NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

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Title: **CRYOGENIC TESTS OF MMIC AMPLIFIER**

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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.

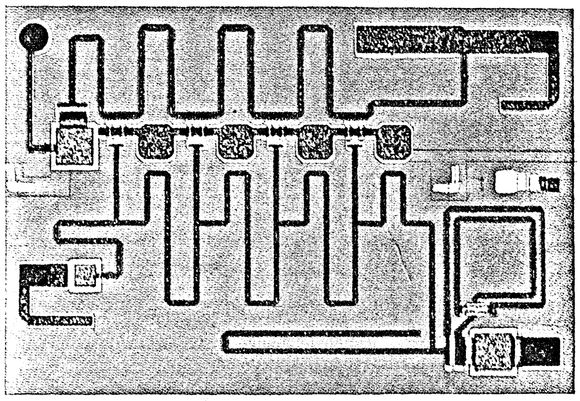
In order to be useful for radio astronomy LNA use, we need better room temperature/cold noise performance and also lower power consumption. The amplifier tested is a four-stage distributed amplifier and dissipated about 125 mW for 6 dB gain. The non-distributed amplifiers are somewhat better but still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

$995 KIT

MARTY JONES

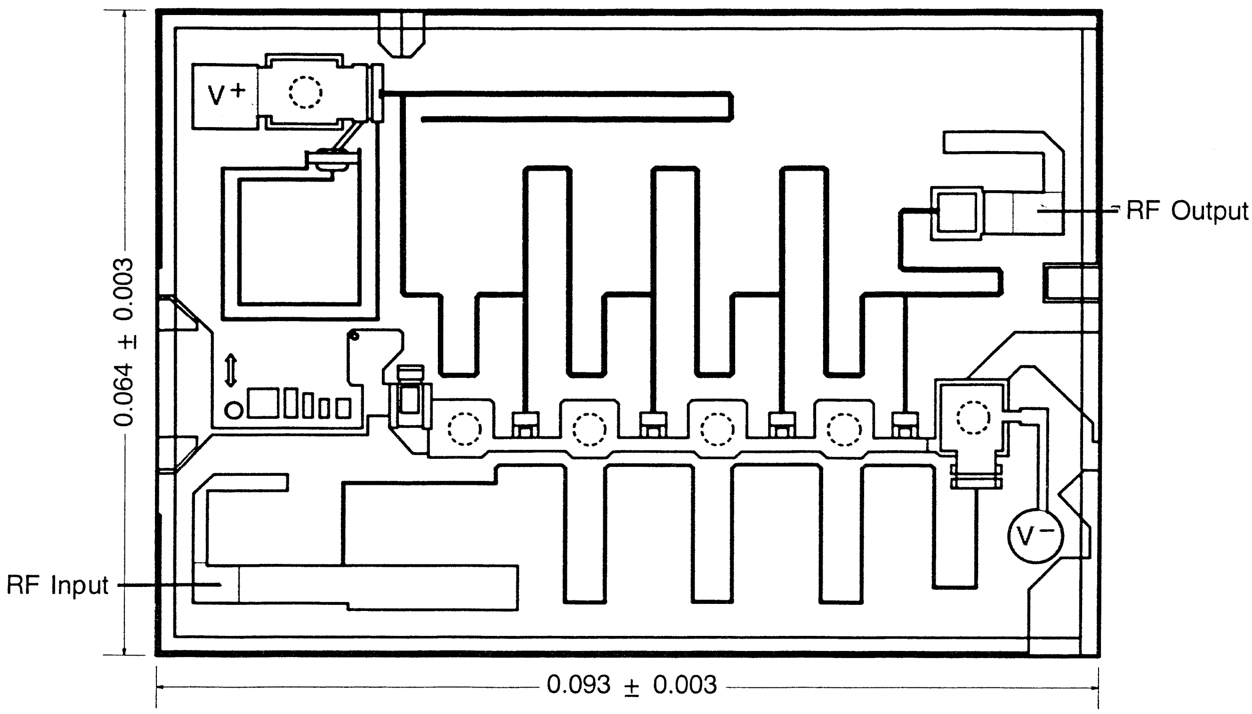
214-995-6464

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.

TI TGA 8300

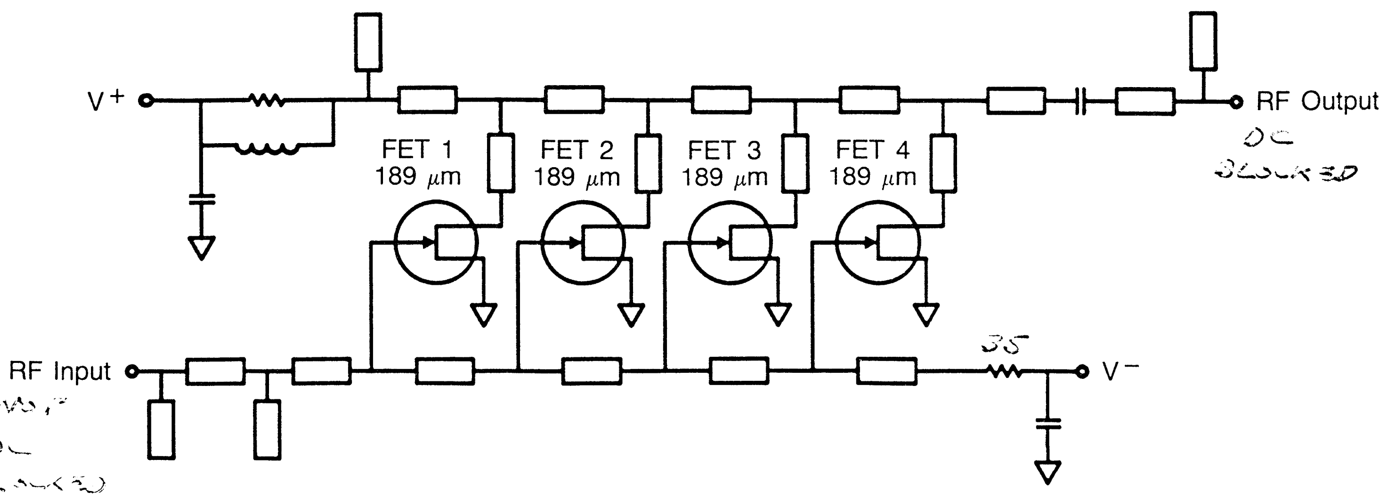
6.5DB GAIN 5-6DB NF 2-18 GHZ

Device Layout



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

Circuit Topology

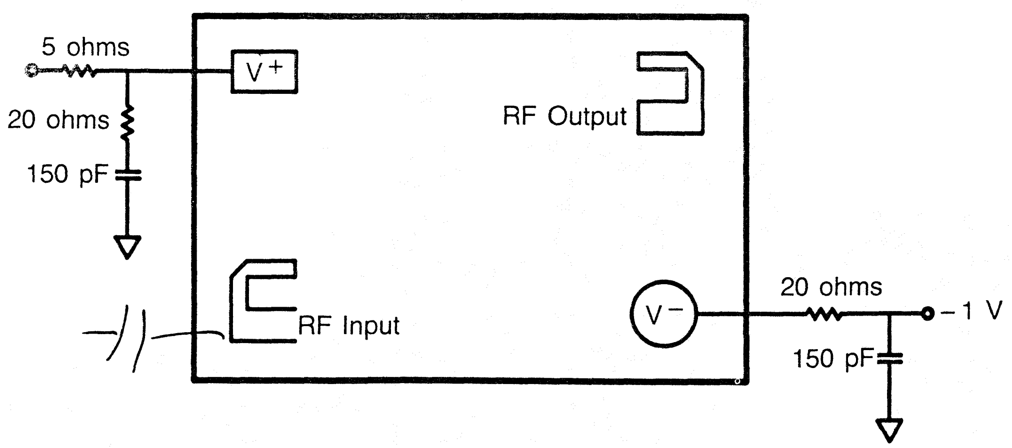


Absolute Maximum Ratings (T_A = 25°C)

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	

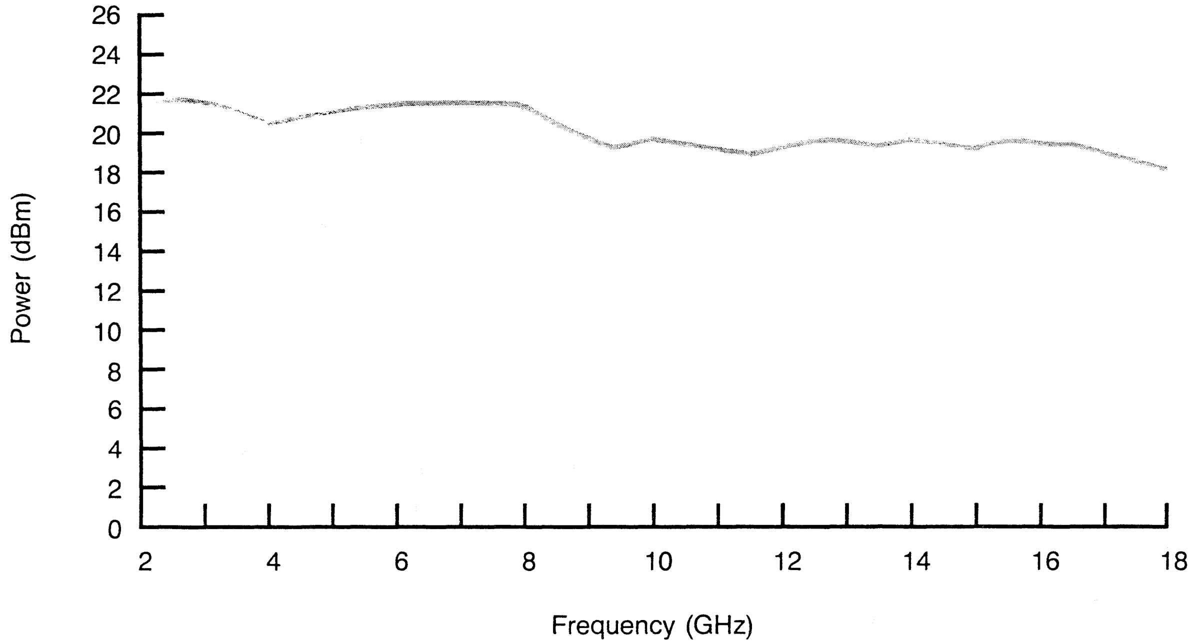
(1) Operating channel temperature will directly affect the device MTTF. For maximum life, it is recommended that channel temperature be maintained at the lowest possible level.

Recommended Bias Circuit

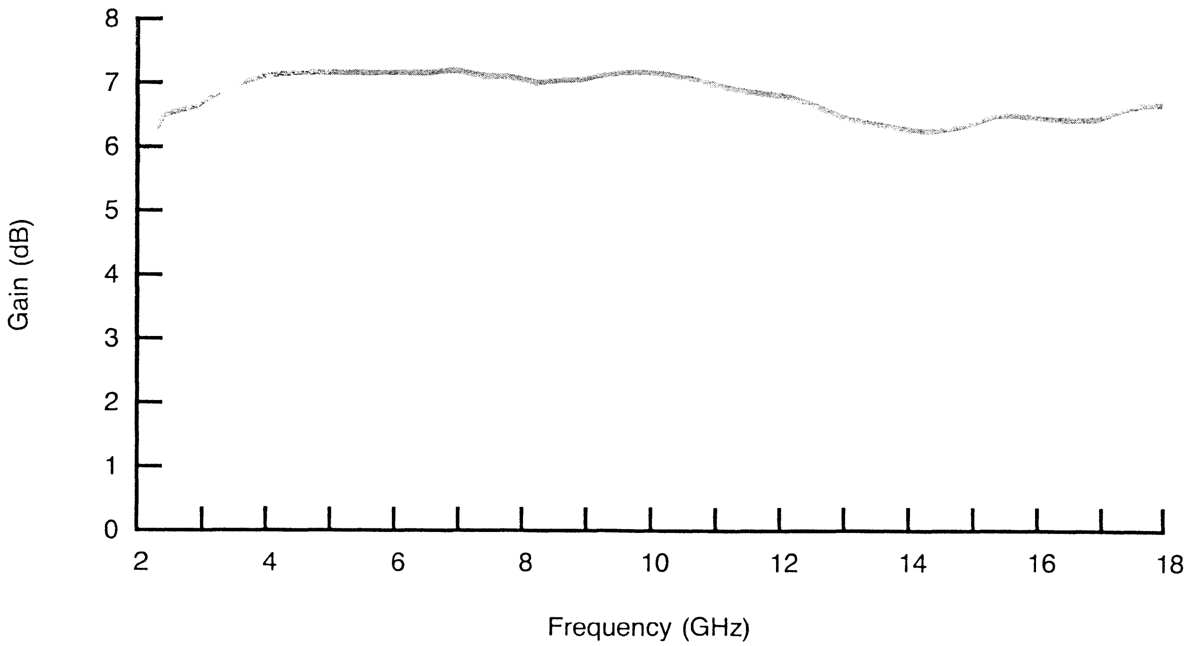


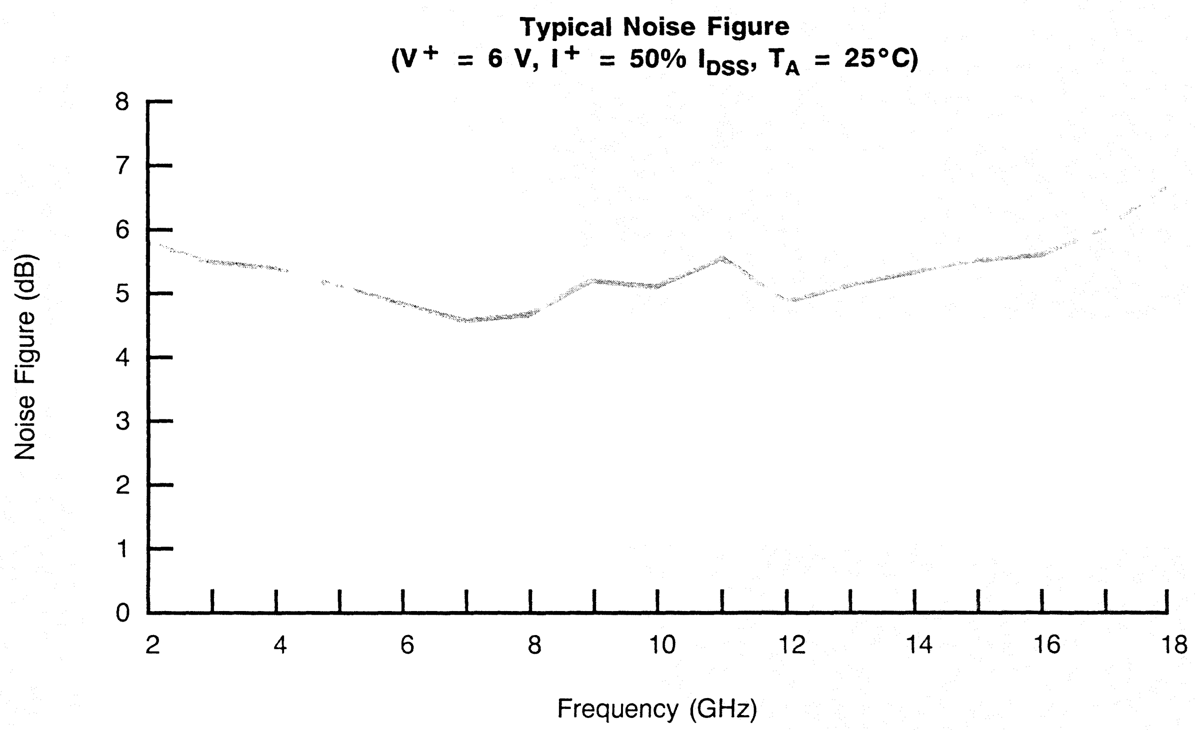
Close placement of external components is essential to stability.

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 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

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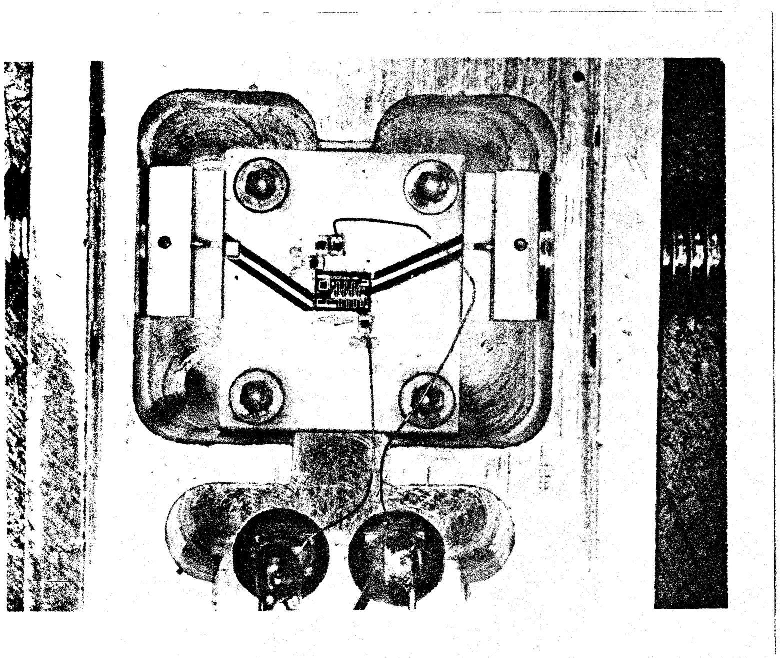


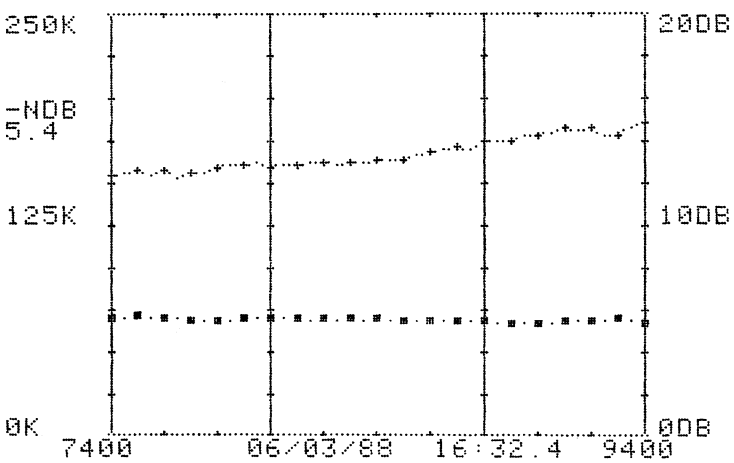
MMIC Amplifier Mounted in Test Fixture

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

$V_{dd} \approx 5V$

$I \approx 25mA$