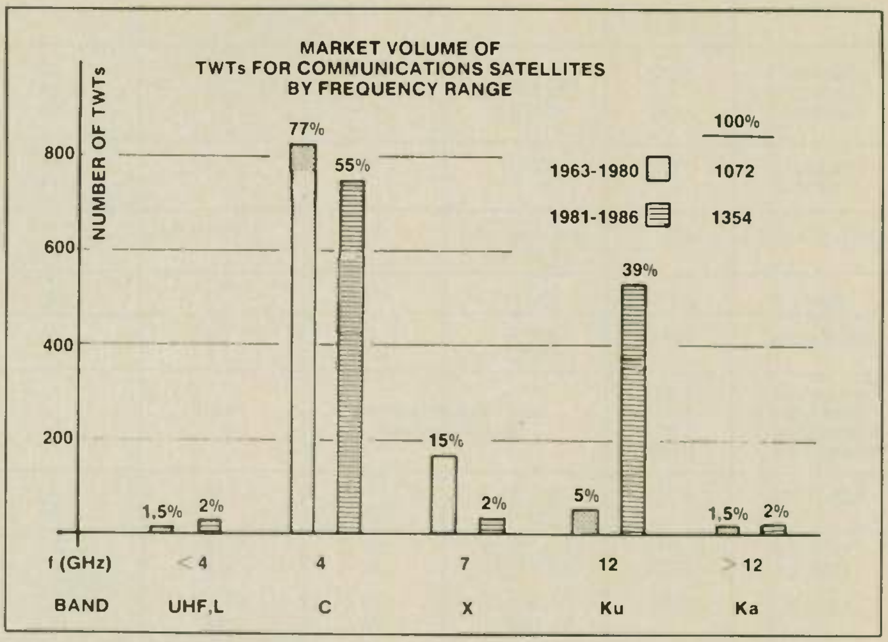

Fig. 4 The market volume includes the number of flight models ordered for spare satellites. In future, the share of 12 GHz TWT's will considerably rise. Although the per cent rate of 4 GHz TWT's falls, the number of tubes remains fairly constant.

THE MARKET FOR COMMUNICATIONS SATELLITES TWT'S

The data of Table I are evaluated in Figures 2-5. Figure 2 shows the yearly number of satellite launches and the number of TWT's carried by these satellites. In the 18-year period from 1963 to 1980, a total of 134 satellites was launched. One hundred twenty two of them carried 1070 TWT's into space. The rest had exclusively solid-state amplifiers on board. Due to launch vehicle failures, 25 satellites (20.5%) with 182 TWT's (17%) did not reach their orbit. There are no figures available in the literature if all 888 TWT's on board the 97 satellites which were put into operation did work after launch. However, it can be assumed from recent data that the number of microwave device failures in power amplifiers during launch is very low.

Between 1981 and 1986 the launch of 63 satellites is planned. Five of them are equipped with solid state power amplifiers. A total of 1117 TWT's will be installed on board of the 58 satellites. Some of these satellites will carry additionally solid state amplifiers.

Figure 3 shows above the TWT numbers accumulated. The number of TWT's launches in the next six years is a little larger than the number of the last 18 years. These figures reflect the growing use of satellite communications on a worldwide basis. In the above numbers, TWT's for installation in spare satellites are not included. These satellites are stored on the ground until the necessity for their launch arises either by a launch

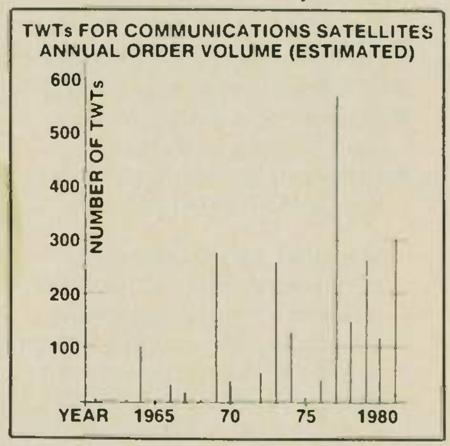

Fig. 5 With more satellite systems put into operation, the annual order volume becomes less dependent upon the large Intelsat orders. A steady order volume of 150 tubes per year seems realistic and desirable from the tube manufacturers' point of view.

[*continued on page 60*]

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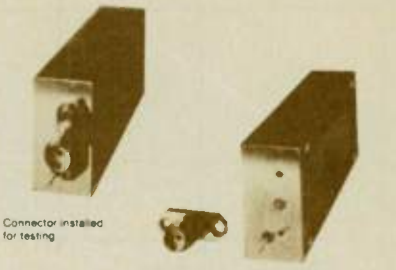
81-82 EDITION

FET AMPLIFIERS

DROP-IN WIDE BAND TEMPERATURE COMPENSATED

MODEL	FREQUENCY GHz	GAIN dB NOMINAL	MAXIMUM NOISE FIGURE dB	MINIMUM POWER OUT dBm	VSWR	mA MAX +15VDC
8081-1601	2.0-8.0	7.0	5.0	+7	2.0:1	40
8081-1602	2.0-8.0	14.0	5.0	+7	2.0:1	80
8081-1603	2.0-8.0	22.0	5.0	+7	2.0:1	180
8081-1604	2.0-8.0	28.0	5.0	+7	2.0:1	220
8081-1605	2.0-8.0	34.0	5.0	+7	2.0:1	260
8081-1611	2.0-6.0	25.0	4.5	+14	2.0:1	140
8081-1612	2.0-6.0	34.0	4.5	+14	2.0:1	180
8081-1201	6.0-18.0	14.0	8.0	+9	2.0:1	180
8081-1202	6.0-18.0	18.0	8.0	+9	2.0:1	220
8081-1203	6.0-18.0	23.0	8.0	+9	2.0:1	260



Connector installed for testing

Connector removed for installation

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CIRCLE 43 ON READER SERVICE CARD

FERRITES

BANDWIDTH vs. GUARANTEED PERFORMANCE
8 - 18 GHz

Percent BW	Isolation dB MIN.	Insertion Loss dB MAX.	VSWR MAX.
10	20	0.4	1.25
11	18	0.4	1.30
12	17	0.5	1.35
13	16	0.5	1.40
14	15	0.6	1.45
15	15	0.6	1.45

Weight: 600mg
Temperature Range: -55 C to +95 C
NOTE: Case can be soldered to metals at temperatures up to +150 C

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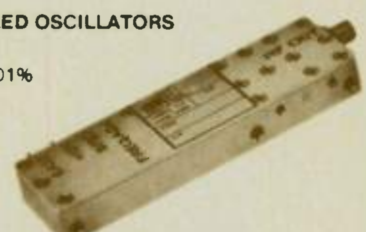
2.5 - 10 GHZ MINIATURE CRYSTAL CONTROLLED OSCILLATORS

ELECTRICAL PARAMETERS (general)
Frequency set accuracy at room temperature: ±0.001%
Frequency stability: ±0.003%
Aging rate: ±0.005% per year
Power variation with temperature: ±2 dB
Power supply: +15 VDC (other voltages optional)
Temperature Range: -55 to +85°C
(to +125°C with degradation)



MODEL NUMBER	FREQUENCY (GHz)	POWER OUTPUT AT +25°C (dBm min.)	OUTPUT HARMONICS AND SPURIOUS (dBc)	CURRENT (ma nom.)
5044-1311	2.5 - 4.0	+10	>40	100
5044-1611	4.0 - 8.0	>10	>40	110
5045-1911	8.0 - 10.0	+10	>40	120

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CIRCLE 46 ON READER SERVICE CARD

[*from page 58*] **TUBES**

TABLE II

Project	Launch Date	Device Characteristic: TWT Type or solid state amplif. cat.	Output Power (W)	Frequency (GHz)	Number of TWTs: per Satellite	per Project	Notes
Comstar 1	2/81	a) 275 H b) 277 H c) 272 H	5 5.5 1.5	4 4 4	12 12 4	48 48 16 102	See also Table I
SBS 2 SBS 3	4/81 Spare	TL 12026	20	12	16 16	48	See also Table I
Intelsat V 1 Intelsat V 2 Intelsat V 3 Intelsat V 4 Intelsat V 5 Intelsat V 6 Intelsat V 7 Intelsat V 8 Intelsat V 9	11/80 3/81 6/81 1982 1982 1983 Spare 1984 1984	a) TH 3559 b) 244 H c) 249 H	10.5 4.5 8.5	12 4 4	10 33 6	90 297 54 441	No. 5-7 to include a maritime transponder Options for a total of 15 satellites. see also Table I
APPLE	6/81	299 H	5	4	2	2	
Marecs 1 Marecs 2 Marecs 3	10/81 2/82 1983	a) Solid State amplifier b) Hughes*		1.5 4	6*	18	
Fleetsatcom 5	1981	solid state amplifiers, details unknown		UHF	—	—	
Satcom (RCA) 4 Satcom (RCA) 5	10/81 1982	a) 296 H b) Solid state amplifier	5	4 4	24 —	48 —See also Table I	No. 6 and 7 planned
Anik 'C' 1 Anik 'C' 2 Anik 'C' 3	Spare 11/81 1982	TL 12016	15	12	20	60	
Westar 4 Westar 5	1/82 1983	a) 275 H b) 276 H	5 0.4	4 4	24 —	84 6 90	See also Table I

TABLE II

Project	Launch Date	Device Characteristic			Number of TWTs		Notes
TDRS A TDRS B TDRS C TDRS D TDRS E	Spare 1982 1982 1982 1983	a) TL 12030 b) 845 H c) 230 H d) 278 H	30 1.5 5.5 26	13 13 4 2.1	6 4 12 4	30 20 60 20 130	
Anik 'D' 1 Anik 'D' 2	6/82 Spare	Hughes*		4	24	48	
ECS 1 ECS 2 ECS 3 ECS 4 ECS 5	1982 1982 1985 1986 Spare	a) TI 12025 b) TH 3525	20 20	12	6 6	30 30 60	
Insat 1A Insat 1B	1982 1983	a) Hughes* b) Hughes*	4.5 50	4 2.5	12 2x3	24 12 36	
DSCS II 15 DSCS II 16	1982 1983	a) 265 H b) 263 H c) 293 H	20 0.5 40	7 7 7	2 2 2	24 32 8 64	see also Table I
CS 2 (Sakura 2) a CS 2 (Sakura 2) b	1983 1983	a) 292 H b) NEC	4.5 4	4 20	2 6	4 12 16	
Telstar 1 Telstar 2 Telstar 3	1983 1984 spare	a) FET power amplifiers by Bell Lab. b) 275 H *	18.5 5	4 4	— 10	— 30	
Palapa II 1 Palapa II 2	1983 1984	Hughes*	10	4	24	48	
Telecom 1 A Telecom 1 B Telecom 1 C	5/83 1983 Spare	a) Thomson b) Hughes c) Hughes*	20 8.5	12 4 7.5	6 6 2	18 18 6 42	
TV-SAT D 1 TV-SAT D 2 TV-SAT D 3	1984 1985 1986	TL 12260*	250	12	5	15	

[continued on page 62]

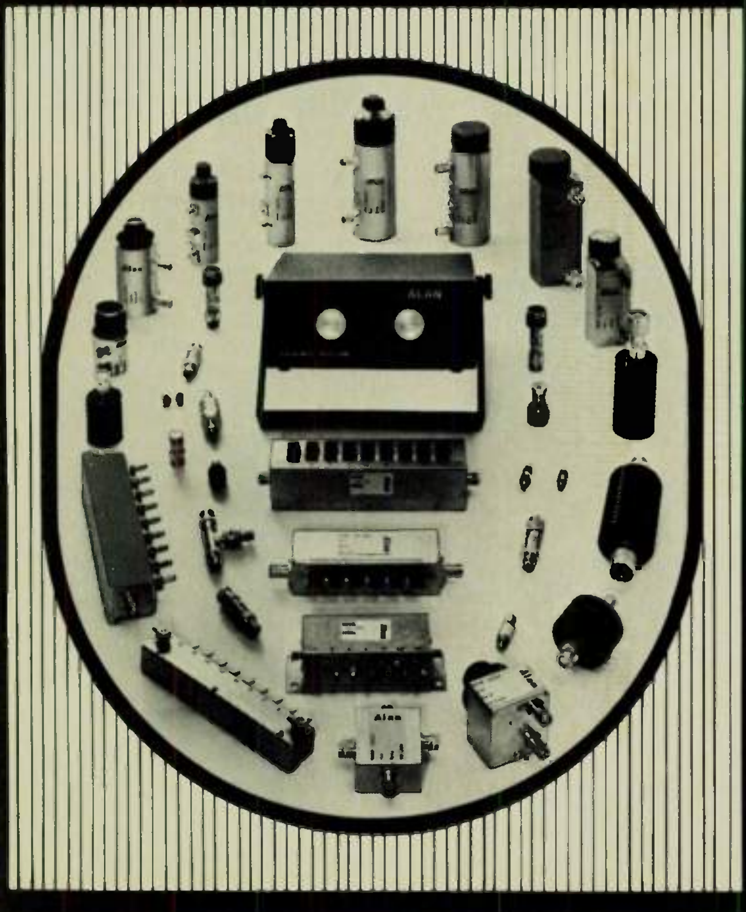

TABLE II

Project	Launch Date	Device Characteristic			Number of TWTs		Notes
TV-SAT F 1 TV-SAT F 2 TV-SAT F 3	1984 1985 1986	TH 3619*	2 x 160	12	3 x 3	27	Parallel operation with 2 out of 3 redundancy
BS 2 A BS 2 B	1984 1985	TH 3599	100	12	7	14	
Leasat A Leasat B Leasat C Leasat D Leasat E	1984 1984 1986 1986 spare	solid state amplifiers, details unknown		UHF	—	—	similar to Fleetsatcom
G-Star 1 G-Star 2 G-Star 3	1984 1984 spare	a) NN b) NN	20 30	12 12	21 3	63 9 72	
Southern 1 Pacific 2 3	1984 1984 spare	a) NN b) NN	5 20	4 12	18 6	54 18 72	
Australia-Sat 1 Australia-Sat 2 Australia-Sat 3	1985 1985 spare	a) NN b) NN	15 30	12 12	12 6	36 18 54	
L-Sat 1 L-Sat 2	1985 1986	NN NN NN NN NN NN	230 20 30 2,5 20 4,5	12 12 12 20 20 30	4 4 4 1 4 1	8 8 8 2 8 2 36	Two units will be constructed of which one is launched as a preoperational satellite

*) = estimate

F = Due to launch vehicle failure spacecraft did not reach orbit

Tube Manufacturers' Index:

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Hughes Electron Dynamics Division = ... H or HD
Litton Electron Tube Division = L- . . . . .
Thomson-CSF = TH . . . . .
Watkins-Johnson = WJ- . . . .
Varian/Eimac = X- . . . . .
NN = tube manufacturer not yet nominated

or operational failure of a satellite or by growing communications demand. Table I includes 12 spare satellites with 239 TWT's. Including these spares, 192 satellites are listed which are equipped with 2426 TWT's. This is the total market volume as estimated in early 1981 for flight model TWT's for communications satellites of the Western World.

Figure 4 shows this market volume for the two periods of Table II divided into frequency ranges. In future, 12 GHz will become more important with the percentage being raised from 5 to 39%. The real numbers of 4 GHz TWT's only show a slight decrease. It does not demonstrate the impact of solid-state devices on the market of these tubes in the future. The data for 20 GHz tubes show that this frequency range stays experimental for some time. The market volume for 1981-1986 shows a 26% increase over the period 1963-1980.

Finally, in Figure 5 the annual order volume is estimated. For projects where no exact order date was available, a two-year lead time for tubes was assumed. The order volume was subject to large variations in the past. Until the middle of the seventies there was a four-to-five-year cycle between peaks. The maximum was reached in 1977 with the award of the large orders for Intelsat V and TDRSS. With a rising demand for satellite communications, a more stable order volume of 150 TWT's per year seems realistic. This is also desirable from the tube manufacturers' point of view in order to keep experienced personnel on the job.

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2-STAGE IF AMPLIFIER (2A SERIES)*

Model	LO/RF Freq. (GHz)	RF/IF Gain (Min.dB)	Noise Figure (dB) Typ.	Noise Figure (dB) Max.	Dynamic Range (dBm)	Nom.DC Power (+15 V,mA)	Outline
1-150 MHz IF AMPLIFIER							
MLO-2A-0115	1-2	22	6.5	7.5	0	40	2
M45-2A-0115	1.8-6.5	22	7.0	8.0	0	40	6
M35-2A-0115	3-10	22	7.5	8.5	0	40	6
M30-2A-0115	4-15	22	7.5	8.5	0	40	6
M20-2A-0115	6.5-18.5	22	8.0	9.0	0	40	6
M2C-2A-0115	2-18.5	22	8.0	9.0	0	40	6
1-500 MHz IF AMPLIFIER							
MLO-2A-0150	1-2	22	7.0	8.0	8	55	2
M45-2A-0150	1.8-6.5	22	7.5	8.5	8	55	2
M35-2A-0150	3-10	22	7.5	8.5	8	55	6
M30-2A-0150	4-15	22	8.0	9.0	8	55	6
M20-2A-0150	6.5-18.5	22	8.5	9.5	8	55	6
M2C-2A-0150	2-18.5	22	8.5	9.5	8	55	6
5-1000 MHz IF AMPLIFIER							
M45-2A-000510	2-6	17	8.5	9.5	0	35	6
M35-2A-000510	3-10	17	9.5	10.5	0	35	6
M30-2A-000510	4-15	16	9.5	10.5	0	35	6
M20-2A-000510	6.5-18.5	16	10.5	11.5	0	35	6
400-2000 MHz IF AMPLIFIER							
M35-2A-0420	3-10	14	8.0	9.0	5	35	6
M30-2A-0420	4-15	14	8.5	9.5	5	35	6
M20-2A-0420	6.5-18.5	14	9.0	10.0	5	35	6

MIXERS

Model	RF & LO Band (GHz)	IF Band (GHz)	Conv. Loss (dB) Typ.	Conv. Loss (dB) Max.	Min Isolation LO/RF	Min Isolation LO/IF
OCTAVE BAND DESIGNS						
MLO	1-2	0-0.5	5.0	6.0	25	15
MSO	2-4	0-1.0	5.0	6.0	25	20
MCO	4-8	0-2.0	6.0	7.0	25	20
MXO	8-12.5	0-3.0	6.5	7.5	25	20
MKO	12-18.5	0-3.0	6.6	7.5	20	15
M2D	4-8	8-16	7.5	8.5	25	25
M4D	2-4	4-8	7.5	8.5	25	25
WIDEBAND MULTIOCTAVE DESIGNS						
M45	1.8-6.5	0-1.0	6.0	7.0	25	20
M35	3-10	0-2.0	6.0	7.0	20	20
M30	4-15	0-2.5	6.5	7.5	20	15
M20	6.5-18.5	0-3.0	7.0	8.0	20	15
M2C	2-18.5	0-.6	7.0	8.0	20	15
M2C	3-12	0-.6	6.5	7.5	25	25

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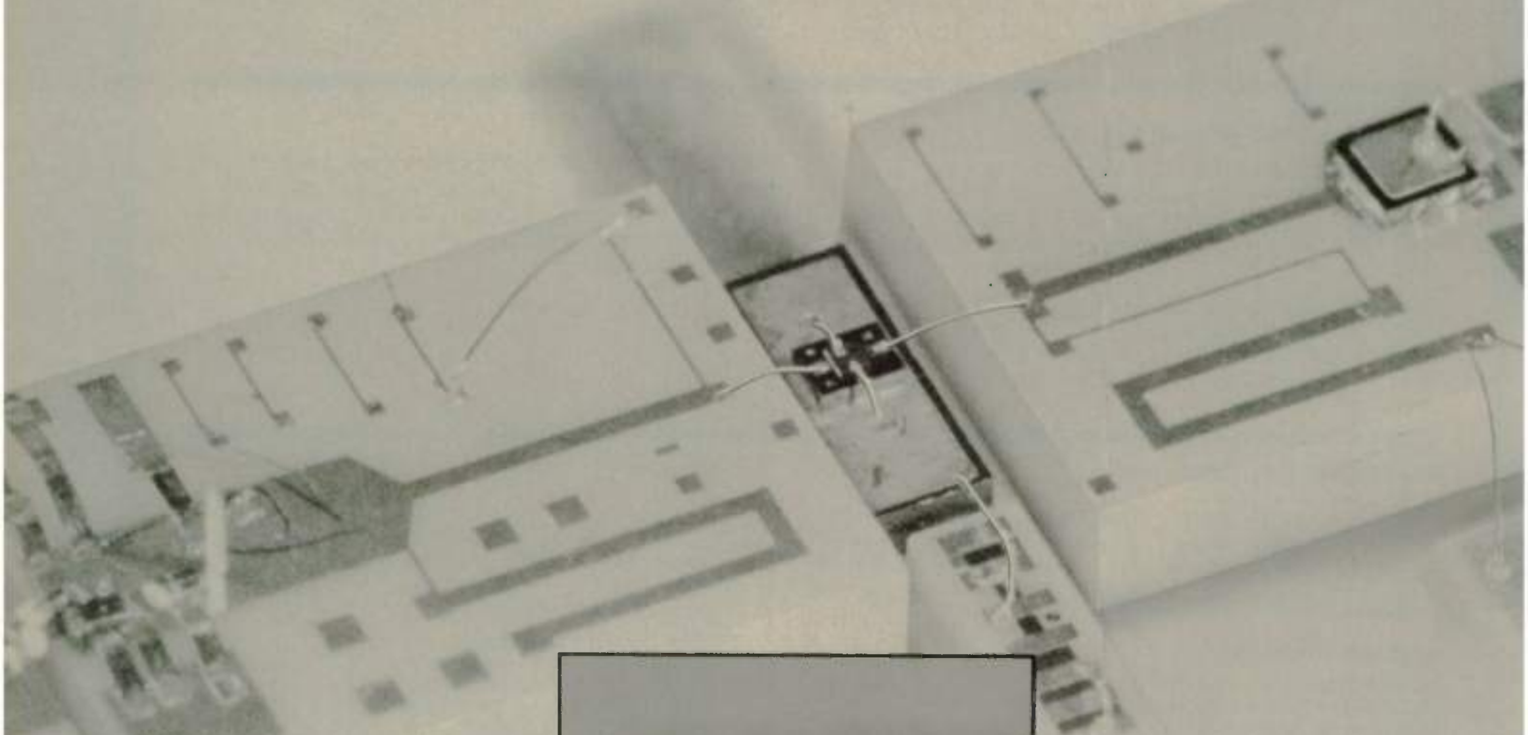

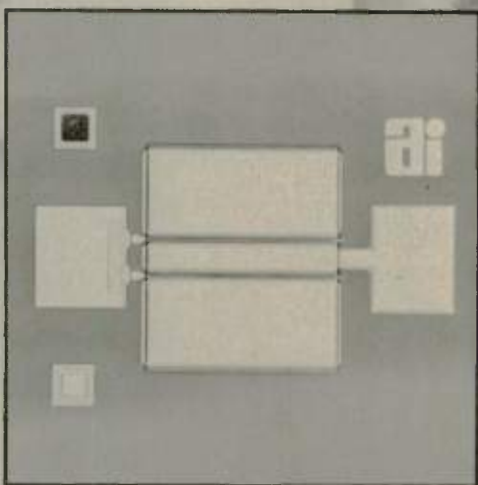

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		f = 8 GHz	—	2.6	3.0		f = 8 GHz	7.5	9.0	—

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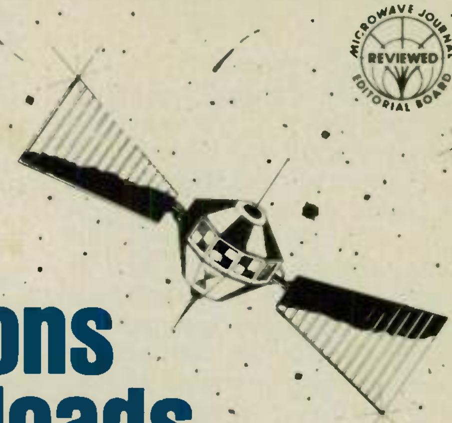
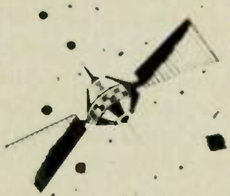


FET Applications In Satellite Payloads



ROLF ROSENBERG
Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrte. V. [DFVLR], Cologne, W. Germany

A survey is presented on the possible applications of field-effect transistors in satellite transponders. Taking as an example the German Television Broadcasting Satellite TV-SAT, presently under development, it is shown to what extent field-effect transistor technology has become popular in satellite applications.

INTRODUCTION

Basic tasks to be fulfilled by an active transponder are: 1) reception of the up-link signals in a specified up-link frequency range by means of the satellite receive antenna; 2) conversion of the signals to the down-link frequency range (single conversion) or to an intermediate frequency range (double conversion); and 3) power amplification in the transmit stage, in the event of double conversion following prior conversion to the down-link frequency range. In association with the transmit antenna gain, the necessary Effective Isotropic Radiated Power (EIRP) is thus made available for the ground receiving stations.

To fulfill these tasks, certain key components are used including, e.g., low-noise preamplifiers, mixers, high-gain channel amplifiers and transmit amplifiers. In multi-channel transponders, additional components are required — an input multiplexer to split the receive frequency band into the individual channels and an output multiplexer for joining the high-power-amplified channel frequency bands to constitute the transmit frequency band.

Taking as an example the German Television Broadcasting Satellite TV-SAT, it can be shown which of the above-mentioned key components were designed by applying the latest field-effect transitor (FET) technology. The payload (Figure 1) of the German satellite TV-SAT operates according to the principle of a single-conversion transponder in a receive frequency range of 17.3 to 17.7 GHz and a transmit frequency range of 11.7 to 12.1 GHz. The satellite payload essentially consists of the receive antenna, a redundant broadband section with telecommand signal (TC) output, a five-channel section with traveling-wave tube power amplifiers, the output multiplexer with additional telemetry (TM) signal input, and the transmit antenna. The third section of this article will deal with those components suited for application of the field-effect transistor technolgy that has been verified in the TV-SAT.

FET'S FOR RADIO-FREQUENCY APPLICATIONS

In a field-effect transistor (FET), the charge carrier flow from a source electrode to a drain electrode is controlled by one or more gate electrodes. The various types of field-effect transistors are distinguished essentially by the mechanism applied for insulation of the gate electrode, by the gate electrode material, by the method of fabrication of the source-drain channel and by whether the transistor consists totally of massive semiconductor material (bulk transistor) or whether the semiconductor material is applied only where it is indispensable for the function. If the classification is determined by the gate electrode set up, it makes a difference whether the metallic electrode is directly applied on the semiconductor material (Schottky barrier; MESFET) or acts on a p-n semiconductor junction (barrier layer and/or junction FET; JFET) or is insulated from the semiconductor material by means of an insulating oxide layer (SiO_2: MOSFET; with other non-oxide insulating layers MISFET and/or IGFET) or is separated from the actual semiconductor by a semiconducting insulating layer (SIGFET).

For radio-frequency FET's, normally use is made of gallium-arsenide (GaAs) as the semiconductor material, which compared to the other standard silicon semiconductor material, provides a higher electron mobility and greater maximum electron drift velocity. The most important FET type for microwave applications is the its basic setup is shown in a schematic representation in Figure 2. The flow of electrons from the source to the drain is controlled by applying a negative gate voltage; at higher negative gate voltage the channel between source-drain electrodes is narrower, i.e. the resistance is greater than at a lower voltage; hence this is a so-called depletion-type transistor.

For specific applications (e.g. gain control), field-effect transistors are available with two-gate electrodes (dual-gate FET), where one gate electrode may carry out gain control. Furthermore, there are also field-effect transistors for power amplification applications.

Most recent developments in the area of field-effect transistor technology are directed towards the improvement of RF properties by reducing the gate electrode length which establishes the frequency-determining charge carrier transit time through the source-drain channel.

FIELD EFFECT TRANSISTORS IN SATELLITE TRANSPONDERS

Low-Noise Input Amplier

The low-noise input amplifier, in association with the receive antenna gain, establishes the input sensitivity of a transponder. In the past, the amplifier function was assured by tunnel diode amplifiers or by low-loss frequency converters in connection with a subsequent low-noise amplifier. In later satellite payloads, the family of low-noise receive amplifier was enlarged by parameteric amplifiers and FET amplifiers.

In terms of the noise figure, the parametric amplifier holds the top position: e.g., at 14 GHz in an uncooled type, noise figures of 1 to 2.3 dB are achieved. If modern Gunn diode oscillators are applied as pumping frequency generators for the parametric amplifiers, the noise figure is kept at a constant level over a long period of time. The field-effect transistor amplifier and the tunnel diode amplifier jointly come second with noise figures of 5 to 6 dB each at 14 GHz, the frequency converter with subsequent amplifier stage reaches in total a noise figure of 8.5 dB at 14 GHz. The last-mentioned mixer amplifier is rarely used in satellites any more, the field effect transistor amplifier shows significant advantages over the tunnel diode amplifier, such as smaller dimensions, lower weight and a dynamic range increased by about 20 dB. In two-state parametric amplifiers, the FET amplifier can replace the second stage without any significant degradation of the overall noise figure, which, because of the large dynamic range of FET amplifiers, results in a dynamic gain of about 20 dB as compared with two-stage parametric amplifiers. In future, the FET amplifier will be able to completely replace the parametric amplifier, which will allow savings to be made in terms of cost, dimensions, and weight reaching a power of 10 in each case.

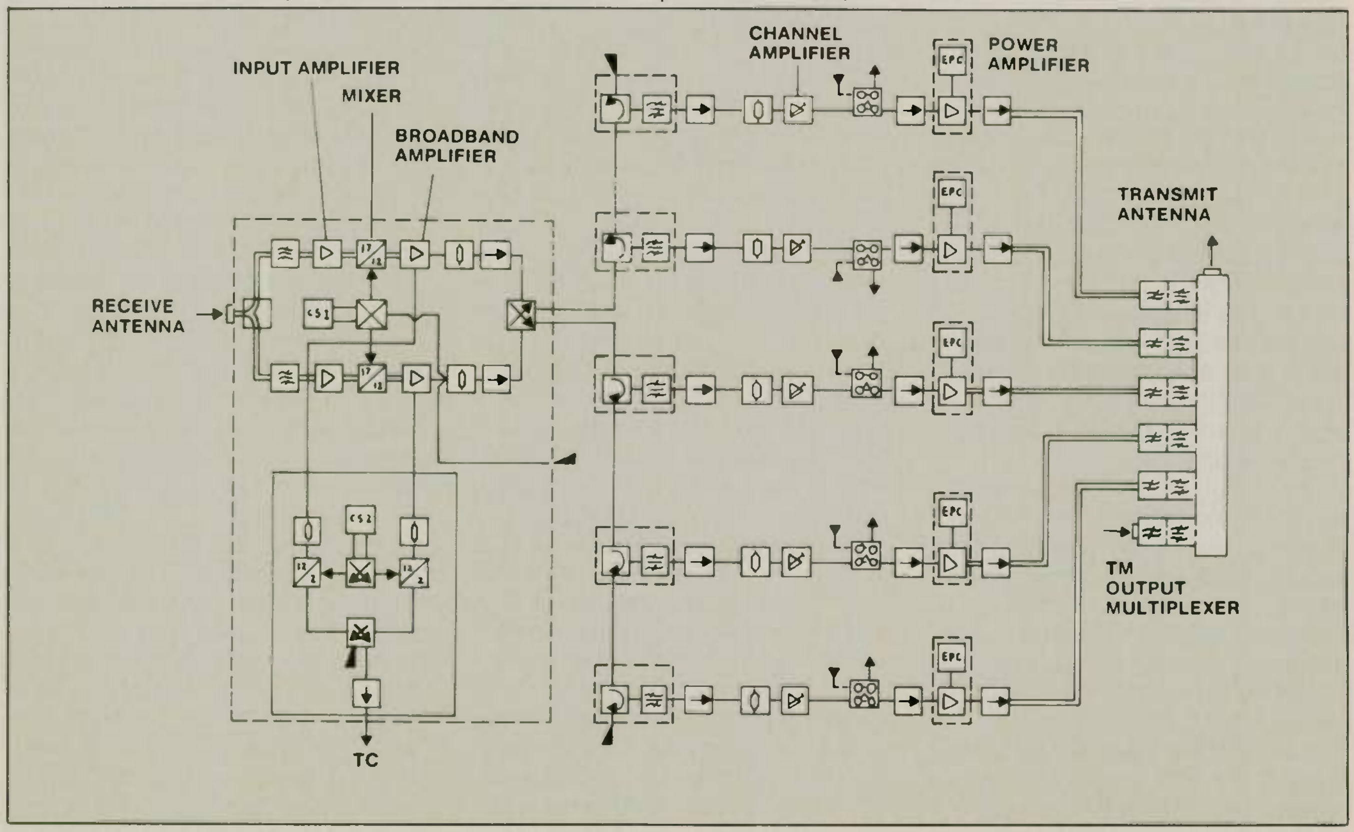


Fig. 1 Block diagram of the German TV-SAT satellite transponder.

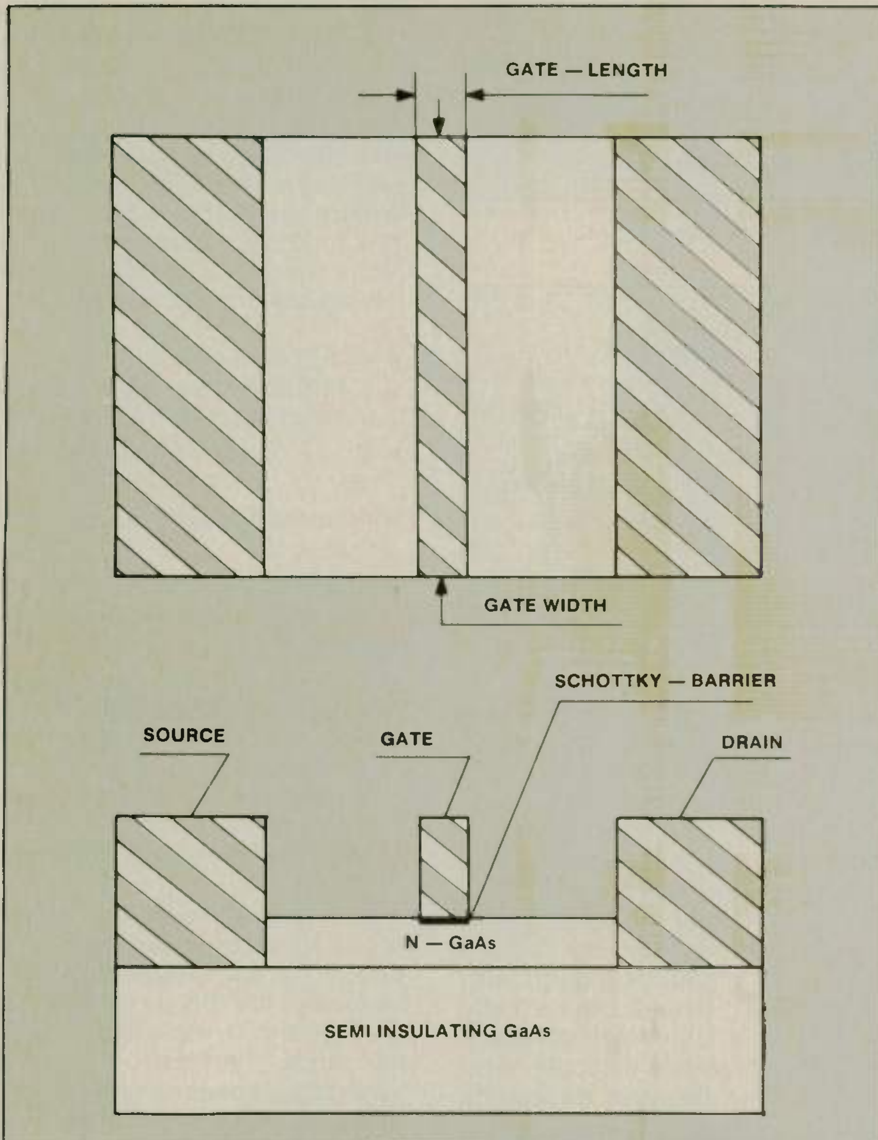


Fig. 2 GaAs FET simplified physical model.

Latest developments are aimed at cooling the FET amplifier, in order to achieve lower noise temperatures and with it also better noise figures. Cooling the amplifier to about 80°K reduces the noise figure by about 2 dB in the frequency range of 4 to 18 GHz. The NEC company (Nippon Electric Company) has demonstrated 20 GHz FET amplifiers with noise figures of 3.4 dB.

In the German Television Broadcasting Satellite, an uncooled parametric amplifier is used as input amplifier. In the frequency range 17.3 to 17.7 GHz, a noise figure of 5 dB and a gain of 11.3 to 14.7 dB is achieved.

Mixer

Due to its physical setup, the field-effect transistor mixer assures a high isolation of useful signal channel and oscillator branch. The conversion losses and also with it the mixer's noise figure however, are increased if the mixer oscillator is applied to the gate electrode of the transistor, although a considerable internal intermediate frequency gain is achieved. With the application of the mixer oscillator to the drain circuit of the transistor, a noise figure of 4 dB and a conversion gain of 3 dB was achieved for a 6/4 GHz converter.

For the German Television Broadcasting Satellite, two mixer types will be utilized which do not contain field-effect transistors. An 18/12 GHz mixer uses GaAs Schottky diodes achieving a noise figure of 5 dB at a bandwidth of 400 MHz. The second 12/2 GHz mixer is provided with silicon Schottky diodes will be applied for conversion of the telecommand signals contained in the receive band.

Controllable Channel Amplifier and Broadband Amplifier

The low-power FET amplifier is suited for high-gain applications in the range of 4 to 20 GHz, with gains per FET chip of approximately 8 to 10 dB in the 4 GHz frequency region and of up to 6 dB in the 20 GHz region. If dual-gate FET's are used, an additional gain control is possible by applying the useful signal to be amplified to one gate electrode and the gain control signal to the second gate electrode.

Main applications of the FET amplifiers are in the field of broadband and channel amplifiers, specifically for the German Television Broadcasting Satellite TV SAT. The 12 GHz FET amplifiers developed for this purpose enable single conversion to be applied, i.e. the receive frequency band is directly transformed to the transmit frequency band by means of an input mixer without any intermediate conversion.

The TV-SAT amplifiers are of a modular structure consisting of two-stage FET small signal amplifiers modules and two-stage FET large signal amplifier modules. The small signal amplifier module is optimized with respect to high gain and low noise figure. Using the GaAs MESFET NE 38883 made by NEC, a gain of more than 17.5 dB is achieved in the frequency range of 11.7 to 12.5 GHz with a gain variation of less than 0.5 dB. The output power in the 1 dB compression point is 11 dBm, the gain variation in the specified temperature range of -15 to +55°C is smaller than 1.2 dB. The large signal amplifier module shows a high output power together with a high linearity and low intermodulation products at the output. By using the GaAs MESFET NE 69406 (NEC), a gain of 13 dB with less than 0.6 dB gain variation is achieved in the frequency range of 11.7 to 12.5 GHz. In the 1 dB compression point, the output power amounts to 21 dBm, the

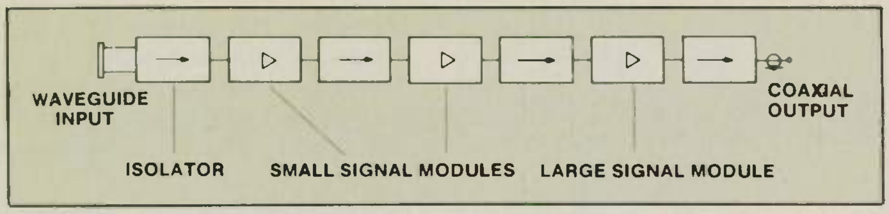


Fig. 3 Block diagram of broadband amplifier for German TV-SAT.

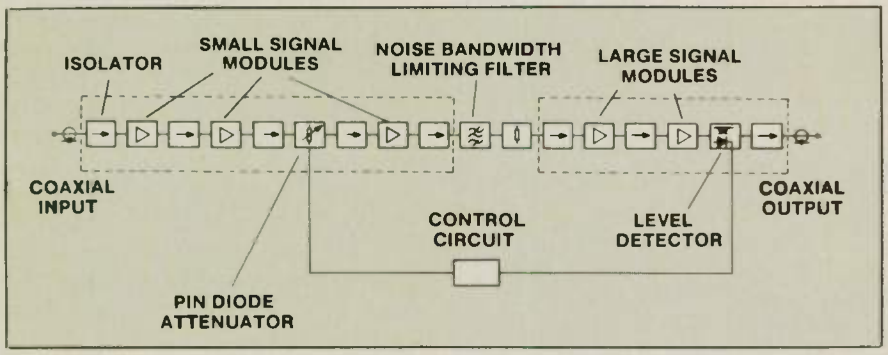


Fig. 4 Block diagram of channel amplifier for German TV-SAT.

gain variation in the specified temperature range (-15 to +55°C) is less than 2.5 dB.

Circuits of the modules are made in microstrip technique on aluminium oxide (Al_2O_3) substrate, the radio frequency resistors are realized in tantalum nitrite (TaN) in thin-film technique. Matching of the individual modules in cascading to the broadband and/ or channel amplifier is made by means of isolators ("single-ended The 12 GHz FET broadband amplifier (Figures 3, 4) is composed of two small signal amplifier modules, the first one being particularly low-noise, and of one large signal amplifier module. Most important figures in the frequency range of 11.7 to 12.5 GHz and in the temperature limits from O° to +40°C are:

- 47 dB small signal gain with less than 1 dB (peak-peak) gain variation.
- Noise figure smaller than 3.5 dB.
- Input and output SWR better than 1.2.
- AM/PM conversion factor (input-power-dependent phase distortions of the radio frequency output signal) less than O.1°/dB at -3.5 dBm output power.

The 12 GHz FET channel amplifier (Figures 5, 6) consists of three small signal and two large signal amplifier modules. An attenuation element (four PIN diodes), inserted after the second small signal amplifier module; a level detector (coupler with backward diode), inserted after the second large signal amplifier module; and a trigger and control circuit assure a channel amplifier function, with adjustable gain and automatically controllable output, level by means of ground station telecommand signals. A four-cycle waveguide

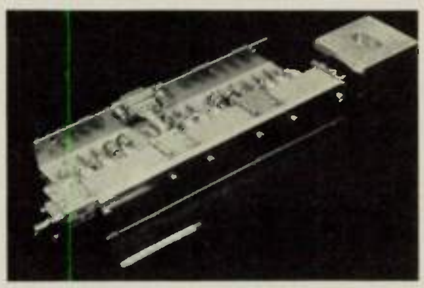


Fig. 5 Electrical model of broadband amplifier. (AEG-Telefunken).

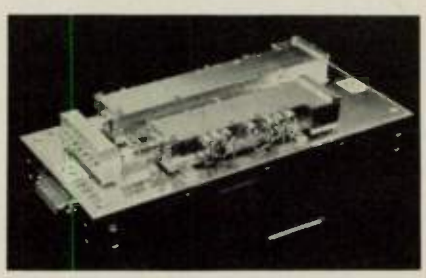


Fig. 6 Electrical model of channel amplifier. (AEG-Telefunken).

filter is inserted in the amplification chain for noise power limitation. The channel amplifier provides at the output the necessary power for triggering the transmit amplifier stage (in the case of TV-SAT this is a traveling-wave tube). Within the frequency range of 11.7 to 12.5 GHz and temperature limits from O° to +40°C, the following specifications are met:

- 44 to 74 dB gain with less than 1.4 dB (peak-peak) gain variation, adjustable in 124 steps.
- Noise figure smaller than 5.8 dB.
- Input SWR less 1.2, output SWR than 1.12.
- AM/PM conversion factor less than O.8°/dB at 18 dBm output power.
- 3 to 18.7 dBm output power, adjustable in 127 steps; in the ALC mode (ALC: Automatic Level Control), the output power is automatically kept at a constant level for input power variations by as much as 20 dB.

With respect to gain control of the channel amplifier, tests were carried out using dual-gate FET's instead of the PIN diode attenuation element. In these tests a dynamic range of the gain, adjustable via a gate electrode, was achieved of 26 dB (6 dB to -20 dB). The additional amplifying property of the dual-gate FET control, in comparison to the PIN diode control, could eliminate one small signal amplifier module. However, as space-qualified dual-gate field-effect transistors are not available on the market, this elegant approach of gain control could not be considered for the TV-SAT; for future applications, however, this approach is absolutely favorite.

Power Amplifier

Together with the transmit antenna gain, the power amplifier of a satellite transponder provides the necessary transmit power (EIRP: Effective Isotropic Radiated Power) for the downlink to the ground receiving stations. Usually, this function is carried out by traveling-wave tube transmit amplifiers, whose special characteristics are a high lifetime and excel-

[continued on page 72]

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[*from page 70*] **FET**

lent reliability. In the frequency range around 12 GHz, the transmit band assigned for European television satellites, traveling-wave tubes of the 10 W to 700 W classes are available for space applications. The use of multiple collector technology for traveling-wave tubes leads to efficiencies of up to 50% (dc supply-to-RF output power efficiency). The FET transmit amplifier is suited to replace the traveling-wave tube in the 5 through 10 W class at frequencies of 12 GHz, higher power classes are still reserved for the traveling-wave tubes.

For the German Television Broadcasting Satellite TV-SAT, tube transmit amplifiers will be used in the transmit frequency range of 11.7 to 12.1 GHz. The amplifiers supply 260 W of radio frequency output power at gain factors of 40 to 47 dB.

OTHER APPLICATIONS

The field-effect transistor is not only suited for use as versatile amplifier but also fulfills various kinds of radio frequency signal switching and control functions. For FET's, the switching speeds are in the 100 picosecond range and thus markedly outdo the nanosecond switching speeds of the transistor-transistor-logic (TTL) with bipolar transistors and PIN diode switches. Even compared to the as yet fastest Schottky diode switches and the emitter-coupler logic (ECL), with switching speeds of 500 - 800 picoseconds, this is a significant improvement. Main field of application of the fast FET high hes is for matrix switches, time division multiple access (TDMA) and pulse modulation procedures.

A specific application of field-effect transistors is in the area of digital data transmission with high bit rates. The bipolar transistor in an emitter-coupled logic (ECL) allows data rates of as much as one gigabit per second (Gbps). For the requirements of future satellite systems with ever increasing data rates, the FET logic with data rates of 2-4 gigabits per second appears to be the most suitable candidate; there are only the transferred electron devices (TED), with data rate capabilities of up to 10 Gbps, which are still superior to the FET.

CONCLUSIONS

Development of the payload of the German Television Broadcasting Satellite TV-SAT has shown that the application of field effect transistors is primarily in the field of low-noise broadband amplifiers and of channel amplifiers with large gain dynamics. The technological progress achieved for FET's will allow future applications at frequencies above 20 GHz.

In the foreseeable future, parametric input amplifiers will be replaced by smaller, lower-weight and lower-cost FET amplifiers. In the field of fast transmission of high data rates, the field-effect transistors will replace the emitter-coupled transistor logic (ECL) which has been used up to now. And in the area of power amplifiers, higher power classes continue to be reserved for the traveling-wave tube amplifiers, FET amplifiers will only be able to push into the lower power class (e.g. 5 W to 10 W at frequencies around 12 GHz).

ACKNOWLEDGEMENT

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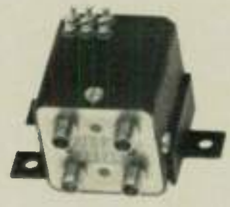

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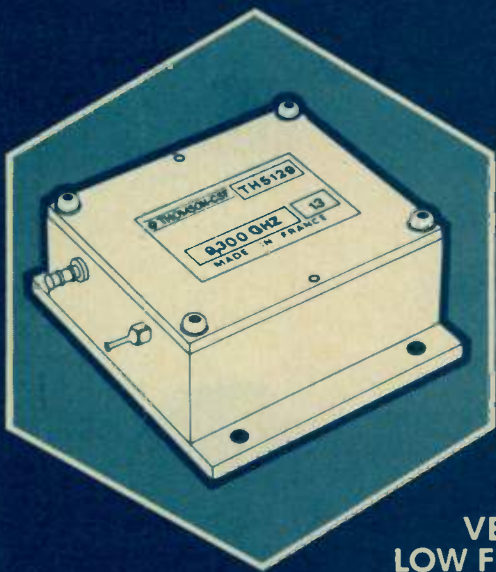

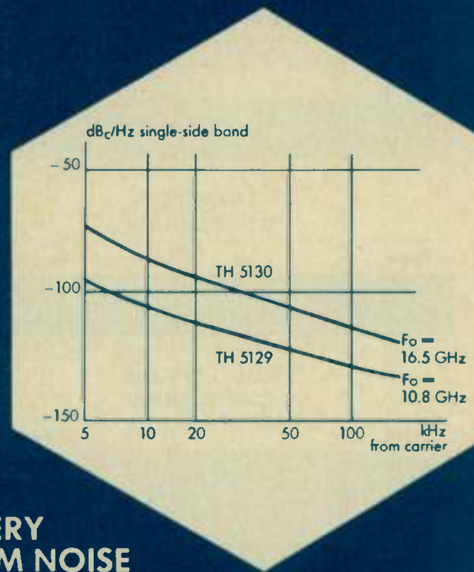

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Type number	TH 5129	TH 5130	
Frequency range	8 - 12.4	13 - 17	GHz
Output power	10	10	mW
Frequency stability vs. temperature (max.)	5	7	ppm/°C
Short term stability	10^{-7}	10^{-7}	/s

ADDITIONAL INFORMATION

Data-sheets on this product line are available upon request.

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CG 4490

A 7.5 GHz Microstrip Phased Array for Aircraft-to-Satellite Communication

FRANK W. CIPOLLA,
Ball Aerospace Systems Div.
Boulder, CO

The demand for high gain full hemisphere coverage for aircraft to satellite communications is ever increasing. Many approaches to this problem have been investigated; including, a parabolic dish under a radome and the more conformal hybrid-scan array under a radome.[1] Both are heavy and protrude a significant distance from the aircraft skin.

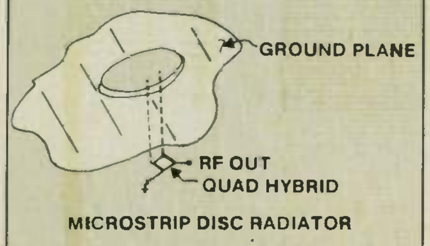
An ideal solution to the problem may be a completely conformal lightweight microstrip phased array. Ball Aerospace Systems Division (BASD) has developed a unique technology in building this type of phased array.

INTRODUCTION

Reported here are results of a research and development program conducted at BASD under a contract with Rome Air Development Center to investigate, design, and fabricate a microstrip phased array for the SHF SATCOM communications systems. A 7.5 GHz receive-only microstrip phased array has been developed which achieved a gain of 19.8 dBic for the broadside beam. It is left-hand circularly polarized and has 3-bit digital PIN diode phase shifters for steering the beam. A micro-processor-based beam steering controller was also provided for calculating the phase shifter settings for each beam position. The entire array including radiating elements, quadrature hybrid, phase shifters, corporate feed, RF chokes and dc bias is in microstrip medium. Some requirements of this phased array are:

Frequency	7.5 GHz (Receive Only)
Bandwidth	500 MHz
Gain	20 dBic
Polarization	Left Hand Circular
Efficiency	50%
Scan Volume	Θ = ±45° Φ = 0° or 180° Θ = ±60° Φ = 90° or 270°
Beam Steering Control	Microprocessor-Based System

In order to achieve these goals, these requirements were put on each sub-system of the microstrip phased array.



BANDWIDTH — OVER 500 MHz ON 1/32" THICK DIELECTRIC
BEAMWIDTH — ~120°
AXIAL RATIO — 0-4 dB OVER THE BAND
SIZE — ~35λ DIAMETER
EASE OF MANUFACTURABILITY — SIMPLE PHOTOETCH PROCESS: HIGH REPEATABILITY

Fig. 1 Microstrip disk radiator.

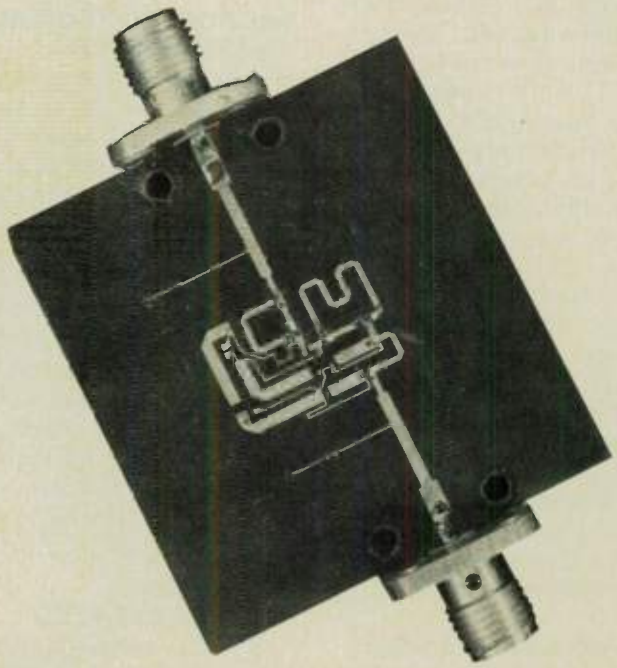


Fig. 2 Microstrip 3-bit digital phase shifter

This work was supported by the Air Force Systems Command Development Center, Rome Air Development Center, Griffiss AFB, New York, under the direction of Tom Treadway, Contract No. F30602-78-C-0329

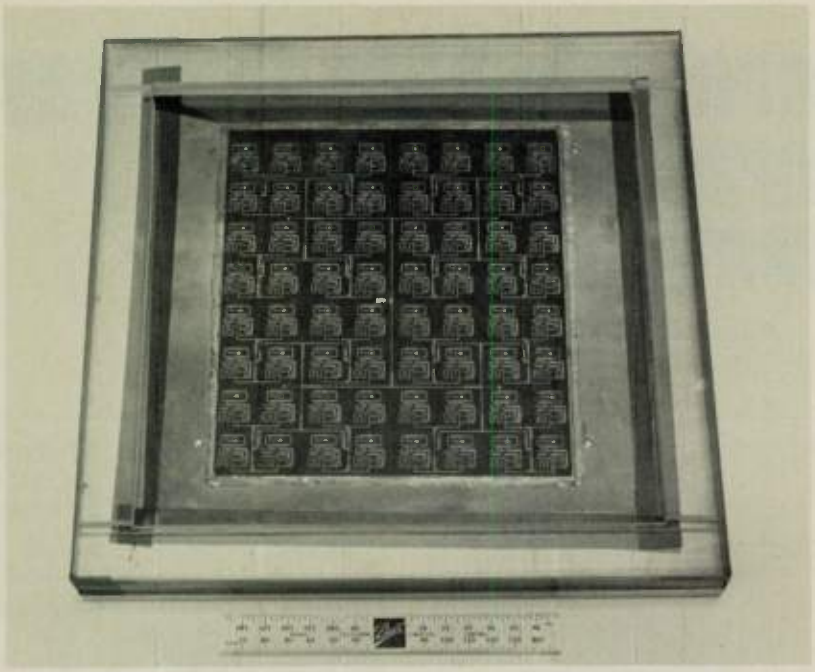


Fig. 3 Microstrip corporate phase shifters for SHF module.

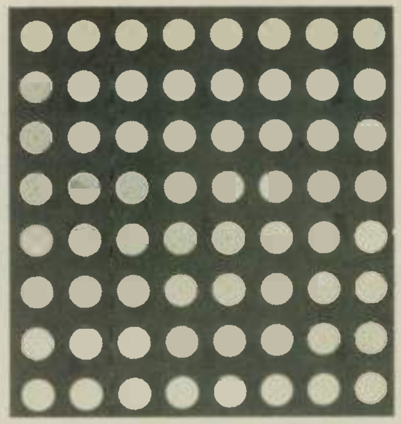


Fig. 4 Element layout for SHF module.

MICROSTRIP RADIATING ELEMENT

The two major features incorporated on the microstrip radiating element on this phased array are the bandwidth of 7% and the element's beamwidth. To achieve the bandwidth at this frequency, a 0.794mm (.03125 in)-thick substrate material was used. The substrate material is woven teflon-fiberglass. This thickness gave the needed bandwidth requirement. The beamwidth is a function of the type of element used. That is, the half-wave microstrip patch, quarter-wave patch, microstrip crossed-slot, or the circular disk element. Since circular polarization is a requirement, the quarter-wave element could not be used. Manufacturing constraints caused the microstrip crossed slot to be eliminated. And finally, the half-wave patch was eliminated because of the packing factor or closeness of the elements in the array lattice. Therefore, the disk radiating element was chosen.

To achieve circular polarization, the disk element is fed in phase quadrature at the appropriate locations to excite orthogonal modes. This was done with a branch-line hybrid as depicted in Figure 1.

This element achieved a bandwidth of over 500 MHz under a 2:1 SWR, a beamwidth of 110° and an axial ratio of 0 to 4 dB over the entire band within the 3 dB points. The element is easy to manufacture using a photo-etch process.

MICROSTRIP DIGITAL PHASE SHIFTER

A 3-bit digital phase shifter was specified for use in steering the beam of this phased array. This gives eight possible phase positions that are multiples of 45° at each element. A switched line type phase shifter was used for the 180° and 90° bits and a loaded-line type was used for the 45° bit. Thus, a total of 10 PIN diodes is required for each phase shifter. The entire phase shifter including RF chokes is in microstrip on a .508mm (.020 in)-thick Duroid type substance. It is shown in Figure 2. The final version achieved an insertion loss of 1.2 ±3 dB.

MICROSTRIP CORPORATE FEED

The corporate feed provides a uniform amplitude distribution to the radiating elements. Therefore, all power divisions are equal. It is accomplished entirely in microstrip on the same substrate as the phase shifters as shown in Figure 3. The module shown is an 8 x 8 element array. This is the basic module size. Larger arrays can be constructed by arraying these modules and using another lower-loss type medium to feed the modules, such as waveguide or low-loss coax. The basic 8 x 8 array module is ~17.9 x 16.3 cm (7.1 x 6.45 in) in size and only 1.8 mm (.071 in.) thick.

ARRAY CONFIGURATION

Basic module has 64 elements in an 8x8 rectangular lattice. The element spacing is $\sim .51\lambda$ in the 60° scan plane and $\sim .56\lambda$ in the 45° scan plane at center frequency. This is based on the max-

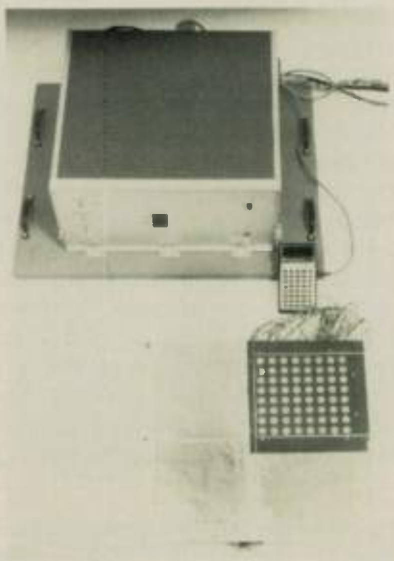


Fig. 5 SHF microstrip phased array and microprocessor controller.

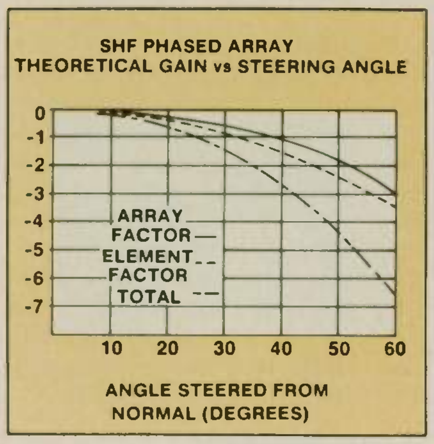


Fig. 6

imum spacing before the appearance of a grating lobe at the highest frequency of operation. Figure 4 shows the element layout of a module. The element circuit board was placed ground plane to ground plane with phase-shifter corporate feed board. Feedthroughs were used to excite the element from the branch line hybrid on the phase shifter-corporate board.

The dc bias was applied to the 3-bit phase shifters through vertical pins soldered to the RF chokes on the phase-corporate feed board. Wires with contacts were used to connect these pins with the decoder/driver electronics.

MICROPROCESSOR CONTROLLER

A TI9900 microprocessor was used to calculate the phase shifter settings for each commanded beam position. This desired beam position is entered on a teleprinter or microterminal in θ, ϕ coordinates (elevation and azimuth) in degrees. The processor uses a simple row-column steering technique to calculate the necessary phase shifter setting for each of the 64 phase shifters. The processor sends this data serially over 22 wires to the decoder/driver electronics which are mounted directly in back of the array. The decoder/-driver electronics determine which element gets the corresponding phase shifter setting. The entire system is shown in Figure 5.

RESULTS

The 8 x 8 array module has a theoretical directivity based on its aperture area given by:

$$10 \log (4\pi A/\lambda^2)$$

This is 23 dBi.

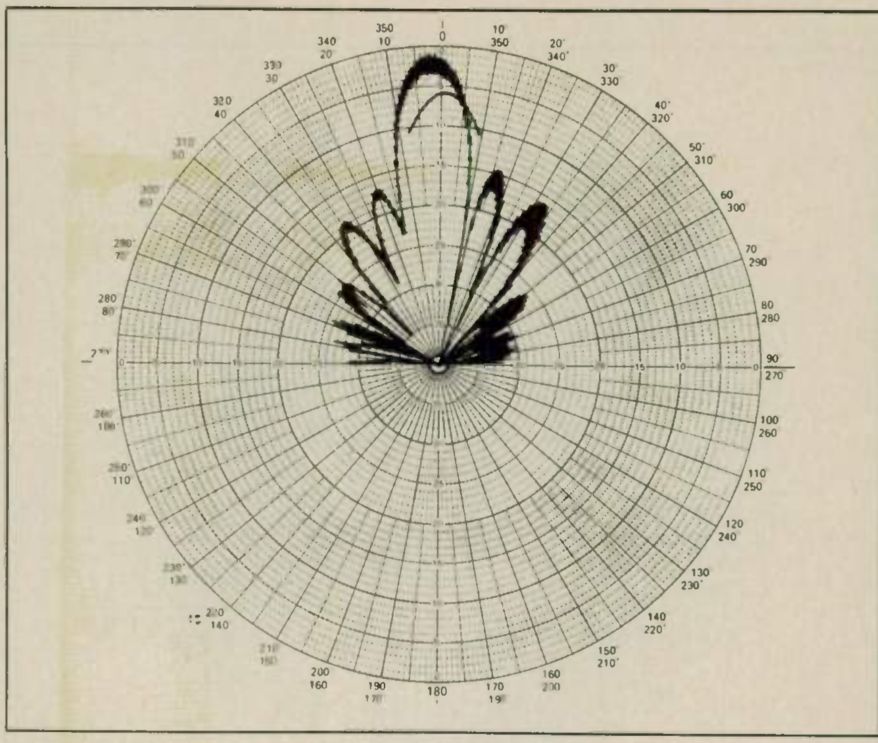


Fig. 7 Broadside beam.

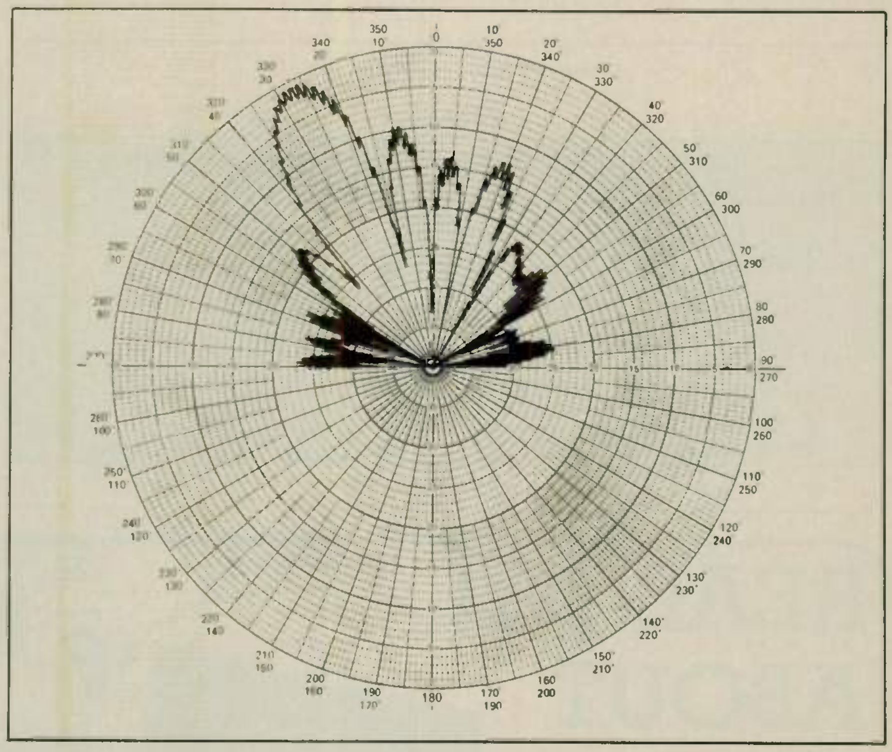


Fig. 8 Beam steered to 26°

TABLE I

SHF MICROSTRIP PHASED ARRAY AVERAGES 46% EFFICIENCY

Steering Angle	Theoretical Gain (dB)	Actual Gain (dB)	Efficiency %
0	23	19.6	45.7
14.1	22.7	19	42.7
29.2	21.7	18.5	47.9
42	19.7	16.6	49.0
53	17.9	14.4	44.7

This can be increased by improving the SWR.

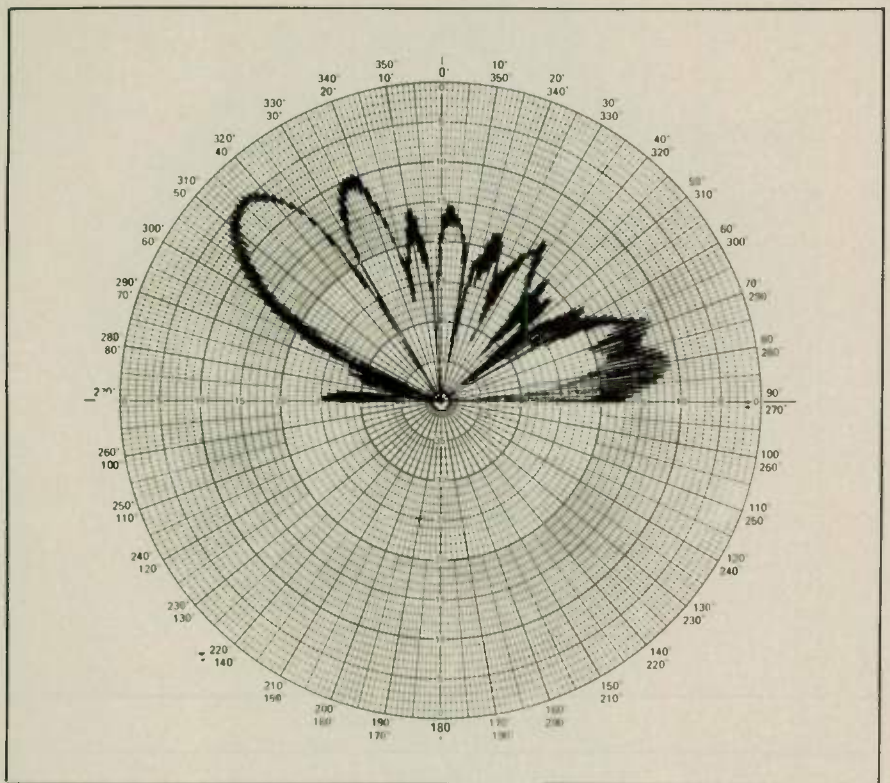


Fig. 9 Beam steered to 45°

Figure 6 shows the element factor and array factor which governs the gain fall-off with the steering angle. Table 1 shows the measured gain at a number of beam positions and the corresponding efficiency. A loss budget for the array module is given in Table 2. Antenna patterns showing axial ratio and scanning are shown in Figures 7-9. The axial ratio was ~2-3 dB for the broadside beam over the 500 MHz bandwidth.

TABLE II

LOSS BUDGET FOR THE SHF MICROSTRIP PHASED ARRAY		
Theoretical Gain ($4\pi A/\lambda^2$)		23 dBi
Losses		
Element Cavity	.6 dB	
Feedline	.7 dB	
Phase Shifter	1.2 dB	
Quadrature Hybrid	.2 dB	
SWR (2.2:1)	.7 dB	
Total	3.4 dB	-3.4
Expected Gain For Broadside Beam		19.6 dBic

CONCLUSIONS

The overall efficiency of this first 64 element microstrip phased array at 7.5 GHz has proven the feasibility of an all-microstrip, conformal phased array. Further work is necessary to improve the SWR and axial ratio. This will also help to increase the efficiency from 46% to above 50%

Major advancements were made in the manufacturing procedures developed in fabricating this antenna. Packaging and environmental protection of the array for the airborne environment is still being improved. With the decoder/driver electronics replaced by hybridized microelectronic circuitry, the total thickness of the array including the electronics can be reduced to ~1.9 cm (.75 in).

REFERENCES

1. Maune, James J, "An SHF Airborne Receiving Antenna," presented at the 22nd Annual Symposium on USAF Antenna Research and Development, October 1972.

AEG-TELEFUNKEN

TL 12200
TL 12450

High-power TWT's for satellite direct broadcasting

A number of countries are now developing systems for direct broadcasting of TV programmes from space.
One of the key components in such systems will be advanced J-Band TWT's capable of producing a few hundred watts of output power. This is a whole order of magnitude greater than present-day satellite TWT's.

In order to achieve the very good efficiencies required for high-power satellite TWT's, AEG-TELEFUNKEN has employed its techniques of multi-stage collectors already well-proved in other satellite programmes. To dissipate the heat, collectors of self-radiating design have been developed. These project outboard of the spacecraft and radiate energy directly into space.

Tubes have been developed with various output powers - from 100 Watt up to 700 Watt. The two TWT's illustrated here, types TL 12200 and TL 12450 have output powers of 200 Watt and 450 Watt respectively. Both tubes operate in the 11,7 to 12,5 GHz frequency band. The TL 12200 features a helix delay line for good broadband performance and a multi-stage collector.

The TL 12450 has a coupled cavity delay line system and a five-stage collector. An efficiency of over 50% has been measured with a TWT of this type.

It is advanced studies of this type, combined with the wide experience of AEG-TELEFUNKEN with travelling-wave tubes that are helping to get direct-broadcasting satellites off the ground.

TL 12200	f	= 11,7 . . .	12,5 GHz
	P_2	=	200 Watt
	V_p	=	45 dB
	η	=	45 %
TL 12450	f	= 11,7 . . .	12,5 GHz
	P_2	=	450 Watt
	V_p	=	50 dB
	η	=	50 %

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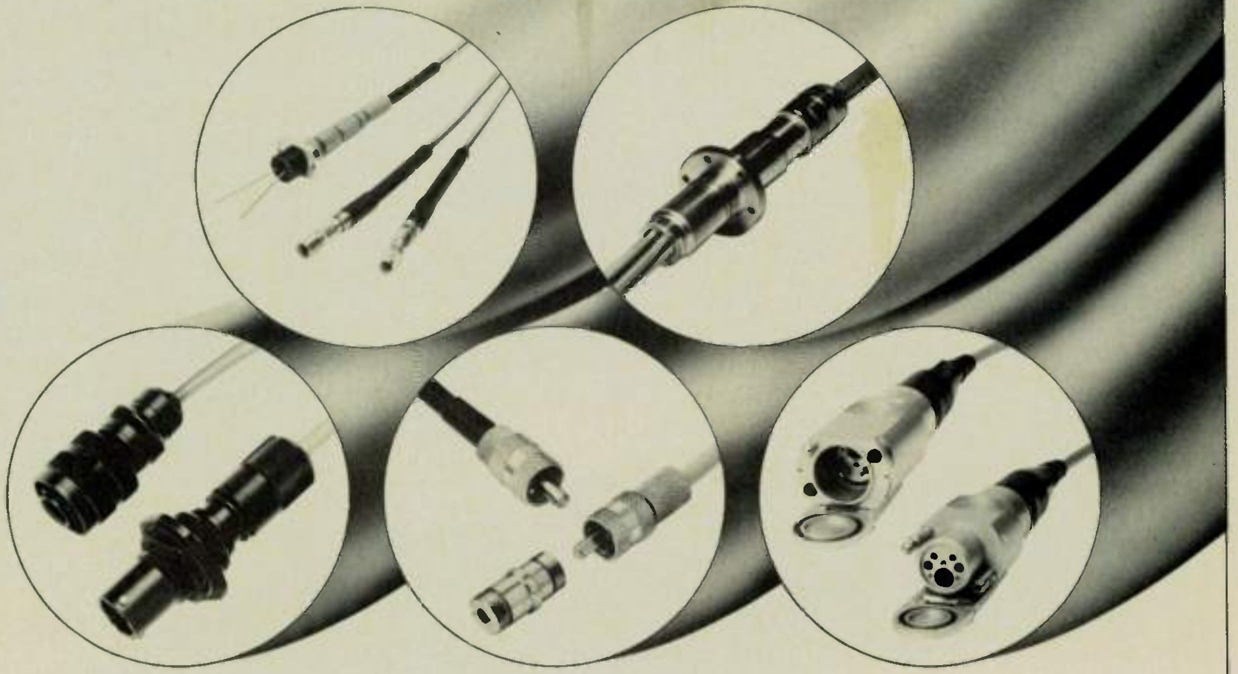

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Medium-Power 6 GHz TWT's for Low-Cost Unattended Earth Stations

D. HENRY AND E.D. MALONEY
Thomson-CSF Electron Tube Div.
Paris, France

INTRODUCTION

The coming worldwide boom in national or "domestic" satellite-communications systems will create a strong need for simple, rugged, and reliable 6 GHz uplink amplifer output tubes, with output power in the range of 70 to 100 watts, approximately. These tubes will mostly be used in unattended earth stations, and often in developing countries. Therefore, not only extreme reliability but also ease of operation and of eventual tube changes will be at a premium. Another important factor will obviously be cost, as a relatively dense ground infrastructure may be necessary, implying hundreds and perhaps even *thousands* of small earth stations in any one national system.

The challenge for electron tube manufacturers, then, is to design amplifier tubes capable of sophisticated RF performances, yet as simple, robust, and economical as possible. And the necessary number of electrical parameter adjustments both at initial start up and at tube replacement must be strictly limited. Not only that, but these tubes must be capable of weeks and months of reliable unattended operation, sometimes under environmental conditions that are far from ideal.

Characteristics	Developmental Specification	Design Goal	Results Obtained (prototype)
AT SATURATION			
Output power, P_O	≥ 75 W	—	≥ 79 W
Variation of P_O in the band at constant drive	≤ 0.5 dB	≤ 0.3 dB	0.2 dB
Drive power for min. P_O	≤ 10 dBm	—	< 7 dBm
Gain slope at full power	≤ 0.03 dB/MHz	≤ 0.015 dB/MHz	≤ 0.01 dB/MHz
AM/PM conversion at full power	≤ 6°/dB	≤ 4°/dB	≤ 2°/dB
Efficiency (depressed collector)	—	≥ 25%	27%
Harmonic ratio	≤ -12 dB	≤ -15 dB	≤ -27 dB
UNDER SMALL-SIGNAL CONDITIONS (P_O = 20 W)			
Gain	45 dB ≤ G ≤ 50 dB		49 dB ≤ G ≤ 49.6 dB
Peak-to-peak gain variation in the band	≤ 3 dB	≤ 2 dB	0.6 dB
Gain slope	≤ 0.03 dB/MHz	≤ 0.02 db/MHz	≤ 0.01 dB/MHz
AM/PM conversion	≤ 3°/dB	≤ 2°/dB	≤ 1.5°/dB
3rd-Order Intermodulation for two 10 W carriers	≤ -21 dB	≤ -24 dB	-25 dB
Noise in a 4 kHz window between 5.9 and 6.4 GHz	≤ -75 dBW	—	-90 dBW
Noise figure	≤ 35 dB	≤ 32 dB	28 dB

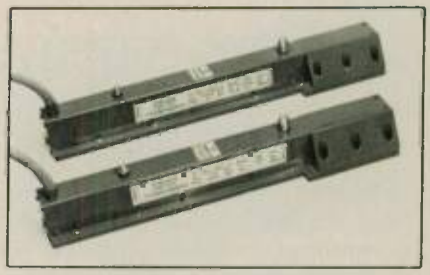

Fig. 1 Physically, the TH 3641 and TH 3642 are nearly identical.

THE RESPONSE

Drawing on extensive experience with 11 GHz satellite TWT's and a long-term involvement in the field of microwave-link tubes and TWT amplifiers which posed similar requirements, the development of a pair of helix TWT's for this application, the TH 3641 and TH 3642 (Figure 1) has been completed. The development was supported by the French PTT Administration. These tubes deliver a minimum output power at saturation of 75 and 150 watts, respectively. Both have high gain and well over 25% efficiency at saturation. They employ PPM beam confinement and simple conduction cooling and have been designed for an average operating life of 20,000 hours.

DESIGN BASIS

Maximum Commonality

At the outset, it was decided that the design and development of the two tubes would be conducted in parallel. By ensuring the greatest possible degree of commonality, the production costs can be cut to the greatest extent possible, and there are also potential benefits to the user. Therefore, the basic technology of these TWT's is identical.

The common parts and sub-assemblies are the electron gun, the

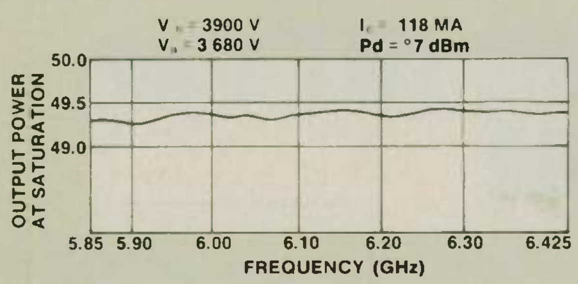

Fig. 2 Saturated power output across the band at a constant drive power level (TH 3641 prototype).

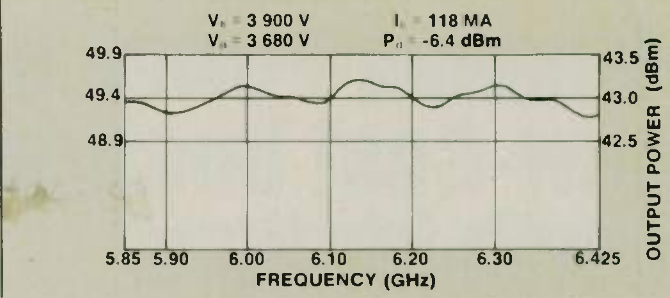

Fig. 3 Small-signal gain (TH 3641).

collector, the RF-structure envelope, the helix wire, the periodic permanent magnets and the RF feed-throughs. The housings are identical, except for their length (the TH 3642 being slightly longer). The main differences between the two TWT's lie in the RF structure itself, the matching and the PPM beam-confinement stack arrangement.

To achieve this degree of commonality, however, several constraints must be accepted. These include an identical beam perveance, a collector that is sized for the more powerful of the two tubes, and permanent magnets whose dimensions correspond to the stronger magnetic field.

Slow-Wave Structure

The TWT operating points were determined in assuming a helix-beam interaction efficiency of about 18%. An electronic efficiency this high can only be obtained by using helixes having pitch variations that are characterized as a "double taper," a development originating from activities in the field of satellite tubes. They make it possible to simultaneously optimize the interaction efficiency and minimize the phase shift and the presence of second-order harmonics in the output signal.

For the TH 36412 and the TH 3642, the helix-pitch variations employed are frequency- and power-scaled from the "tapers" determined for the 11 GHz satellite TWT's. Computations were then made to verify that the results obtained were satisfactory before advancing further in the tube design.

Electron Gun

An important guideline in the design of these tubes was the goal of an average operating life of over 20,000 hours. The operating life of an electron tube essentially depends upon the cathode's emission density, and a much potential life can be attained with an impregnated cathode having a current density under 1 A/cm^2 and operating at a temperature near 1060° C.

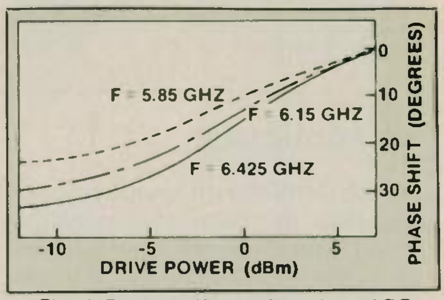

Fig. 4 Phase shift as a function of RF drive power for three frequencies in the band (TH 3641).

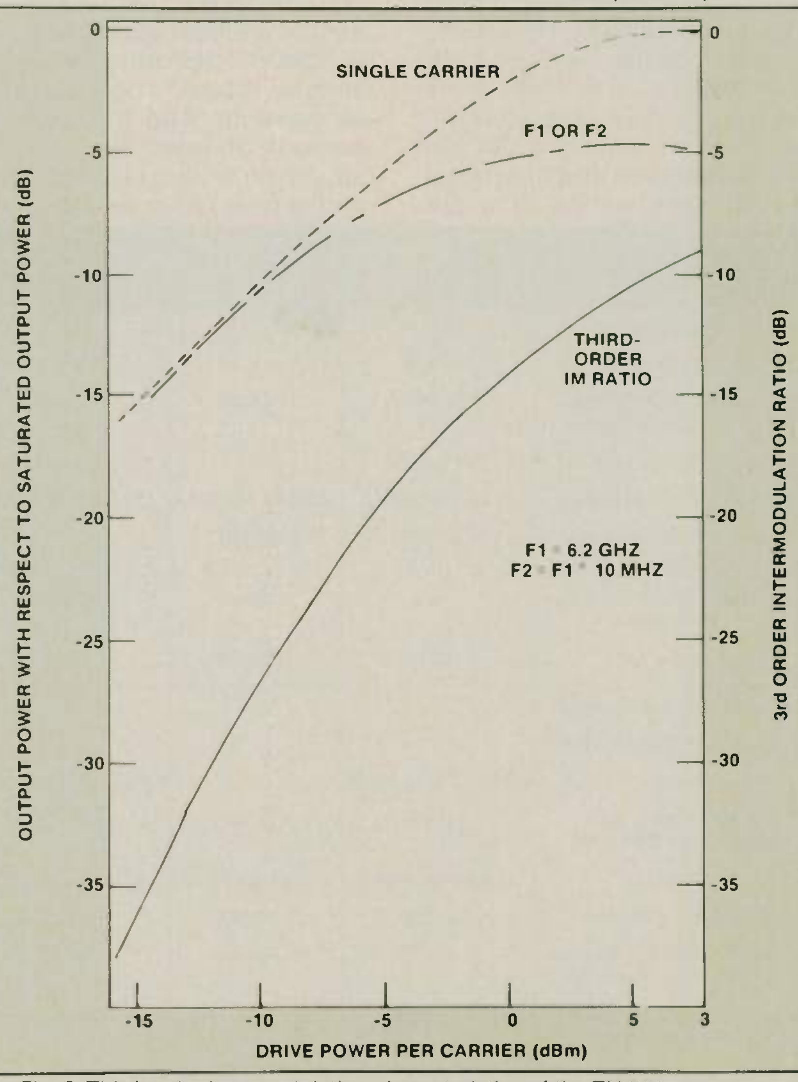

Fig. 5 Third-order intermodulation characteristics of the TH 3641 prototype.

[*continued on page 88*]

Introducing HP's new 8350A Microwave Sweeper. It makes your swept measurements easier, faster and more efficient.

Once you put your hands on the new HP 8350A Microwave Sweeper, you just may not want to let go. It's been designed from the ground up to help you make just about every swept measurement you need with near-faultless simplicity and convenience.

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Burlington, MA

INTRODUCTION

Faced with rapidly rising travel costs and the need to increase productivity and efficiency, many corporations with geographically dispersed offices will turn to technologically sophisticated communications systems in the 1980s. MACOMNET, a small aperture earth station network, enables management to access freeze-frame teleconferencing, high-speed facsimile, corporate-wide electronic mail and numerous computer communications services on a highly cost-effective basis. The key to MACOMNET's viability is the DYNAC™ earth station developed by M/A-COM. This digital earth station uses the latest microwave technology to reduce the cost of the antennas and the frequency converters and a low-cost microprocessor-controlled baseband terminal.

NETWORK DESCRIPTION

MACOMNET uses a Time Division Multiple Access (TDMA) transmission scheme to achieve a fully connected mesh configuration (See Figure 1). In this mesh configuration, each earth station transmits a burst of data, in a predetermined time slot, once every 60 ms. (See Figure 2). Each earth station's data burst run-in contains all of the data traffic that was collected since the station's-last data burst transmission, 60 ms before. Within a particular data burst, there can be data that is bound for any other station in the network.

The TDMA technique permits the data throughput rate of each station to be selected to correspond to the traffic requirements of the station. The network can also dynamically adjust to changes in traffic requirements. The total available data rate for the system is currently 500 kbps.

FUNCTIONAL DESCRIPTION

Figure 3 shows the basic DYNAC™ earth station which consists of the baseband equipment, the frequency converter,

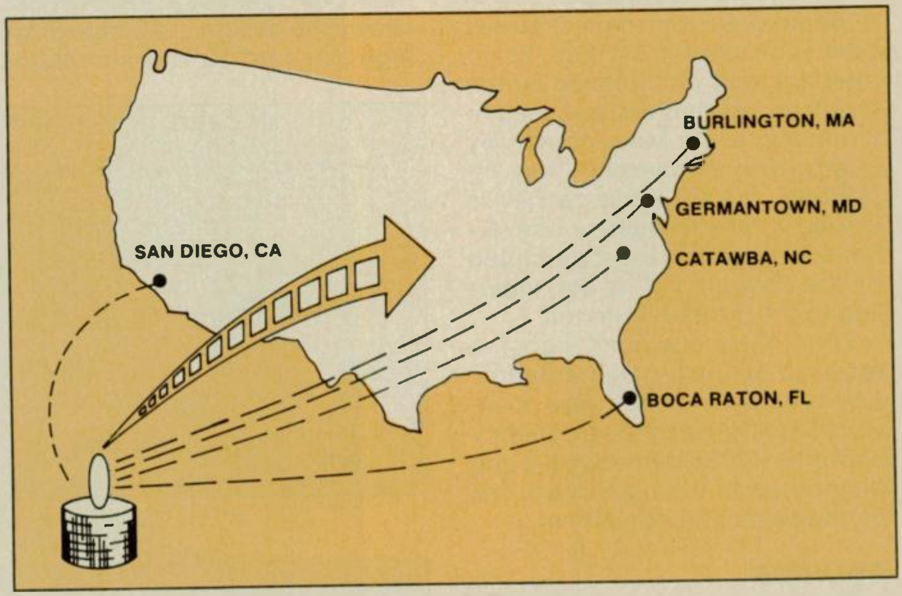

Fig. 1 MACOMNET system.

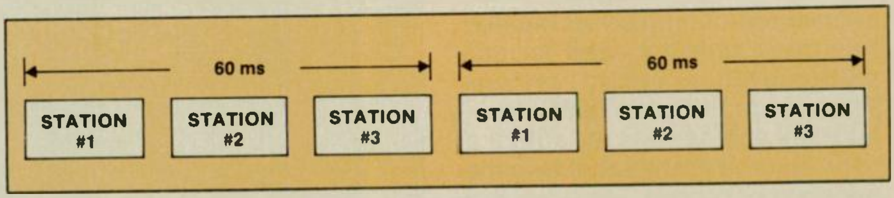

Fig. 2 TDMA frame format.

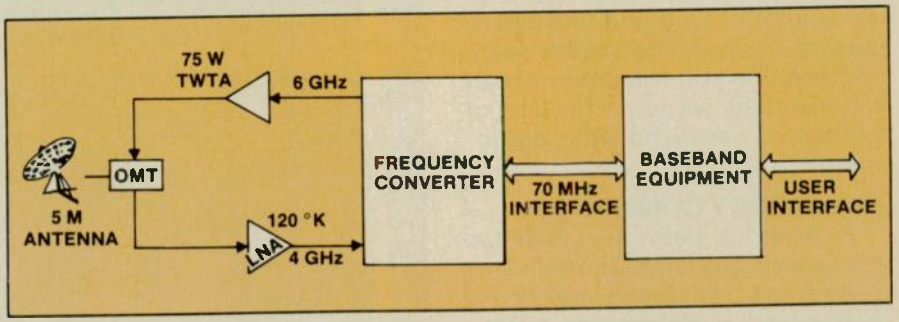

Fig. 3 DYNAC™ Earth Station — block diagram.

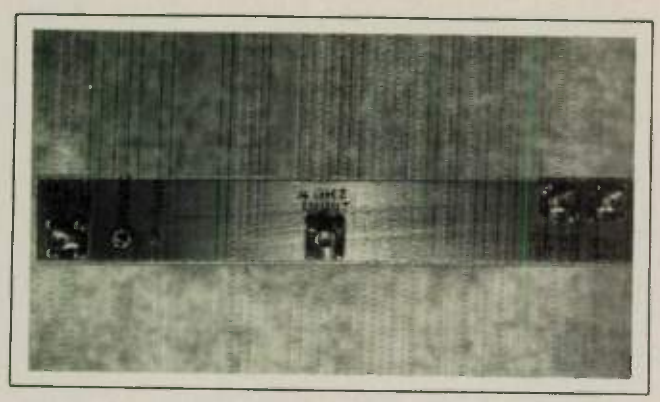

Fig. 4 Up and downconverter designs in stripline assemblies.

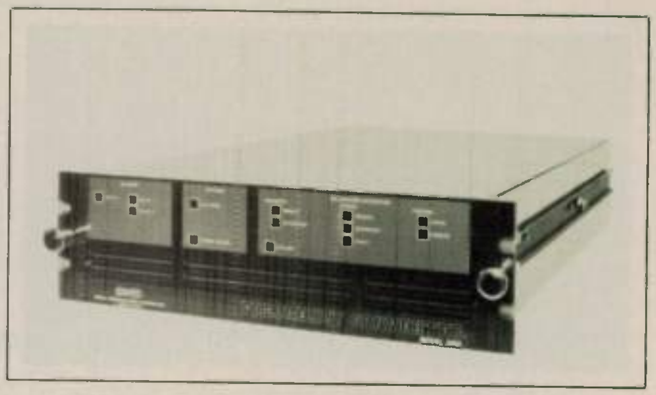

Fig. 5 Mountable chassis housing up and downconverter.

the 75 watt traveling-wave tube amplifier (TWTA), the 120° K low-noise amplifier (LNA), the orthomode transducer (OMT) and the 5-meter antenna.

The uplink transmission signal is generated from data that has been collected from the user interface and multiplexed by the baseband equipment and used to modulate a 70 MHz carrier by quadrature phase-shift keying (QPSK). the 70 MHz carrier is shifted by the frequency converter to the 6 GHz range, amplified by the 75-watt TWTA and supplied to the 5-meter antenna.

The 4 GHz downlink signal is received by the 5-meter antenna, amplified by the LNA, downconverted to 70 MHz by the frequency converter, QPSK demodulated and distributed to the user interfaces by the baseband equipment.

ANTENNA

The 5-meter antenna utilizes a high efficiency Cassegrain feed, a segmented compression molded fiberglass reflector, and an azimuth/elevation mount system. This mount utilizes a 360° circular track and permits the antenna to be pointed at any satellite in the geostationary orbit. The reflective surface of the antenna is provided in 12 interlocking and interchangeable segments which are field-replaceable and the antenna can be installed without the use of cranes or heavy hoisting equipment.

FREQUENCY CONVERTER

In order to meet objectives for low-cost implementation with emphasis on reliability, minimum maintenance, and maximum flexibility, the up and downconverter designs use stripline assemblies (See Figure 4). Use of this technology eliminates the need for discrete components and provides high-density packaging with optimum performance at low cost and allows the design of a single 5.25" high standard 19 rack mountable chassis (See Figure 5) housing for both the up and downconverters.

To provide maximum flexibility for changing the frequency converter operating frequencies, both converters employ dual conversion. Filter changes are not re-

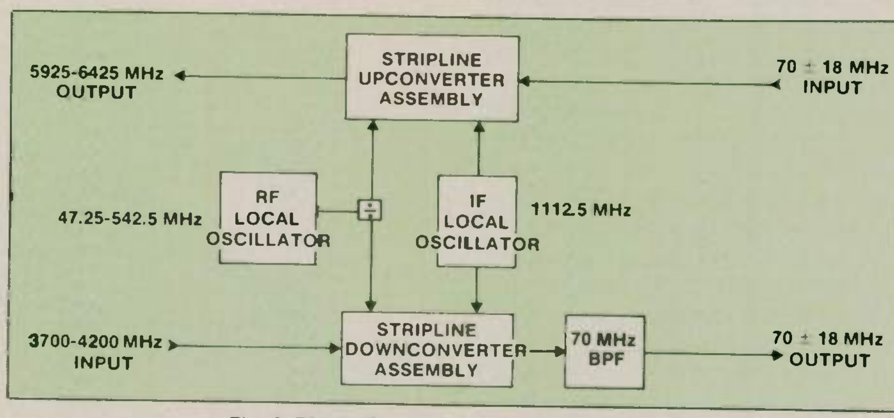

Fig. 6 Block diagram of frequency converter.

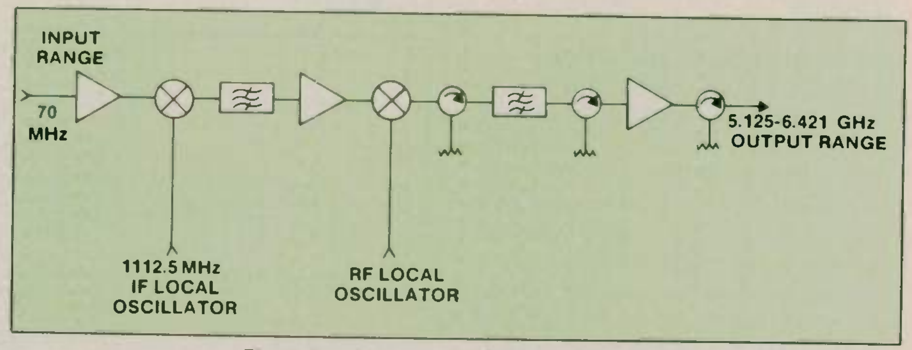

Fig. 7 Block diagram stripline upconverter.

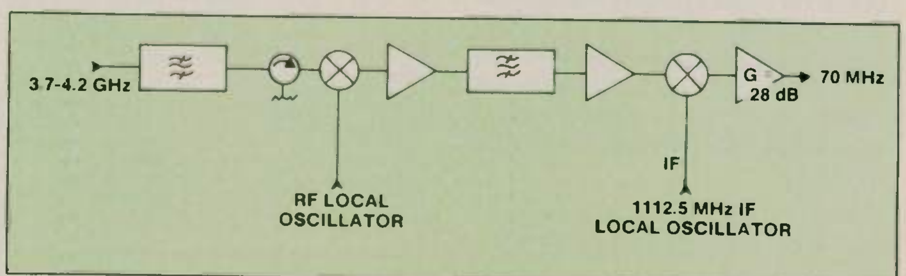

Fig. 8 Block diagram stripline downconverter.

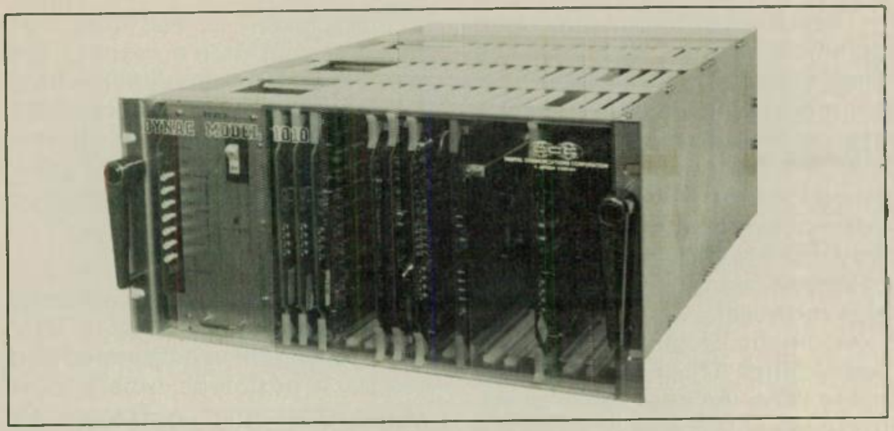

Fig. 9 TDMA terminal.

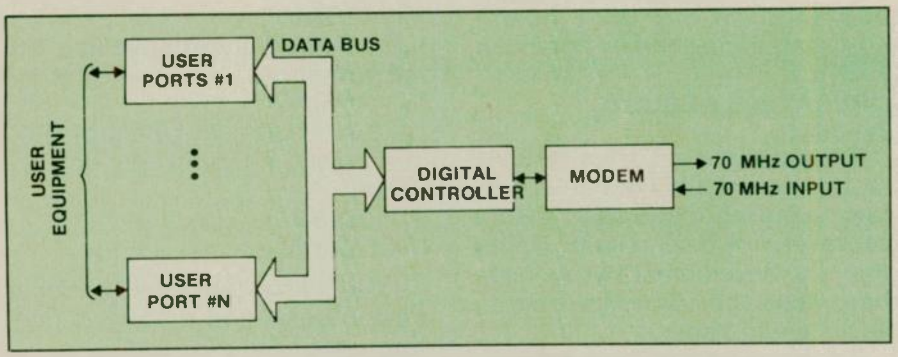

Fig. 10 Block diagram of baseband TDMA terminal.

TABLE I

UPCONVERTER PERFORMANCE PARAMETERS

Nominal input frequency	70 MHz
Nominal input level	-25 dBm
Output frequency range	5925-6425 MHz
Translated bandwidth	36 MHz
Gain	20 dB
Gain flatness	±0.5 dB
Gain stability	±0.3 dB
1 dB compression point	+12 dBm
Input/output impedance	50 ohms unbalanced
Operating temperature range	10°C to 40°C
Noise figure	15 dB
Frequency stability	0.1 PPM/month

TABLE II

DOWNCONVERTER PERFORMANCE PARAMETERS

Input frequency range	3200-4200 MHz
Nominal output frequency	70 MHz
Translated bandwidth	36 MHz
Gain	45 dB
Gain flatness	±0.5 dB
Gain stability	±0.3 dB
1 dB compression point	+12 dBm
Input/output impedance	50 ohms unbalanced
Operating temperature range	10°C to 40°C
Noise figure	15 dB
Frequency stability	.1 PPM/month

quired when the operating frequencies are altered and local oscillators are common to both converters (See Figure 6). A single local oscillator frequency converter uses a fixed local oscillator which is adjustable anywhere from 4762.5 to 5202.5 MHz.

The up-converter is designed to operate with input signals at a nominal frequency of 70 MHz. It translates a 36 MHz bandwidth centered around 70 MHz to a similar bandwidth in the 5925 MHz to 6425 MHz frequency range. Referring to Figure 7, the input signal is amplified and then mixed with the fixed local oscillator frequency of 1112.5 MHz. After filtering and amplifying the first nominal IF frequency of 1182.5 MHz, the signal is mixed with the desired C-band local oscillator frequency and filtered before final amplification at 6 GHz. The filtering is broadband covering the full 5925 MHz to 6425 MHz range. GaAs FET's are used to provide the final amplification. Table 1 lists typical performance parameters for the up converter.

The downconverter is designed to operate with input signals in the 3.7 GHz to 4.2 GHz frequency range. It is capable of translating a 36 MHz bandwidth within the input frequency range to a nominal IF frequency of 70 MHz. Referring to Figure 8, the input signals are passed through a 500 MHz wide filter and fed to a mixer. The C-band local oscillator frequency is selected so that the desired transponder center frequency is converted to an IF frequency of 1042.5 MHz. The signal is amplified, filtered, and amplified again before being fed to the second mixer where the fixed local oscillator frequency of 1112.5 MHz produces the nominal output IF frequency of 70 MHz which is amplified before leaving the converter. Table 2 lists typical performance parameters for the downconverter.

BASEBAND EQUIPMENT

The primary component of the baseband equipment is the TDMA Terminal (See Figure 9). This terminal contains a QPSK modem, digital controller, user interface ports and a modem (See Figure 10). The interface can be selected to provide data service from 300 bps to 1.544 Mbps or voice service with a 32 kbps delta modulation codec port. The user interface port data is multiplexed or demultiplexed on a data bus that connects to the digital controller.

The digital controller processes the user interface port data for transmission by the modem or after reception by the modem and provides local and remote control of the earth station with the use of the microprocessor. The modem is designed to be fully compatible with the burst transmission and reception requirements of the TDMA.

TELECONFERENCE ROOM

One of the primary motivations for MACOMNET is to provide high quality video teleconferencing capabilities. Using the high data rates available through the system, a freeze-frame teleconference facilities have been established at all MACOMNET stations. These allow users to send "snap shots" of subjects within the teleconference rooms every 7 seconds to single or multiple stations within M/A-COM, thus providing multisite teleconferencing. This capability, combined with high-speed facsimile, provides a very powerful management tool for the exchange of data in a business conference environment.

Additionally, such communications capability can easily be expanded to other tiers of management within the same building by coax or fiberoptic cable. Expansion of the system between or among buildings can easily be accomplished by microwave point-to-point equipment.

Freeze-frame video was selected, as opposed to full motion video, because it requires only 56 kbps data rates versus 1.5 Mbps for full motion. This greatly decreases communications link costs and, in addition, full motion video equipment costs five to ten times as much as freeze-frame equipment. Since the principle use of a teleconference facility is for vugraph, slide or blackboard presentations, a freeze-frame video system is adequate.

The MACOMNET teleconference rooms also include high quality audio channels for the voice segments of teleconferencing, as well as a high-speed facsimile unit to transfer documents between sites.

SUMMARY

The integration of several low-cost technologies in MACOMNET has permitted the implementation of a cost-effective communications network. This network is capable of providing assorted services that are of great benefit to the user in terms of management productivity.

[*from page 82*] **6 GHz TWT's**

Therefore, in the electron gun common to these two TWT's, a 5mm-diameter cathode was chosen, making it possible to operate at an emission density of no more than 950 mA/cm^2 for the more powerful tube. A relatively high beam convergence is then necessary, quite within the capabilities of today's beam-focusing technology, however.

An anode is provided for the beam cutoff. This makes it possible to leave the beam and collector voltages applied to the TWT and use the anode voltage to start or shut down the tube's operation, simplifying the use of these TWT's.

OPERATING RESULTS

TH 3641

The development of the TH 3641 is now essentially complete. Following the fabrication and testing of several tubes, results better than the development goals have been achieved across the board, as shown in Table I.

The beam transmission is excellent over a large range of anode-voltage values. For example, the typical current intercepted by the helix is only 0.20 mA without drive and 0.90 mA with drive, while the anode current is less than 0.01 mA, for a cathode current of 118 mA. Figures 2 though 5 illustrate some of the more important RF performances achieved with this prototype model across the operating-frequency band or at a given point in the band.

TH 3642

Several different developmental models of this 150 watt, 6 GHz TWT having been assembled and tested, a prototype tube is now ready for acceptance. The operating point of this TWT is as follows:

V_h = 5085 V
I_h = 0.5 mA without drive and 1.8 mA with drive
V_a = 4640 V
I_a = 0.30 mA (a slight electron gun modification should reduce this value)
V_c = 3000 V
I_c = 170 mA

Table II lists the specifications, design goals and prototype performance of the TH 3642.

CONCLUSIONS

The TH 3641 and TH 3642 offer the performance characteristics important to low-cost, unattended small earth station applications.

Characteristics	Developmental Specification	Design Goal	Results Obtained (prototype)
AT SATURATION			
Output power, P_O	≥ 150 W	—	≥ 166 W
Variation of P_O in the band at constant drive	≤ 0.5 dB	≤ 0.3 dB	0.2 dB
Drive power for P_O min.	≤ 10 dBm	—	≤ 7 dBm
Gain slope at full power	≤ 0.03 dB/MHz	≤ 0.015 dB/MHz	≤ 0.01 dB/MHz
AM/PM conversion at full power	≤ 6°/dB	≤ 2°/dB	
Depressed-collector efficiency	—	≥ 25%	31%
Harmonic ratio	≤ -12 dB	≤ -15 dB	-27 dB
UNDER SMALL-SIGNAL CONDITIONS (P_O = 40 W)			
Gain	48 dB ≤ G ≤ 53 dB	—	51.5 dB ≤ G ≤ 52.2 dB
ΔG, peak-to-peak, in the band	≤ 3 dB	≤ 2 dB	0.7 dB
Gain slope	≤ 0.03 dB/MHz	≤ 0.02 dB/MHz	≤ 0.02 dB/MHz
AM/PM conversion	≤ 3°/dB	≤ 2°/dB	≤ 1.2°/dB
3rd-Order Intermodulation ratio (two 20 W carriers)	≤ -21 dB	≤ -24 dB	-25 dB
Noise in a 4 kHz window between 5.9 and 6.4 GHz	≤ -72 dBW	—	-90 dBW
Noise figure	≤ 35 dB	≤ 33 dB	24 dB

From the Power Handlers...

CABLE ASSEMBLIES, flexible or semi-rigid, with a variety of connector options, in low-loss, high-power-handling configurations with documented performance to frequencies as high as 26.5 GHz. HORN ANTENNAS, high power, all polarizations, octave and 3:1 bandwidths, broad beamwidth, up to 18 GHz. BLADE ANTENNAS, ultra-wide bandwidth, high power, both horizontal and vertical polarization, omnidirectional, streamlined for airborne applications, to 18 GHz. BICONICAL ANTENNAS, circular and linear polarizations, angular coverage from small sector to 360°, to 18 GHz. SPIRAL ANTENNAS, amplitude and phase tracking, broad bandwidth, planar and conical, to 4 GHz. SPECIAL ANTENNAS, arrays, ultra-thin paste-ons, cavity-backed slots, missile, high-power quad-ridge horns with 3:1 bandwidth.

For more than twenty years, we have specialized in solving difficult RF power transfer problems, particularly airborne and shipboard, ECM, navigation, communications, data link, and ASW. We can do the same for you. Call or write us about your RF power transfer problems. We'll handle it.

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Designers Tip

Two Stage GaAs FET LNA Bias Supply

GARY McCOLLUM
California Eastern Labs, Inc.
Santa Clara, CA

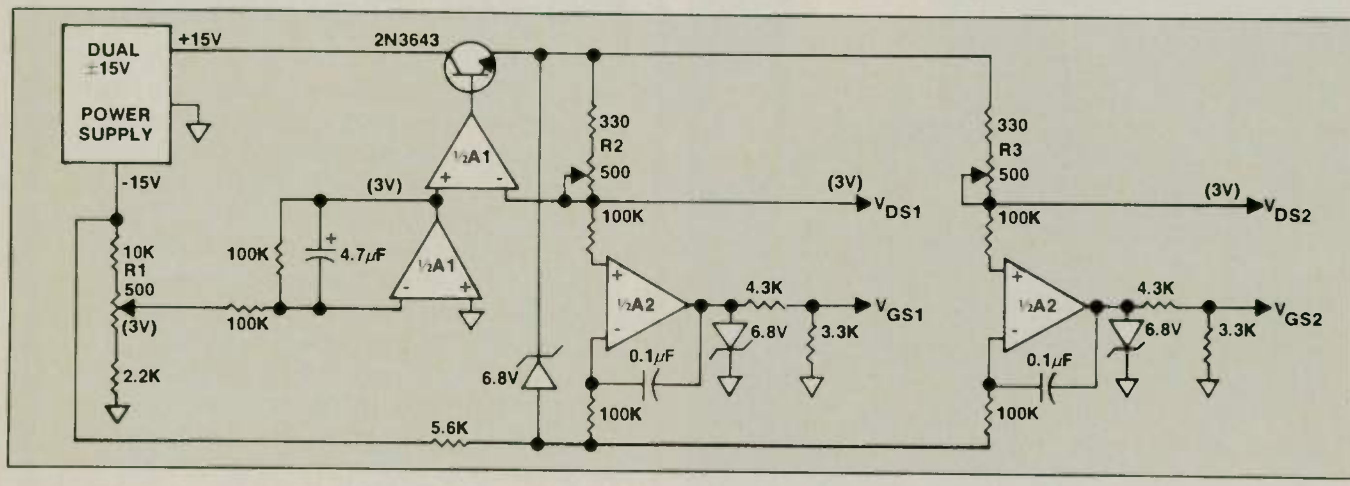
INTRODUCTION

This regulator is recommended to bias a two-stage, grounded source GaAs FET LNA with constant drain currents.[1] With minor modification two additional bias stages could be added to this circuit.

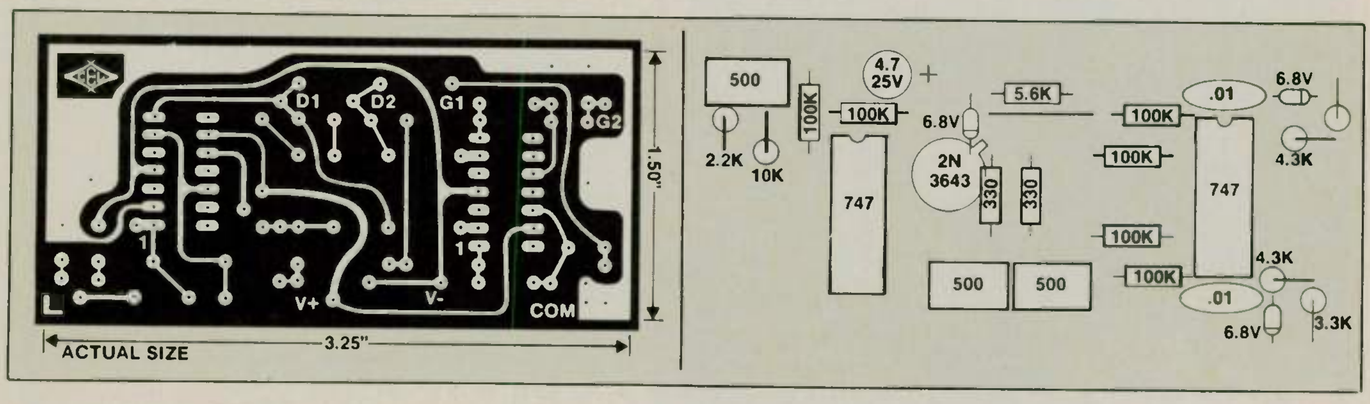
SPECIFICATIONS

V_{DS} = 2.8 to 3.2 volts, adjustable
V_D = 8 to 20 MA, adjustable

CIRCUIT DIAGRAM



CIRCUIT BOARD AND LAYOUT



CIRCUIT OPERATION

As the ±15 volt power supply is turned on, integrator A1 ramps on allowing V_{DS} and $-V_{GS}$ voltages to also ramp on. The drain to source voltage (V_{DS}) is a constant voltage, which is adjusted by the variable resistor R1. The constant drain currents of I_{D1} = 10 MA and the comparator A2 and is adjusted by R2 for stage one and R3 for stage two. Nodal voltages are shown in the circuit diagrams for drain currents of I_{D1} = 10MA and I_{D2} = 20 MA. The resistance values for the above conditions are R2 = 350Ω R3 = 10 Ω.

REFERENCE

Lane, D., "'Smart' Bias Supply for Delicate MW Transistors," *Microwave Journal, June 1978, pp. 126-142.*

side of the planet, were found. No clear cut explanation accounts for this; some theories include the notionof a change in light scattering due to small icy particles (comparable to the wavelength of light) which cool during the dark part of the orbit and warm during the sunny portion.

As part of the talk ,Dr. Stone played a tape recording of the radio noise detected by the Voyager. It sounded like lightning discharges in a terrestrial thunder storm. This demonstrated that there is a plasma environment in Saturn's rings. An estimate suggests voltages of 20,000 volts are developed in the B ring.

Views of Saturn's moons including Raga, Dione, Tethys, and Enceladus, Minas, and Titan (itself larger than the planet Mercury) showed that many of them contain long linear features suggestive of geologic activity, for example, volcanic-like eruptions consisting of water or liquid methane, which produce the contours of freezing at the moon's surfaces. Closing with a "Future Attractions Preview," Dr. Stone noted that the Voyager II will arrive at Saturn August 25th of this year. Meanwhile, continuing on its journey, Voyager I will go on to Uranus, reaching it on January 24th of 1986, and Neptune on August 24, 1989. If the picture transmissions continue, you can see that the subject matter for future Plenary Sessions is in the making.

Well, that's why I love the Plenary sessions. These talks were given in the largest conference room, accommodating 1000 people — it was filled throughout the talks. Others must love them too.

Microwave Products

Devices

GaAs FET SERIES FEATURES 1 W POWER, SPANS 15 GHz BAND

A series of six (three basic chips, in packaged or unpackaged form) features up to 35% power-added efficiency and operation through 15 GHz. AT-8140/-8141 (packaged/unpackaged) provide +30 dBm minimum output power (1 dB gain compression) and 8 dB associated gain at 4 GHz (typical values of +26 dBm and 6 dB, respectively, at 12 GHz). AT-8150/-8151 deliver +27 dBm at 9.5 dB gain at 4 GHz and AT-8160/-8161, +24 dBm and 10 dB gain at 4 GHz. Packaged versions are supplied in 100-mil metal/ceramic stripline package with a high-conductivity copper mounting flange. Power dissipation levels are 4.5 W, 2.5 W, 1.5 W for the respective devices with derating above +75° C case temperature. The GaAs FET's may be qualified to MIL-STD-750. **Avantek, Inc., Santa Clara CA. Charles Cochran, (408) 727-0700. Circle 133.**

UNIT AMPLIFIER TRANSISTOR COVERS dc-500MHZ

Model MPA-201 is a unit-amplifier transistor which gives both broadband and narrowband performance from dc to 500 MHz. Device has a typical output power of 500 mW at 500 MHz, a typical 3rd-order intercept point of +45 dBm at 70 MHz and a typical low noise figure of 5.5 dB at 70 MHz. Small signal gain is 13 dB (typ.) from 2-500 MHz. Bias requirements are 12.5 V and 250 mA, typical. Package is hermetically sealed. Internal 50Ω matching makes cascading feasible. Units are also suitable for oscillator or modulator functions. **Varian Associates, Palo Alto, CA. (415) 493-4000. Circle 134.**

Systems

PORTABLE COMMUNICATIONS SYSTEMS

EJ Series portable microwave communications systems accommodate a video signal and 1-2 audio channels over a line-of-sight path up to .7 miles using horn antennas. This system is available in the 7, 13 and 15 GHz bands. **International Microwave Corporation, Cos Cobb, CT. (203) 661-6277. Circle 132.**

Cable

COAXIAL CABLE ASSEMBLIES SPAN 0-34 GHZ

A cable assembly line covers requirements from 0-34 GHz. Standard assemblies are available in 6 semi-rigid cable sizes from 0.47" to .5000" O.D. and standard RG flexible cable sizes. Cables may be terminated with N, C, BNC, SC, SMA, SMB, or SMC connectors in straight or right-angle plug; straight, panel, jack, and bulkhead and others. Cable assembles are supplied with strain relief boots epoxied into the assembly for added moisture seal and longer life under strain conditions. Phase matched assemblies and precision assemblies for instrumentation are also offered. **Amphenol N. America, Bunker Ramo Corp., Oak Brook, IL. Art Morse, (312) 986-2322. Circle 131**

Instrumentation

PROGRAMMABLE AM/FM SIGNAL GENERATOR

Model 1020 is a programmable AM/FM signal generator which covers the 150 kHz to 540 MHz frequency range (optional coverage to 1.08 GHz). CW RF output level is +19 dBm the entire frequency range and RF output level can be programmed with a resolution of 0.1 dB. Frequency can be incremented in both present and user-defined step sizes. Instrument also provides FM up to 300 kHz deviation with less than 0.1% distortion at 100 kHz deviation, AM up to 99.9% and phase modulation up to 3 radians. This microprocessor-based instrument is fully compatible with with the IEE-4888 interface bus. Price $13,950. **Boonton Electronics, Parsippany, NJ. Scott Elkins, (201) 887-5110. Circle 180**

SPECTRUM ANALYZER RACK AND BENCHMOUNT VERSIONS

Option 30 and Option 31 (rackmount) and Option 32 (benchmount) configurations are offered to facilitate use of Model 492 and 492P Spectrum Analyzers. The Option 30 version provides additional cooling and a front right accessorty drawer for convenient storage of testing items. Rackmount plus rear panel access to all front panel connectors is offered by Option 31. Option 32 is a rackmount configuration with side panels, trim, tilt bail, feet and carrying handle. Size: Option 30 — 8.75" x 16.89" x 25"; Option 32 — 9.25" x 17.9" x 25". Weight: 54 lbs. Price and Avail: $790 — 2 wks. for Option 30; $940 — 2 wks. for Option 32. **Tektronix, Inc., Beaverton, OR. Collin Chamberlain, (503) 642-8929. Circle 138.**

Microwave Products

GENERATORS PROVIDE 370 ps IMPULSE

Impulse generators Model-1000A (benchtop version) and Model-1500A (0-69 dB step attenuators and rackmount version) provide 45 V and 370 ps (50%) impulse into a 50Ω load. Spectrum amplitude is 90 dB μV/MHz. Other features include: back matched 50-ohm source impedance, 500 kHz maximum repetition rate and low trigger to impulse jitter of 20 ps. Instruments contain built-in power supply, rep. rate clock and variable trigger delay circuits. Price and Del: Model 1000A, $1950, stock to 6 wks; Model-1500A, $3100, 2 months. **Picosecond Pulse Labs, Lafayette, CO. James R. Andrews, (303) 494-0700. Circle 135.**

SERIES MM-WAVE RADAR FRONT ENDS

A series of millimeter-wave instrumentation radar front-ends, available for use at KA band (35 GHz), W band (94 GHz) is offered. Basic configurations include a transmitter module (pulsed or CW) , a receiver module, and an antenna assembly, which include temperature-stabilized oscillators that operate over a baseplate temperature range of 25° ±10° C. Standard options include polarization switches and monitor. Available power outputs are 150 mW (35 GHz) and 100 mW (94 GHz) and 3 and 5 watt (94 GHz) for pulsed mode units. Custom versions are available. **Hughes Aircraft Co., Electron Dynamics Division, Torrance CA (213) 517-6400. Circle 136.**

Components

SERIES OF VARIABLE ATTENUATORS

Models 50R-002 and 50R-003 cover the dc to 1000 MHZ and dc to 1250 MHz ranges, providing 0 to 130 dB in 10 dB steps and 0 to 100 dB in 10 dB steps, respectively. Units have SWR (maximum) of 1.2, dc to 500 MHz and 1.4, 500-1000 MHz or 500-1250 MHz. Insertion loss is .6 dB maximum at 500 MHz and attenuation accuracy is ±.75 dB, dc-500 MHz; ±1.5 dB, 500-1000 MHz (Model 50R-002) and ±.5 dB, dc-500 MHz; ±1.0 dB, 500-1000 MHz (Model 50R-003). Life is 1M steps minimum and temperature range (operating) is -20 to +858C. Available with type SMA, TNC, BNC or N connectors. Price: 1-9 qty, $165 — 50R-002; $155 — 50R-003. Avail: 2-6 wks. ARO. **JFW Industries, Inc., Indianapolis, IN. J. L. Walker, (317) 783-9875. Circle 185.**

400 CW SPDT POWER SWITCH LINE

SPDT high power switches feature power ratings of up to 400 W CW on a 85° C mounting surface, and provide switching speeds of less than 1 μs. Designed for use in the 2-8 GHz frequency range, these switches will operate over a -55 to +105° C temperature range and at altitudes from sea level to 70,000 ft. Insertion loss is 1.0 dB maximum, isolation is 25 dB minimum and SWR is 1.7, maximum. TNC connectors are standard. Available TTL integrated drivers require 28 Vdc at 500 mA. Units are manufactured to MIL-E-5400. **Frequency Sources — Sources Div., Chelmsford, MA. Gary Tamas, (617) 256-4113. Circle 186**

3-CHANNEL COAXIAL ROTARY JOINT

A three-channel coaxial rotary joint, Model 1363, operates on all channels from dc to 2.3 GHz. Peak power is 1 kW with 50 W average. Unit is designed for use in ground control systems. **Kevlin Manufacturing, Woburn, MA. Ernest Lattanzi, (617) 935-4800. Circle 148.**

PIN DIODE TRANSFER SWITCH

Model TS-52 is a PIN diode transfer switch with TTL driver which covers the 2.0-8.0 GHz frequency range. Innsertion loss is 1.75 dB, max. isolation is 50 dB and SWR is 1.65 max. Unit has an RF power rating of 1 W CW and 50 W peak. Size: 1.0" x 1.2" x .75". Avail: 6 wks. ARO. **Triangle Microwave, Inc., East Hanover, NJ. Martin Rabinowitz, (201) 884-1423. Circle 157.**

Microwave Products

PRE-DETECTION DOWNCONVERTER

Model RFC057B is a pre-detection downconverter which consists an image reject mixer integrated with a group delay equalizer and a local oscillator to provide single-step downconversion of 160 MHz IF signals to baseband. Image rejection is typically 40 dB over the output band of 0.8 to 8 MHz, and amplitude and phase ripple are less than 0.75 dB and ±5°, respectively. Third order IM products are 55 dB down, and conversion loss is 11 dB maximum. Size: 3.05" x 9.00" x 0.955" package. Unit is powered by +15 V at 45 mA maximum. **Locus, Inc., State College, PA. Robert M. Dillman, (814) 466-6275. Circle 184**

SMA BETWEEN-SERIES ADAPTORS.

SMA between-series adaptors have been redesigned to improve RF and mechanical performance. Adaptors are available from SMA to Type N, TNC and BNC connectors. Typical performance for the SMA is SWR of 1.05 + .005f (GHz) dc to 18.0 GHz and insertion loss of .04 x f (GHz). Base part numbers for the new designs remain the same as for the older series and the suffix changes to a 100 series, e.g. -001 becomes -101. Price: $8.09, qty. of 1,000. Del: from stock. **Cablewave Systems, Inc., North Haven, CT. Steven Raucci, Jr., (203) 239-3311. Circle 147.**

MIXER COVERS 10-1500 MHz BAND

Model M57T is a mixer designed for use over the 10-1500 MHz bandwidth. It features an intercept point of +27 dBm typical, at an LO drive level of +23 dBm, an IF bandwidth up to 1000 MHz and a typical conversion loss of 7.5 dB. Model is hermetically sealed in a TO8 package. Price: $51, 100 qty. Del: stock to 3 wks. **Magnum Microwave Corp., Sunnyvale, CA. David Fealkoff, (408) 738-0600. Circle 182.**

RFI/PRESSURE WAVEGUIDE GASKETS

Line of conductive gaskets to fit waveguide flanges from WR-650 to WR-28 is offered. They provide RF and pressure sealing of choke, cover and contact flanges and are fabricated from highly conductive silver-copper silicone elastomers. Cover and flat contact flange gaskets are available in CHO-SEAL® 1236 material, and conductive gaskets for choke and grooved waveguide flanges are molded from CHO-SEAL® 1212 material. **Chomerics, Woburn, MA. Brian Reardon, (617) 935-4850. Circle 183**

GaAs AMPLIFIERS

A monolithic GaAs wideband amplifier, Model CGY 21, is offered as a replacement for the commonly used hybrid and discrete amplifiers in wideband applications. It has a frequency range of 40 MHz to 1 GHz and a noise figure of approximately 4.5 dB. Output voltage is 320 mV into 50 ohms or 400 mV into 75 ohms with a gain of 20 dB (minimum). TO-5 or SIL-9 packages are available. Price: $150 each. **Microwave Semiconductor Corp., Somerset, NJ. Jeff Holmquest, (201) 469-3311. Circle 161.**

7.25-7.75 GHZ MINI BAND PASS FILTER

Model 1055001-1 provides a minimum passband width of 500 MHz, centered at 7.5 GHz. Attenuation is 10 dB minimum at 7.85 and 7.1 GHz and 15 dB at 7.9 GHz, with minimum delay distortion. Passband loss is less than 0.6 dB, including an input dc block. Size: 3" x 5/8" x 5/8" with SMA connectors. Input is male SMA, output female. **RS Microwave Co., Inc., Butler, NJ. (201) 492-1207. Circle 154.**

Microwave Products

SATELLITE RECEIVER WITH DUAL CONVERSION

Model SR-1 is a 4 GHz band satellite receiver with a dual conversion design employing a crystal-controlled, synthesized first local oscillator. It offers a fully tunable second audio subcarrier range (4-8 MHz) and simultaneous reception of two audio subcarriers. Unit includes an LNA power supply, a built-in dc block, and remote control. It is available as a TV top model or as rack-mount for CATV systems. **Merrimac Industries, Inc., West Caldwell, NJ. Dan Brodaw, (201) 575-1300. Circle 149.**

MEDIUM POWER DUMMY LOADS

Series 720 are medium power dummy loads designed in accordance with MIL-D-3954 which permit greater power dissipation with lower operating surface temperatures. The rectangular shape of the unit, with mounting holes located in the backplate, permits easy installation in radar and missile systems. Dissipative material is high temperature glossy ceramic that is fully qualified and approved to MIL-D-3954. Series is equipped with standard cover flanges to mate with applicable AN type waveguide. **Micronetics, Inc., Norwood, NJ. Gary Simonyan, (201) 767-1320. Circle 151.**

MINI OCTAVE BAND HYBRIDS SPAN 2-18 GHz

A series of hybrid couplers covering the octave bandwidths in the 2.0-18.0 GHz range is offered. A typical model, 2020-5317-00, is a 90° cross-over design which offers 9.0-16.5 GHz and provides 15 dB minimum isolation, 0.8 dB maximum loss, amplitude imbalance of ±0.2 dB and mean value coupling is 3.2 ±0.4 dB. **Omni Spectra, Inc., a M/A-Com Co., Merrimack, NH. (603) 424-4111. Circle 153.**

HIGH STABIILITY MICROWAVE OSCILLATOR AND SENSOR MODULES

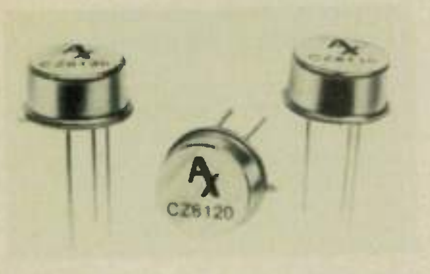
The FO Series includes seven styles of microwave oscillators and sensor modules for communication and sensing systems. Individual modules are 10 and 12 GHz oscillators, a microwave heterodyne receiver and Doppler modules with directional and motion detection capabilities. Electrical characteristics include 6.0-6.5 V_{DD} (V) operating voltages at operating currents from 20 I_D (mA) minimum to 110 $I_{D\ oz}$ (mA), 0.01 to 0.02 $\Delta P_o/\Delta T_o$ (dB/°C) typical power stability and high frequency stability ranges from -12 to ±0.5 MHz typical (Δf_o) at -30 to +60°C operating temperature. Units feature high speed pulse operation of 10.0-12.0 GHz. Modules are assemblied in standard, compact waveguide modules. Del: 4-8 weeks. ARO. **Mitsubishi Electronics America, Inc., Sunnyvale, CA. Joe Iizuka, (408) 730-5900. Circle 152.**

SMA SEMI-RIGID CABLE PLUG CONNECTORS

Part Nos. 2906-6035 (gold) and SF2906-6035 (passivated coupling nut) are SMA plug connectors for use with .047" dia. semi-rigid cable. Part Nos. 2906-6065 and SF 2906-6065 are for use with .034" cable. Connectors have hex style bodies to eliminate solder joint breakage during mating of the SMA coupling nut to the SMA jack connector. They cover a dc to 26.5 GHz frequency range, SWR is 1.05+ .010 (f) GHz, insertion loss is .04 dB x the square root of (f) GHz. Models interface per Mil-C-39012/79 and epoxy captivated contact withstands 10 lbs. min. axial force, 4" oz. radial torque. Price:$4.17, 25-99 qty. for either .047 dia. or .034 dia. Del: 12 wks ARO. **Solitron/Microwave Connector Div., Port Salerno, FL. (305) 287-5000. Circle 155.**

Microwave Products

RF AMPLIFIER SERIES



Model CZ8110, CZ8120 and CZ8130 are wideband, general purpose hybrid RF amplifiers for use in the kHz to 400 MHz frequency range. Amplifiers typically have a gain of 14 dB with a flatness of better than ±1 dB over the frequency band. The 1 dB compression point ranges from -2 dBm to +16 dBm, depending on the unit. Standard units are packaged in 3 TO-39 metal packages and can be screened to MIL-STD-883B, Class B requirements. Price: less than $8. **Amplifonix, Inc., Bristol, PA. Art Riben, (215) 788-2350. Circle 141.**

MODE-FREE TYPE N BULKHEAD CONNECTORS TO 18 GHZ

Type NF bulkhead connectors are mode-free to 18 GHz which are available for .085 and .141 cables. SWR on .141 types is below 1.15 through 18 GHz and below 1.18 to 18 GHz on .085 type. Connectors are constructed of stainless steel and designed for ease of assembly with repeatability and no blind solder joints. Price: $15.00 each in quantity. **United Microwave Products, Torrance, CA, Edwin T. Jacobs, (213) 320-1244. Circle 158.**

MINIATURE VOLTAGE-CONTROLLED OSCILLATORS

Series 8000 voltage-controlled oscillators provide center frequencies between 8 and 15 GHz with an elctronic tuning range of 2%. Output power is +10 dBm and frequency stability is 150 PPM/° C over -20° to +65° C. DC input voltage is between 8 and 20 V, depending upon the frequency; tuning voltage is typically 1-10 V. Spurious noise outputs are -60 dBc maximum and phase noise is -70 dBc/Hz maximum at 10 kHz from the carrier. Size: less than 0.6 cu. in. **Zeta Laboratories, Inc., Santa Clara, CA.. (408) 727-6001. Circle 169.**

TV-CHANNEL ISOLATION BANDPASS

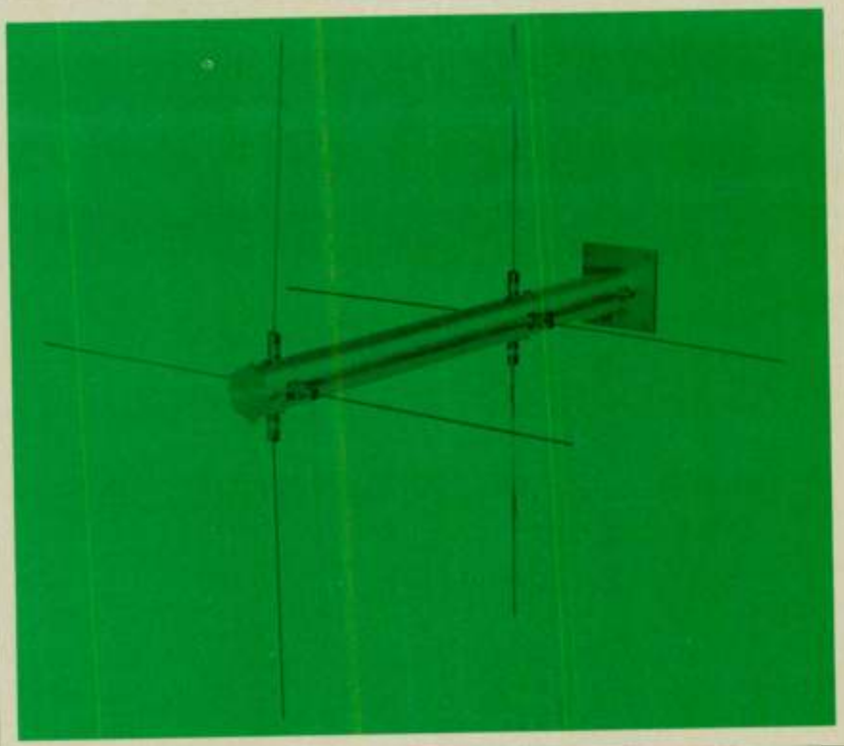
Model 330E TV channel bandpass filter provides 50 dB rejection of adjacent channels and is available for any channel in the 50-300 MHz range. It is a modification of the 3303 series, with selectivity increased to 50 dB on the lower, upper and both skirts by integrating appropriate traps. The filter is delivered on a standard 19" rack panel that is 1.75" wide. Price: from $215-$339. Del: 2 wks. **Microwave Filter Co.,East Syracuse, NY. Emily Bostick, (315) 437-3953. Circle 160.**

MIXER FOR 3.7-4.2 GHz SATELLITE DOWNLINK BAND

Model MD-179 is a mixer designed to cover the 3.7-4.2 GHz satellite down link band. Unit features flat 4 5 dB typical, 6.0 dB maximum conversion loss and 20 dB minimum isolation on all ports. This mixer also features a starved 0 dBm operating capability. Price: hermetic units for $200 in module form and $275 for SMA connectorized versions. Avail: from stock. **ANZAC Div., Adams-Russell Co., Inc., Mark Rosenzweig, (617) 273-3333. Circle 145.**

PREAMPLIFIER FOR 2-18 GHz SWEEP OSCILLATOR AND ANALYZER

Model MPA20BR preamplifier is designed for use with a 2-18 GHz sweep oscillator in a scalar measurement system. Unit provides 20 dB minimum gain, from 2 GHz to 18 GHz, and an internal coupler and crystal detector provide an input to the external leveling control of the sweeper. Internal power supply operates on 115 Vac. **Bumble Bee Technology, Boulder Creek, CA. Scott Kendell, (408) 425-13112. Circle 140**



PULSED IMPATT OSCILLATOR

Model AT-SP55 is a pulsed IMPATT oscillator which delivers 15 W, typical, peak power at room temperature in the 5.5-6.0 GHz frequency range. Mechanical tuning range is ±10 MHz; 10 W peak power minimum is available over 0 to +60° C. Size: 3½ x 1" dia., standard. Weight: 4 oz. Price and Avail: $1900, 1-9 qty., 30-90 days. **Ad-Tech Microwave, Inc., Scottsdale, AZ. R.C. Havens, (602) 998-1584.** **Circle 144.**

5-SECTION HELICOIL RESONATOR

A five-section helicoil resonator, centered at 530 MHz provides a 3 dB BW of 9.0 MHz and a 23 dB BW of 20.0 MHz. Insertion loss is 3.5 dB at 530 MHz and SWR is 1.3 minimum. Available with SMA female connectors. Price: $390. Del: 8 wks. ARO. **Coleman Microwave Co., Edinburg, VA. George Brinkley, (703) 984-8848.** **Circle 146.**

HIGH POWER PSEUDO-ELLIPTIC LOWPASS FILTERS

The HPL series of high power, pseudo-elliptic lowpass filters, handle up to 10 kW power and are offered with cutoff frequencies from 2-32 MHz. SWR is ≤1.3 up to fc, passband insertion loss is 0.5 dB maximum; 0.25 dB typical and the reject band is ≥ 40dB external from 1.25 to >10 to 20 fc, depending on model. HPL filters are supplied with Type N or HN female connectors. Standard impedance is 50 ohms; 75 and 93 ohm versions are available. Size: 5 ⅛" H x 9" W x 3¼" D. Price: $945, 1-2 qty. Avail: 8-10 wks. ARO. **Cir-Q-Tel, Inc., Kensington, MD. Paul Leo, (301) 946-1800.** **Circle 141.**

DIGITAL THUMBWHEEL CONTROLLER FOR TUNABLE RF FILTERS

A digital thumbwheel controller is offered for a family of computer-controlled, tunable RF filters. Unit can be used in place of a computer or other BCD input to dial in frequency changes in the digitally addressable RF filters. Using the intelligence/power supply contained in the filter unit, the small and portable thumbwheel can be used as a remote, hand-held method of filter adjustment for test bench or field applications. Price: $250, per unit. Avail: 60 days ARO. **Telonic Berkeley, Laguna Beach, CA, Adam Reed, (714) 494-9401.** **Circle 156.**

WAVEGUIDE BANDPASS FILTER

Model X-5C60-15003/150-WG waveguide bandpass filter operates in the TE 11 right circular cylinder waveguide cavity mode. This fixed tuned five-stage cavity filter offers low loss and a 1.2 typical SWR. Other units are available with 2-9 resonators at any center frequency from 12-18 GHz and bandwidths up to 2% may be specified. Input and output ports are UG1665/U cover flanges. Price: from $300. Avail: 4 to 6 weeks. **K & L Microwave Inc., Salisbury, MD. Charles Schaub, (301) 749-2424.** **Circle 142.**

TTL-COMPATIBLE WAVEGUIDE SWITCH LINE

A line of transistor-to-transistor logic (TTL) compatible waveguide switches operates from a prime power of 115 Vac at 1 A max., 47-70 Hz and a temperature range of 0-65° C maximum. Available in WR-112 to WR-62 waveguide sizes, these switches have a logic prime power of 5 Vdc at 250 mA maximum. Position commands are logic low input: 0 to +0.8 Vdc at 3 TTL loads and logic high input: +3.0 to +5.0 Vdc at 3 TTL loads. Del: 8-16 weeks. **Logus Manufacturing Corp., Deer Park, NY. (516) 242-5970.** **Circle 143.**

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New Literature

GPIB INTERFACE APPLICATIONS NOTE

A four-page technical discussion of how Model 757-57 GPIB Interface can extend applications of a microwave spectrum analyzer provides specific examples with illustrations of how the spectrum analyzer and its companion GPIB interface works with a standard calculator. **AILTECH, Eaton Corp., Ronkonkoma, NY. David Krauthelmer, (516) 588-3600. Circle 162.**

MIC LAUNCHERS CATALOG

A line of hermetically sealed SMA microwave circuit launchers is detailed in an 8-page catalog. Catalog No. 203B includes product line features, description, electrical, environmental and merchanical specifications, installation instructions and outline drawings. **Cablewave Systems, Inc., North Haven, CT. Steven Raucci, Jr. (203) 239-3311. Circle 163.**

CAPABILITIES BROCHURE ON PRODUCT AND SYSTEMS LINE

A 16-page, four-color brochure outlines a wide range of products and systems in a company line. Antenna tracking systems, rotators, and standard as well as special antenna positioners are covered. **Datron Systems, Inc., Chatsworth, CA. C. M. Guarino, (213) 882-9616. Circle 164.**

DEVICE APPLICATION NOTE SERIES

A series of three application notes on varactor diodes, PIN diodes and tuning varactors has been released. Charts, pertinent curves and monographs are included. **Eaton Corporation, Communication Products Division, Sunnyvale, CA. (408) 733-3883. Circle 165.**

APPLICATION NOTE ON AUTOMATIC FREQUENCY MEASUREMENT TO 110 GHz

Application Note 201 is a four-page discussion of automated frequency measurement to 110 GHz. Block diagrams and simplified theory of operation and system implementation and highlights of integration are included. **EIP Microwave, Inc., San Jose, CA. Howard Lurie, (415) 328-4745. Circle 166.**

LNA EARTH TERMINAL BROCHURE

A bulletin sheet describes how a low noise amplifier is designed specifically for earth terminal application. The sheet provides key features, photograph of the amplifier system, and complete specifications for different models. **Internal Microwave Corp., Cos Cob, CT. (203) 661-6277. Circle 168.**

UPDATED CATALOG EDITIONS

Two editions of catalogs titled, "Microwave Components," and "Solid State Noise Sources," have been updated for 1981. Each pamphlet contains a broad range of products in the two categories and includes application information, performance specifications and illustrations. **Micronetics, Inc., Norwood, NJ. Gary Simonyan, (201) Group, Concord, CA. (415) 671-6637. Circle 173.**

RF/MICROWAVE COMPONENT CATALOG

A revised version for 1981 describes four main product lines: RF and microwave amplifiers, thick film hybrid circuits, switches and switch drivers. Capabilities section describes available custom thick-film hybrid products with process charts and photographs of IC's for analog and digital applications. **Optimax Division, Alpha Industries Inc., Colmar, PA. Joe Diesso, (215) 822-1311. Circle 171.**

MIC MICROWAVE AND CATALOG

MIC microwave and IF/RF type products are covered in Catalog 200. This 112-page two-color booklet contains three sections of detailed technical data with photos, graphs, and diagrams, on IF/RF products, MIC mixers and mixer preamplifiers and microwave relay links. Standard specification test methods are provided. **RHG Electronics Laboratory, Inc., Deer Park, NY. Sid Wolin, (516) 242-1100. Circle 172.**

SHORT FORM PRODUCT LINE CATALOG

A four-color, 20-page short-form catalog lists complete line of electronic test instruments. Descriptions and specifications for microwave synthesizers with frequency ranges to 26 GHz, matching range frequency counters, digital multimeters, pulse generators, timing equipment and power supplies, plus a review of the IEEE-488 Bus controller are included. **Systron Donner Instrument Div., THORN EMI Group, Concord, CA. (415) 671-6637. Circle 173.**

MICROPROCESSOR BASED SWEEP GENERATOR BROCHURE

A family of microprocessor-based Series 6600 sweep generators is described in a 24-page booklet. Booklet documents recently developed techniques for making accurate transmission loss/gain and return loss measurements. **Wiltron Company, Mountain View, CA. Walt Baxter, (415) 969-6500. Circle 174.**

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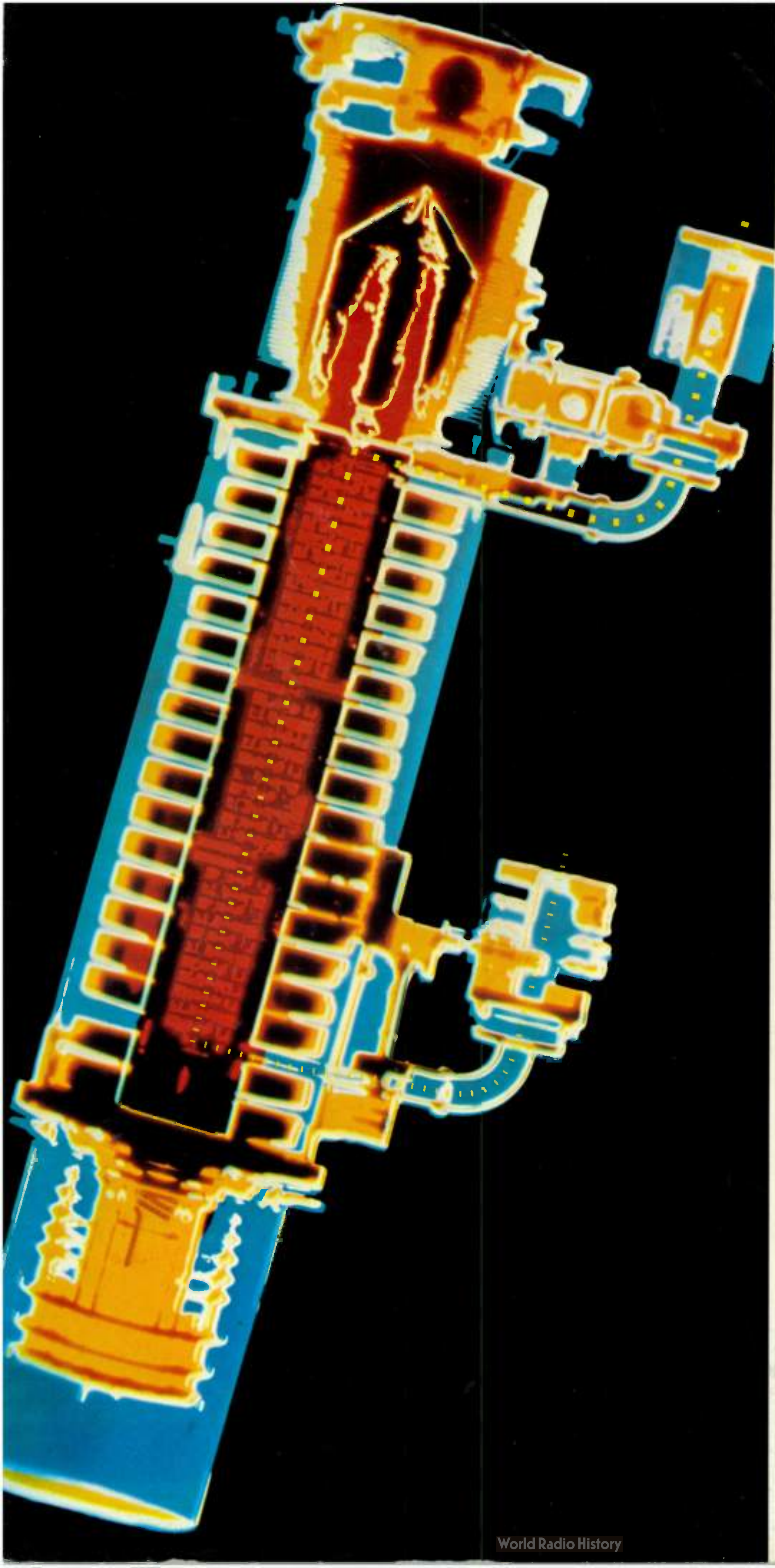

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