NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

ELECTRONICS DIVISION TECHNICAL NOTE NO. 146

Title: **CRYOGENIC TESTS OF MMIC AMPLIFIER**

Author(s): M. Balister and R. Harris

Date: June 22, 1988

DISTRIBUTION:

GB	CV	TU	VLA
GB Library	ER Library	Library Downtown	VLA Library
R. Norrod	IR Library	Library Mountain	P. Napier
R. Weimer	M. Balister	J. Payne	J. Campbell
D. Schiebel	S. Weinreb	R. Freund	W. Brundage
E. Childers	C. Burgess	J. Lamb	
R. Lacasse	S-K. Pan		
C. Brockway	A. R. Kerr		
J. Coe	Nancyjane Bailey		
W. Albing	L. D'Addario		
S. White	N. Horner		
G. Behrens	S. Srikanth		
R. Fisher			
F. Crews			
B. Peery			

CRYOGENIC TESTS OF MMIC AMPLIFIER

M. Balister and R. Harris

GaAs Monolithic Microwave Integrated Circuits are now commercially available at prices that compete favorably with those of discrete component amplifiers with similar performance. Generally, the MMIC amplifiers have wider bandwidths but poorer noise performance than the discrete component amplifiers. Since these are fabricated on GaAs, we decided to check whether they operated at cryogenic temperatures (20 K).

We had some TI TGA-8300 monolithic 2-18 GHz amplifier chips (see data sheet), one of which was mounted in a box with K-connectors, bypass capacitors, and resistors (see photo).

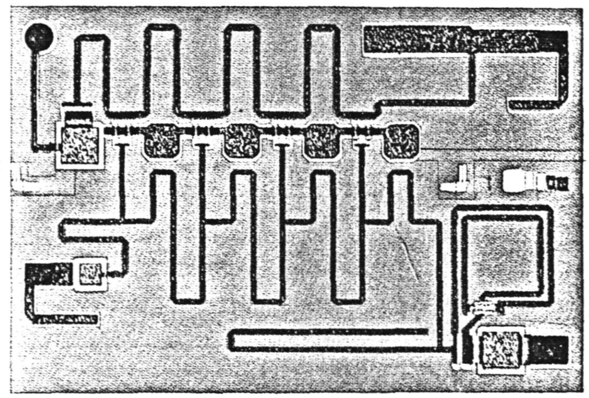
The attached printout shows the performance of the amplifier at 14 K measured in the test setup used for Neptune/Voyager amplifiers. The noise measurement is accurate; the gain curve is in error because of output line losses. The actual gain is slightly higher than the room temperature value of 6.5 dB.

At the moment, however, this chip offers us no particular advantage other than very wide bandwidth over our current discrete component HEMT amplifier designs. It is encouraging, however, that the first device we tested worked at 14 K. Since so much work is going on in the area of MMIC amplifiers, we should monitor the performance of future commercially available amplifiers.

In order to be useful for radio astronomy LNA use, we need better room temperature/cold noise performance and also lower power consumption. The amplifier tested is a four-stage distributed amplifier and dissipated about 125 mW for 6 dB gain. The non-distributed amplifiers are somewhat better but still appear to have fairly high power dissipations at their normal room temperature operating points.

Texas Instruments TGA8300

Monolithic 2- to 18-GHz Amplifier



Features

- 18-dBm typical output power at 1-dB gain compression
- 6.5-dB gain
- Input and output SWR less than 2:1
- Size: 0.093 × 0.064 × 0.006 inch
- Recessed ½-μm gate structure

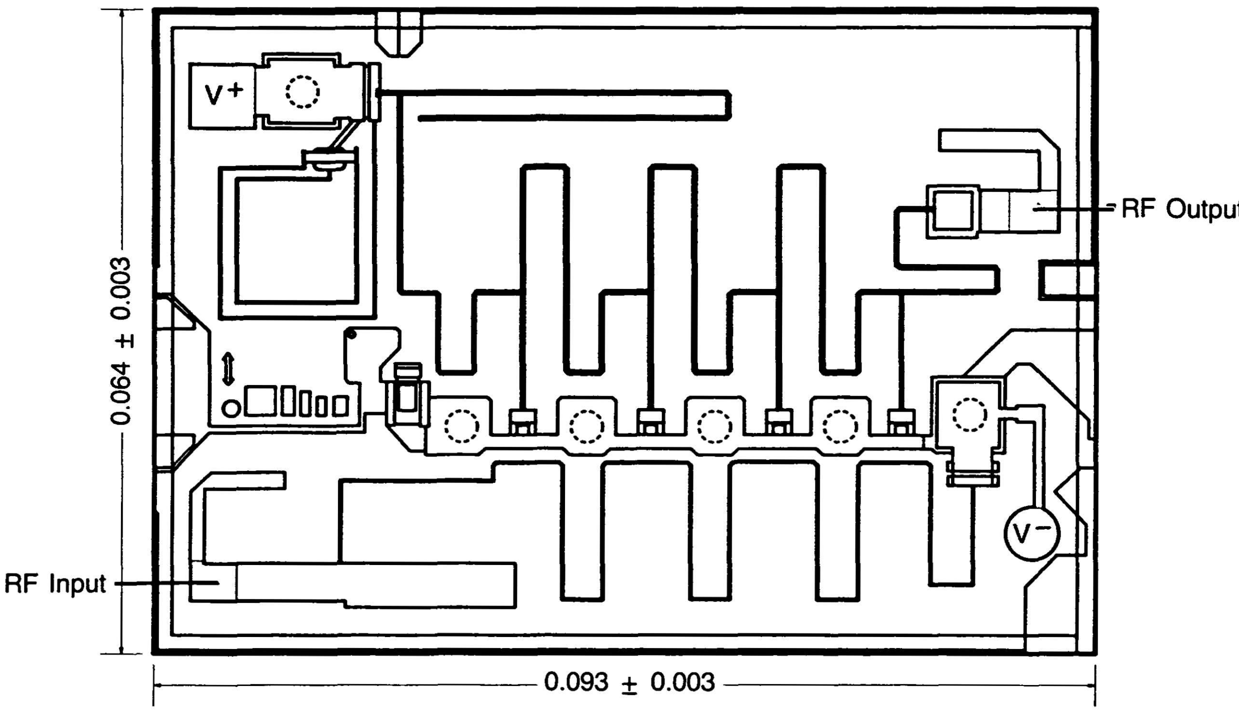
Description

The Texas Instruments TGA8300 is a GaAs monolithic distributed amplifier designed for use as a very broadband general-purpose gain block. Four 189-μm gate width FETs provide 6.5-dB nominal gain and less than 7-dB noise figure from 2 to 18 GHz. Typical power output is 18 dBm at 1-dB gain compression. Input and output SWRs are less than 2:1.

The TGA8300 is supplied in chip form and is engineered for high-volume automated assembly. All metal surfaces are gold plated to be compatible with thermocompression and thermosonic wire-bonding processes.

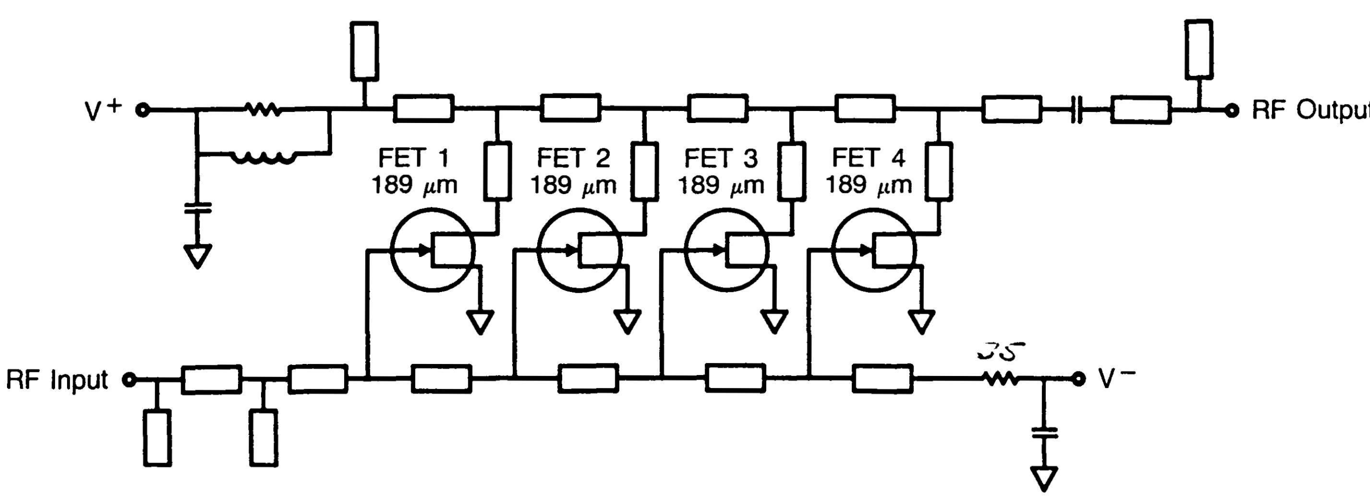
Advance Information documents contain information on new products in the sampling or preproduction phase of development. Characteristic data and other specifications are subject to change without notice.

Device Layout



Units: inches
Thickness: 0.006 (Ref. only)
☐ **Bonding pad area**

Circuit Topology

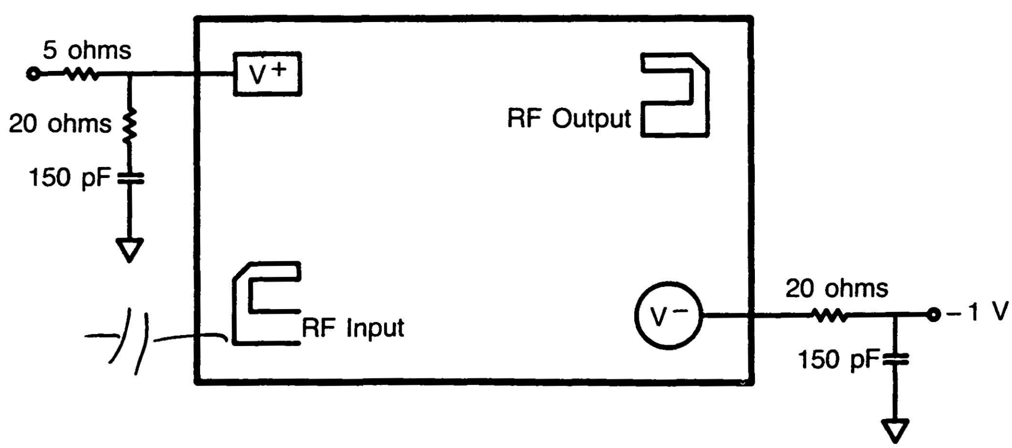


Absolute Maximum Ratings (T_A = 25°C)

Parameter	Symbol	Value	Units	Notes
Positive supply voltage	V^+	8.0	volts	
Negative supply voltage	V^-	0 to −5.0	volts	
Power dissipation	P_{DISS}	1.0	watt	
Operating channel temperature	T_{CH}	150°	C	1
Mounting temperature (30 seconds)	T_M	320°	C	
Storage temperature	T_{STG}	−65° to 150°	C	

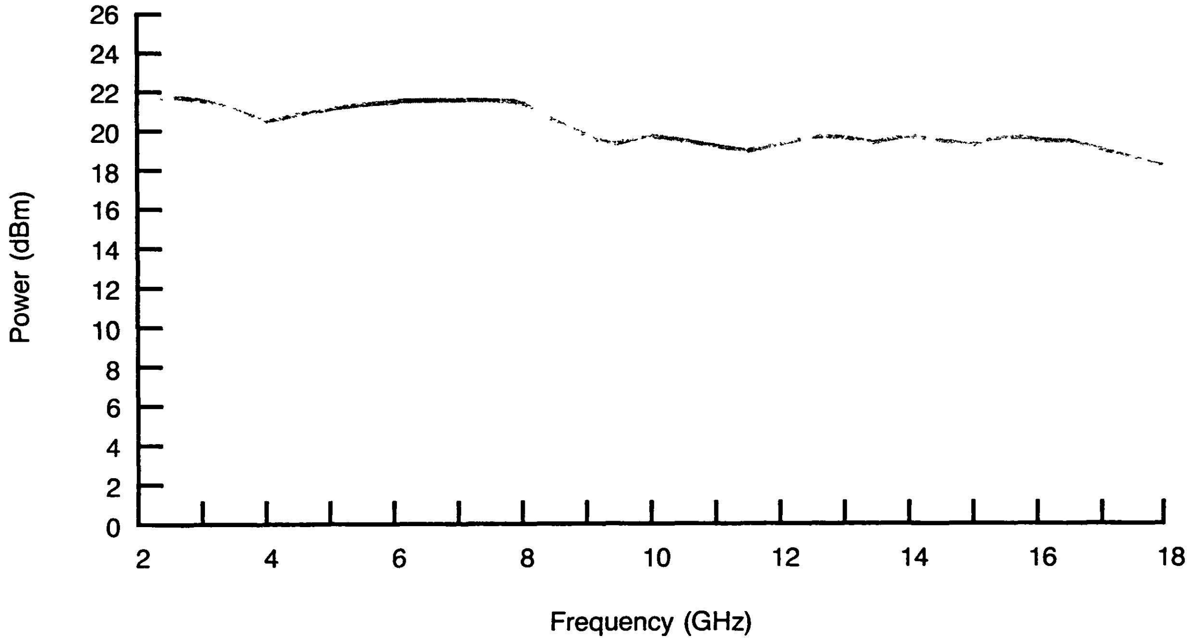
(1) Operating channel temperature will directly affect the device MTTF. For maximum life, it is recommended that channel temperature be maintained at the lowest possible level.

Recommended Bias Circuit

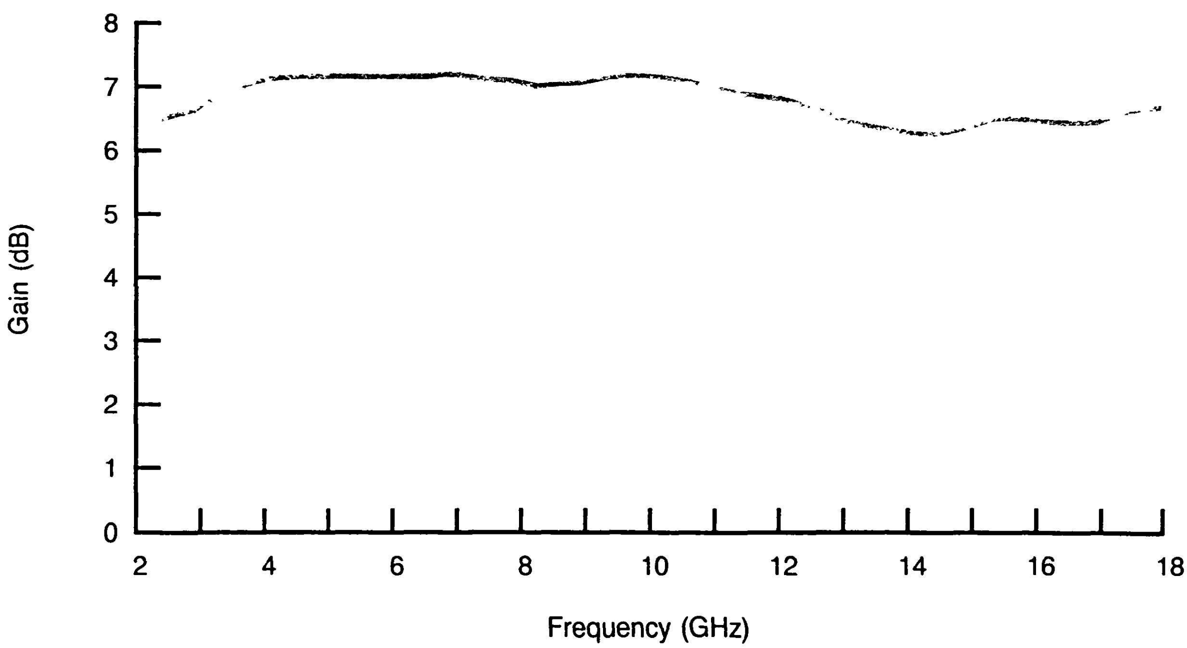


Close placement of external components is essential to stability.

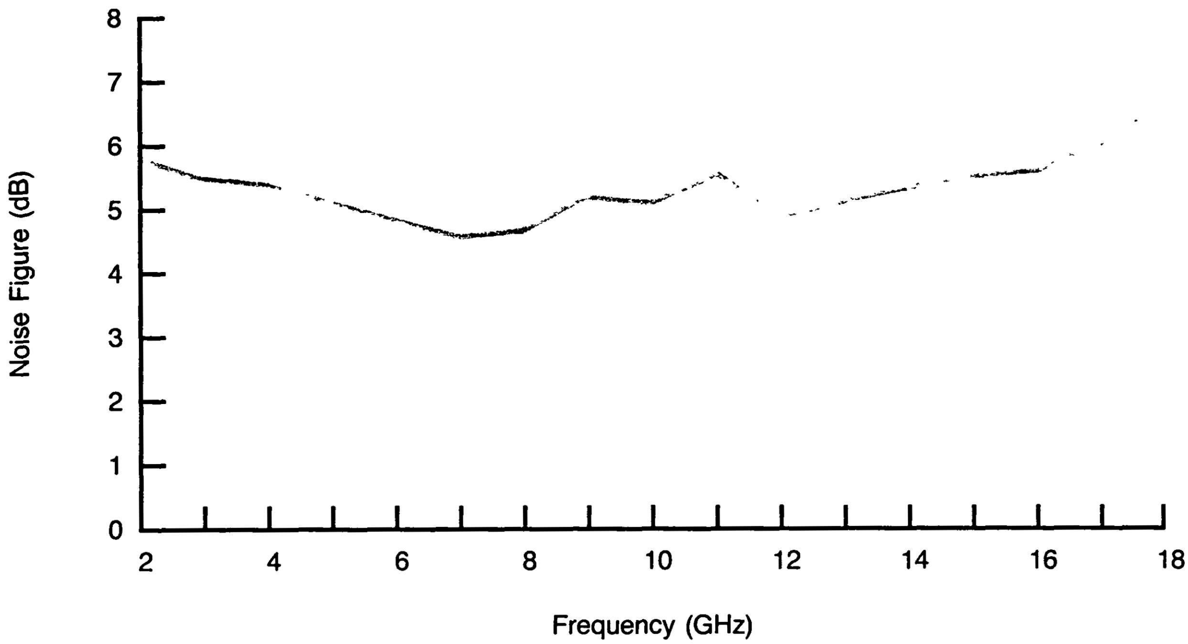
Typical Output Power at 1 – dB Gain Compression
(V^+ = 6 V, I^+ = 50% I_{DSS}, T_A = 25°C)



Typical Small-Signal Gain
(V^+ = 6 V, I^+ = 50% I_{DSS}, T_A = 25°C)



Typical Noise Figure
(V^+ = 6 V, I^+ = 50% I_{DSS}, T_A = 25°C)



Typical DC Characteristics (T_A = 25°C)

Parameter and Test Conditions	Symbol	Min	Typical	Max	Units	Notes
Saturated Drain Current V_{DS} = 2.5 V V_{GS} = 0.0 V	I_{DSS}	80	190	300	mA	1
Pinch-Off Voltage V_{DS} = 2.5 V I_{DS} = 500 μA	$\lvert V_P \rvert$	1	2	6	V	1
Transconductance V_{DS} = 2.5 V V_{GS} = 0.0 V	G_M	90	145		mS	1
Gate-Source Breakdown Voltage I_{SG} = 0.75 mA	$\lvert V_{BGS} \rvert$	6			V	1
Gate-Drain Breakdown Voltage I_{DG} = 0.75 mA	$\lvert V_{BGD} \rvert$	6			V	1

(1) DC data measured with four 189-μm FETs in parallel.

Typical S-Parameters
(V^+ = 6 V, I^+ = 50% I_{DSS}, T_A = 25°C)

Frequency (GHz)	S_{11}		S_{21}		S_{12}		S_{22}		$\|S_{21}\|$(dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG	
2.0	0.11	−99	1.98	159	0.02	95	0.14	−21	5.9
3.0	0.09	−148	2.05	124	0.03	57	0.29	−76	6.2
4.0	0.06	−146	2.12	94	0.04	27	0.29	−92	6.5
5.0	0.09	−120	2.16	64	0.04	−2	0.26	−95	6.7
6.0	0.13	−128	2.16	37	0.05	−30	0.25	−92	6.7
7.0	0.15	−145	2.16	9	0.06	−57	0.24	−91	6.7
8.0	0.13	−154	2.17	−17	0.07	−82	0.21	−93	6.7
9.0	0.10	−137	2.22	−45	0.08	−108	0.16	−93	6.9
10.0	0.19	−96	2.21	−73	0.09	−134	0.15	−61	6.9
11.0	0.10	−119	2.28	−102	0.10	−156	0.09	−51	7.1
12.0	0.14	−148	2.20	−129	0.11	−180	0.15	−30	6.9
13.0	0.11	−175	2.19	−157	0.11	155	0.20	−45	6.8
14.0	0.04	125	2.18	175	0.11	128	0.20	−69	6.8
15.0	0.07	−18	2.17	145	0.11	96	0.16	−94	6.7
16.0	0.13	−56	2.17	114	0.12	62	0.10	−118	6.7
17.0	0.11	−66	2.21	82	0.14	28	0.04	−82	6.9
18.0	0.19	−23	2.37	41	0.18	−7	0.18	−58	7.5

NOTE: Reference planes for S-parameter data located at center of device bond pads.

Typical Electrical Characteristics
(V^+ = 6 V, I^+ = 50% I_{DSS}, T_A = 25°C)

Parameter	Symbol	Test Conditions	Value	Units
Third-Order Intercept	IP_3	8 GHz	32	dBm
		12 GHz	28	dBm
		18 GHz	27	dBm
Standing-Wave Ratio				
Maximum Input	SWR	2-18 GHz	1.5:1	
Maximum Output		2-18 GHz	1.9:1	

Catalog Device Nomenclature

FETs and MMICs

```
TGA8300-S  C C - X
   1 2-5 6  7 8  9
```

Where:

(1) The Product type, coded as

F = Discrete GaAs FET
A = Monolithic amplifier
V = Monolithic VCO
S = Special monolithic function

(2-5) A specific 4-digit number identifying the device, i.e., 8300

(6) Performance screening coded as

S = Standard
X = Special

(7) Packaging coded as

C = Chip form
P = Standard package
S = Special package

(8) Reliability screening coded as

C = Commercial
M = Military

(9) TI internal procurement code X

For Further Information Contact:

U.S. Marketing

Dallas

Texas Instruments Incorporated
Marketing Manager
Microwave Military Components
P.O. Box 655474, M/S 402
Dallas, Texas 75265
Telephone (214) 995-3043

International Marketing

Bonn

Texas Instruments Deutschland GmbH
In Der Raste 24
5300 Bonn 1,
Federal Republic of Germany
TELEX: Germany 526529 TEXI D
TERM: EGBO
Telephone 0228/234081

Sales Offices

ALABAMA: Huntsville (205) 837-7530

ARIZONA: Phoenix (602) 995-1007
Tucson (602) 624-3276

CALIFORNIA: Irvine (714) 660-8187
Sacramento (916) 929-1521
San Diego (619) 278-9601
Santa Clara (408) 980-9000
Torrance (213) 217-7010
Woodland Hills (818) 704-7759

COLORADO: Aurora (303) 368-8000

CONNECTICUT: Wallingford (203) 269-0074

FLORIDA: Ft. Lauderdale (305) 973-8502
Maitland (305) 660-4600
Tampa (813) 870-6420

GEORGIA: Norcross (404) 662-7900

ILLINOIS: Arlington Heights (312) 640-2925

INDIANA: Ft. Wayne (219) 424-5174
Indianapolis (317) 248-8555

IOWA: Cedar Rapids (319) 395-9550

MARYLAND: Baltimore (301) 994-8600

MASSACHUSETTS: Waltham (617) 895-9100

MICHIGAN: Farmington Hills (313) 553-1500
Grand Rapids (616) 957-4200

MINNESOTA: Eden Prairie (612) 828-9300

MISSOURI: Kansas City (816) 523-2500
St. Louis (314) 569-7600

NEW JERSEY: Iselin (201) 750-1050

NEW MEXICO: Albuquerque (505) 345-2555

NEW YORK: East Syracuse (315) 463-9291
Endicott (607) 754-3900
Melville (516) 454-6600
Pittsford (716) 385-6770
Poughkeepsie (914) 473-2900

NORTH CAROLINA: Charlotte (704) 527-0930
Raleigh (919) 876-2725

OHIO: Beachwood (216) 464-6100
Dayton (513) 258-3877

OREGON: Beaverton (503) 643-6758

PENNSYLVANIA: Ft. Washington (215) 643-6450
Coraopolis (412) 771-8550

PUERTO RICO: Hato Rey (809) 753-8700

TEXAS: Austin (512) 250-7655
Houston (713) 778-6592
Richardson (214) 680-5082
San Antonio (512) 496-1779

UTAH: Murray (801) 266-8972

VIRGINIA: Fairfax (703) 849-1400

WASHINGTON: Redmond (206) 881-3080

WISCONSIN: Brookfield (414) 785-7140

CANADA: Nepean, Ontario (613) 726-1970
Richmond Hill, Ontario (416) 884-9181
St. Laurent, Quebec (514) 335-8392

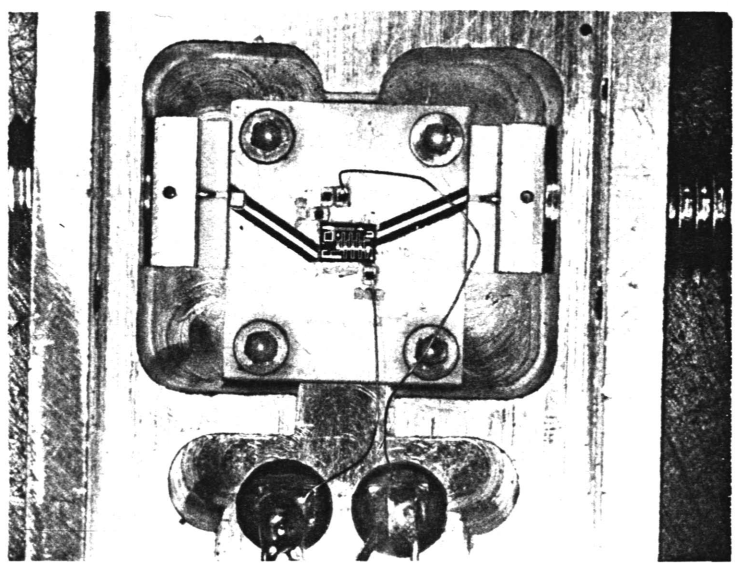
Customer Response Center

TOLL FREE: (800) 232-3200 Ext. 1502

OUTSIDE USA: (214) 995-6611 Ext. 1502
(8:00 a.m. — 5:00 p.m. CST)

TEXAS INSTRUMENTS

Printed in U.S.A. 01-AW-5-87
GMGS007



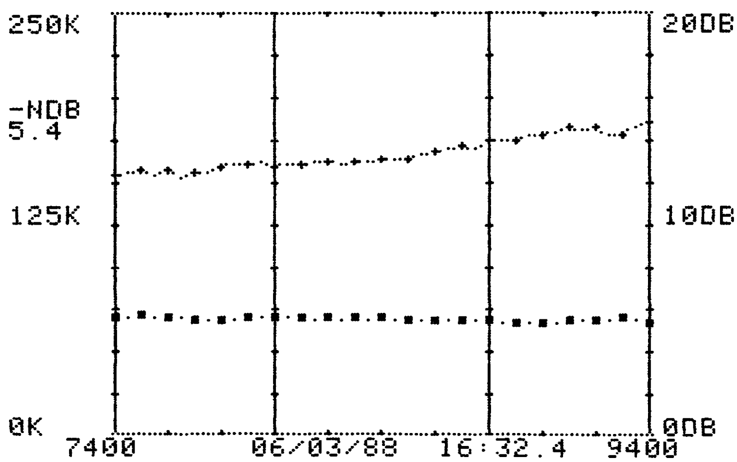
MMIC Amplifier Mounted in Test Fixture

1) GOTO1800
16:26.3 06/03/88 TAV=586884.4 TLO=1728 @ 8750 GL=-32.1 GH=0 T=-1000K

-10,-100,-10 -10,-100,-10 -10,-100,-10 -10,-100,-10

1) 14K MEASUREMENT WITH LOWER DRAIN CURRENT
16:32.4 06/03/88 TAV=164.2 TLO=159 @ 8000 GL=5.4 GH=5.6 T=-1000K

-8.15,-100,-10 -10,-100,-10 -10,-100,-10 -10,-100,-10



16:36.7 06/03/88 ZERO=11.6 ADB=10 TF=16.8 -NDB=5.4

F,GHZ	NOISE	GAIN,DB	F,GHZ	NOISE	GAIN,DB
7.900	159.5	5.6	8.00	159.0	5.5
8.100	160.3	5.5	8.20	161.9	5.5
8.300	161.4	5.5	8.40	163.1	5.6
8.500	163.5	5.5	8.60	168.0	5.5
8.700	170.9	5.5	8.80	173.6	5.4
8.900	174.9	5.3	9.00	177.9	5.3