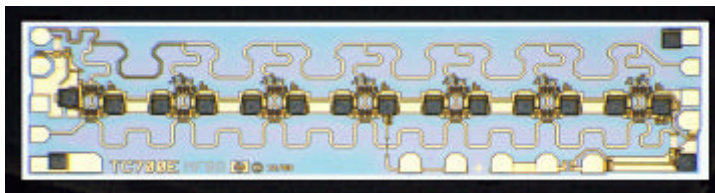


# Agilent HMMC-5021 (2–22 GHz) HMMC-5022 (2–22 GHz) and HMMC-5026 (2–26.5 GHz) 2–26.5 GHz GaAs MMIC Traveling Wave Amplifier

## Data Sheet



Chip Size:	2980 × 770 μm (117.3 × 30.3 mils)
Chip Size Tolerance:	±10 μm (±0.4 mils)
Chip Thickness:	127 ± 15 μm (5.0 ± 0.6 mils)
Pad Dimensions:	75 × 75 μm (2.95 × 2.95 mils), or larger

### Features

- Wide-Frequency Range:  
2–26.5 GHz
- High Gain: 9.5 dB
- Gain Flatness: ± 0.75 dB
- Return Loss:  
Input: –14 dB, Output: –13 dB
- Low-Frequency Operation  
Capability: < 2 GHz
- Gain Control:  
35 dB Dynamic Range
- Moderate Power:  
20 GHz: P<sub>–1dB</sub>, 18 dBm, P<sub>sat</sub>: 20dBm  
26.5 GHz: P<sub>–1dB</sub>, 15 dBm, P<sub>sat</sub>: 17dBm

### Description

The HMMC-5021/22/26 is a broadband GaAs MMIC Traveling Wave Amplifier designed for high gain and moderate output power over the full 2 to 26.5 GHz frequency range. Seven MES-FET cascode stages provide a flat gain response, making the HMMC-5021/22/26 an ideal wideband gain block. Optical lithography is used to produce gate lengths of ≈ 0.4 μm. The HMMC-5021/22/26 incorporates advanced MBE technology, Ti-Pt-Au gate metallization, silicon nitride passivation, and polyimide for scratch protection.

### Absolute Maximum Ratings<sup>[1]</sup>

Symbol	Parameters/Conditions	Min.	Max.	Units
V <sub>DD</sub>	Positive Drain Voltage		8.0	volts
I <sub>DD</sub>	Total Drain Current		250	mA
V <sub>G1</sub>	First Gate Voltage	–5	0	volts
I <sub>G1</sub>	First Gate Current	–9	+5	mA
V <sub>G2</sub> <sup>[2]</sup>	Second Gate Voltage	–2.5	+3.5	volts
I <sub>G2</sub>	Second Gate Current	–7		mA
P <sub>DC</sub>	DC Power Dissipation		2.0	watts
P <sub>in</sub>	CW Input Power		23	dBm
T <sub>ch</sub>	Operating Channel Temp.		+150	°C
T <sub>case</sub>	Operating Case Temp.	–55		°C
T <sub>stg</sub>	Storage Temperature	–65	+165	°C
T <sub>max</sub>	Max. Assembly Temp. (for 60 seconds maximum)		300	°C

#### Notes:

<sup>[1]</sup>Operation in excess of any one of these conditions may result in permanent damage to this device. T<sub>A</sub> = 25°C except for T<sub>ch</sub>, T<sub>stg</sub>, and T<sub>max</sub>.

<sup>[2]</sup>Minimum voltage on V<sub>G2</sub> must not violate the following: V<sub>G2</sub>(min) > V<sub>DD</sub> – 9 volts.

## DC Specifications/Physical Properties<sup>[1]</sup> (Applies to all part numbers)

Symbol	Parameters/Conditions	Min.	Typ.	Max.	Units
$I_{DSS}$	Saturated Drain Current ( $V_{DD} = 7.0V$ , $V_{G1} = 0.0V$ , $V_{G2} = \text{open circuit}$ )	115	180	250	mA
$V_p$	First Gate Pinch-Off Voltage ( $V_{DD} = 7.0V$ , $I_{DD} = 16 \text{ mA}$ , $V_{G2} = \text{open circuit}$ )	-3.5	-1.5	-5	volts
$V_{G2}$	Second Gate Self-Bias Voltage ( $V_{DD} = 7.0V$ , $V_{G1} = 0.0V$ )		2.1		volts
$I_{DSOFF}$ ( $V_{G1}$ )	First Gate Pinch-Off Current ( $V_{DD} = 7.0V$ , $V_{G1} = -3.5V$ , $V_{G2} = \text{open circuit}$ )		4		mA
$I_{DSOFF}$ ( $V_{G2}$ )	Second Gate Pinch-Off Current ( $V_{DD} = 5.0V$ , $V_{G1} = 0.0V$ , $V_{G2} = -3.5V$ )		8		mA
$\theta_{ch-bs}$	Thermal Resistance ( $T_{backside} = 25^\circ\text{C}$ )		36		$^\circ\text{C}/\text{W}$

### Notes:

<sup>[1]</sup>Measured in wafer form with  $T_{chuck} = 25^\circ\text{C}$ . (Except  $\theta_{ch-bs}$ .)

## RF Specifications

( $V_{DD} = 7.0V$ ,  $I_{DD}(Q) = 150\text{mA}$ ,  $Z_{in} = Z_o = 50\Omega$ )<sup>[1]</sup>

Symbol	Parameters/Conditions	2.0–22.0 GHz				2.0–26.5 GHz			Units
		HMMC-5021		HMMC-5022		HMMC-5026			
		Typ.	Min.	Typ.	Max.	Min.	Typ.	Max.	
BW	Guaranteed Bandwidth <sup>[2]</sup>	2–22	2		22	2		26.5	GHz
$S_{21}$	Small Signal Gain	10	8.0	10	12	7.5	9.5	12	dB
$S_{21}$	Small Signal Gain Flatness	$\pm 0.5$		$\pm 0.5$	$\pm 1.0$		$\pm 0.75$	$\pm 1.0$	dB
$RL_{in(min)}$	Minimum Input Return Loss	16	10	16		10	14		dB
$RL_{out(min)}$	Minimum Output Return Loss	13	10	13		10	13		dB
Isolation	Minimum Reverse Isolation	32	20	32		20	30		dB
$P_{-1dB}$	Output Power at 1dB Gain Compression	18	15	18		12	15		dBm
$P_{sat}$	Saturated Output Power	20	17	20		14	17		dBm
$H_{2(max)}$	Max. Second Harm. ( $2 < f_o < 20$ ), [ $P_o(f_o) = 17 \text{ dBm}$ or $P_{-1dB}$ , whichever is less]	-25		-25	-20		-25	-20	dBc
$H_{3(max)}$	Max. Third Harm. ( $2 < f_o < 20$ ), [ $P_o(f_o) = 17 \text{ dBm}$ or $P_{-1dB}$ , whichever is less]	-34		-34	-20		-34	-20	dBc
NF	Noise Figure	8		8			10		dB

### Notes:

<sup>[1]</sup>Small-signal data measured in wafer form with  $T_{chuck} = 25^\circ\text{C}$ . Large-signal data measured on individual devices mounted in an 83040 Series Modular Microcircuit Package @  $T_A = 25^\circ\text{C}$ .

<sup>[2]</sup>Performance may be extended to lower frequencies through the use of appropriate off-chip circuitry. Upper -3 dB corner frequency ~ 29.5 GHz.

## Applications

The HMMC-5021/22/26 series of traveling wave amplifiers are designed for use as general purpose wideband gain blocks in communication systems and microwave instrumentation. They are ideally suited for broadband applications requiring a flat gain response and excellent port matches over a 2 to 26.5 GHz frequency range. Dynamic gain control and low-frequency extension capabilities are designed into these devices.

## Biasing and Operation

These amplifiers are biased with a single positive drain supply ( $V_{DD}$ ) and a single negative gate supply ( $V_{G1}$ ). The recommended bias conditions for the HMMC-5021/22/26 are  $V_{DD}=7.0V$ ,  $I_{DD}=150mA$  for best overall performance. To achieve this drain current level,  $V_{G1}$  is typically biased between  $-0.2V$  and  $-0.5V$ . No other bias supplies or connections to the device are required for 2 to 26.5 GHz

operation. See Figure 3 for assembly information.

The HMMC-5021/22/26 is a DC coupled amplifier. External coupling capacitors are needed on  $RF_{IN}$  and  $RF_{OUT}$  ports. The drain bias pad is connected to RF and must be decoupled to the lowest operating frequency.

The auxiliary gate and drain contacts are provided when performance below 1 GHz is required. Connect external capacitors to ground to maintain input and output VSWR at low frequencies (see Additional References). Do not apply bias to these pads.

The second gate ( $V_{G2}$ ) can be used to obtain 35 dB (typical) dynamic gain control. For normal operation, no external bias is required on this contact and its self-bias voltage is  $\approx +2.1$  v. Applying an external bias between its open-circuit voltage and  $-2.5$  volts will adjust the gain while maintaining a good input/output port match.

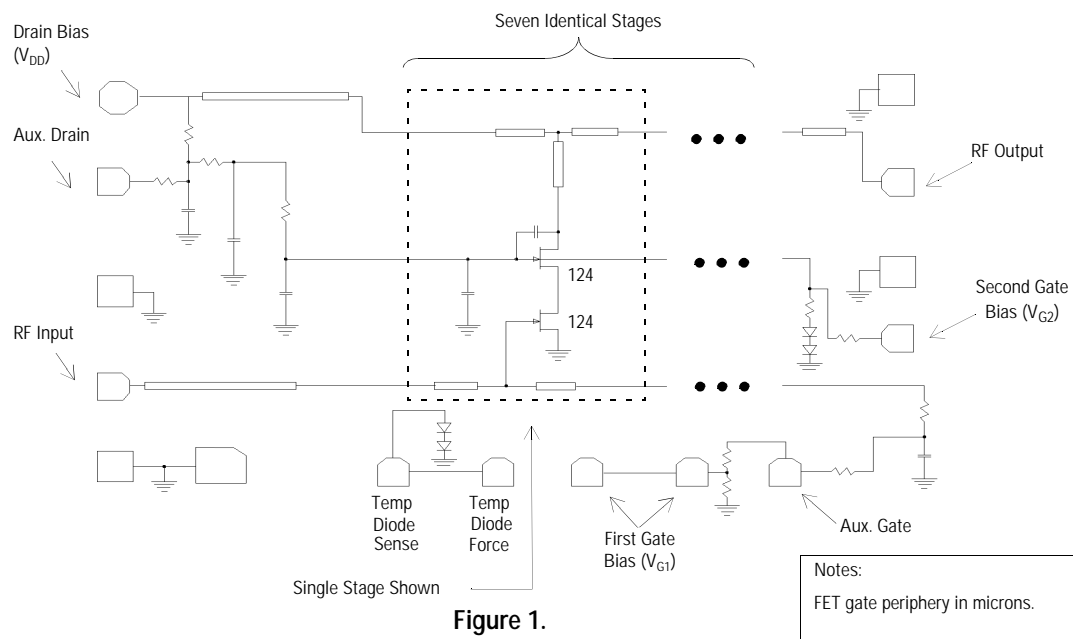
## Assembly Techniques

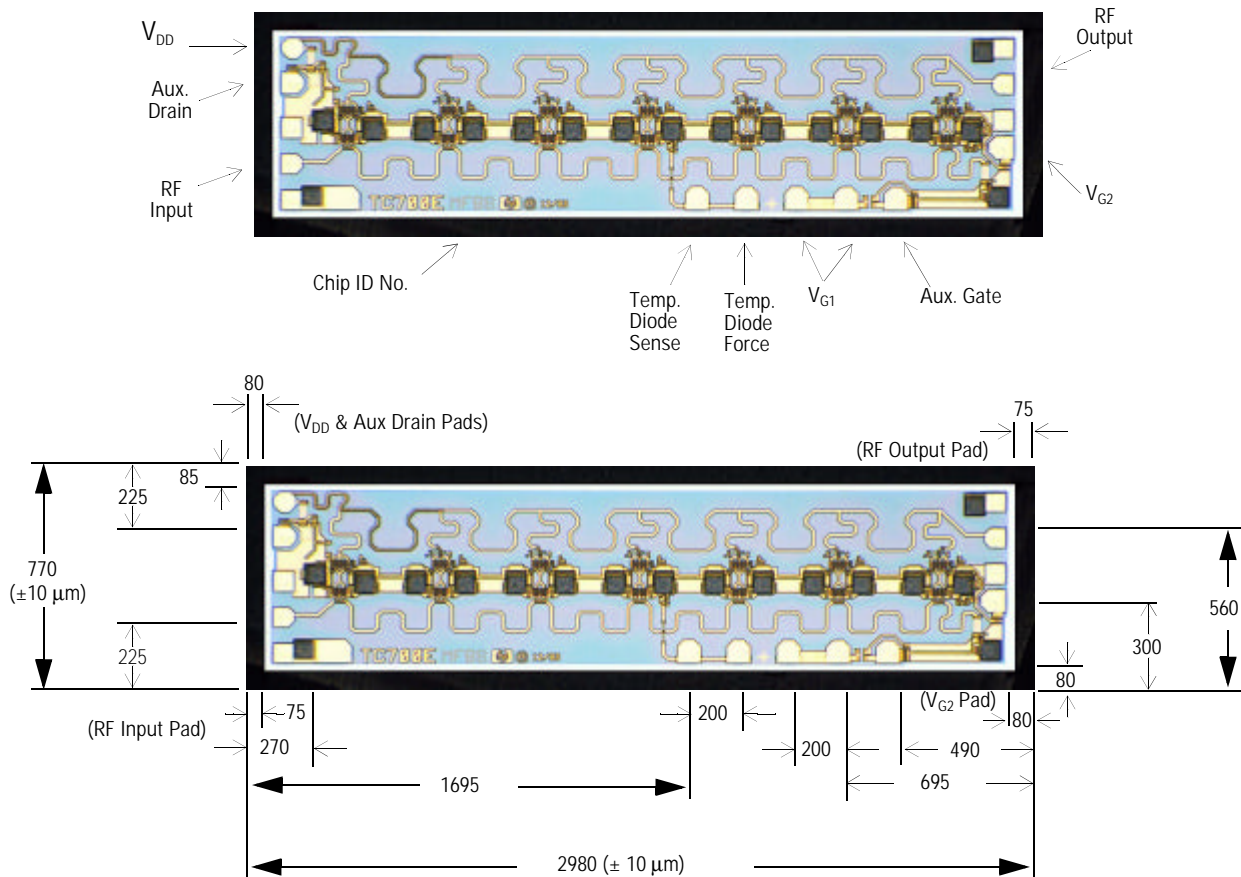
GaAs MMICs are ESD sensitive. ESD preventive measures must be employed in all aspects of storage, handling, and assembly. MMIC ESD precautions, handling considerations, die attach and bonding methods are critical factors in successful GaAs MMIC performance and reliability.

Agilent application note #54, "GaAs MMIC ESD, Die Attach and Bonding Guidelines" provides basic information on these subjects.

## Additional References:

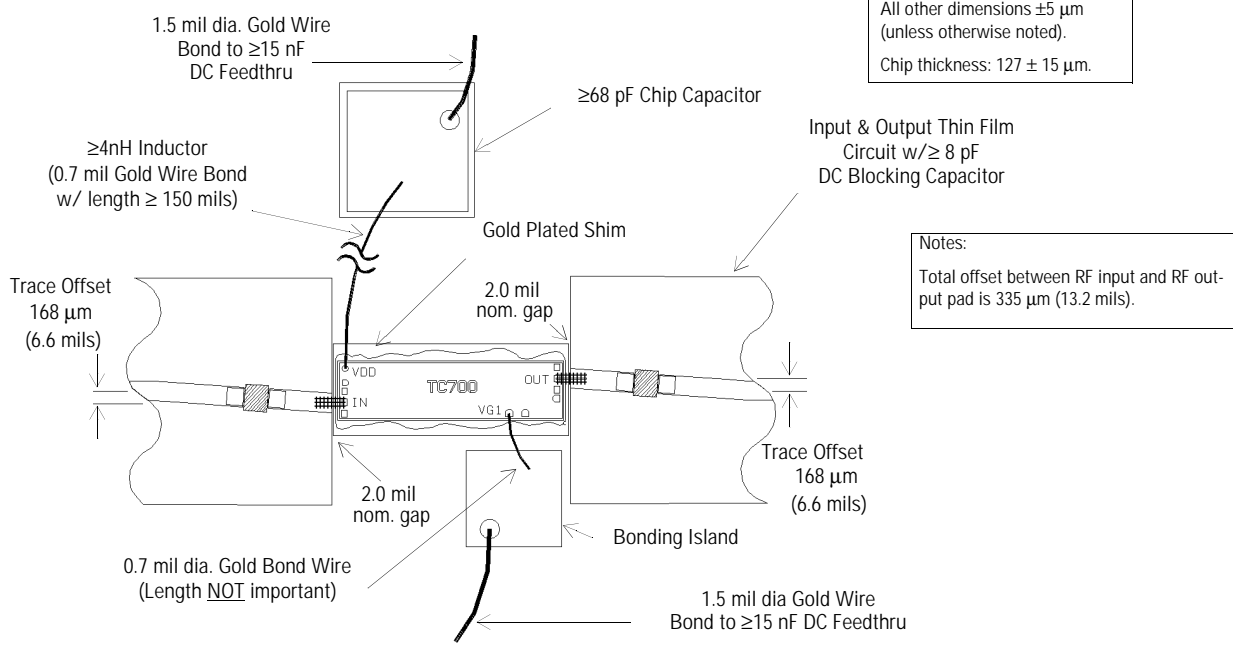
AN# 31, "2–26.5 GHz Variable Gain Amplifier Using HMMC-5021/22/26 and HMMC-1002 GaAs MMIC," AN# 34, "HMMC-5021/22/26/27 TWA Environmental Data," AN# 41, "HMMC-5021/22/26 S-Parameters Performance as a Function of Bonding Configuration," and AN# 56, "GaAs MMIC TWA Users Guide."



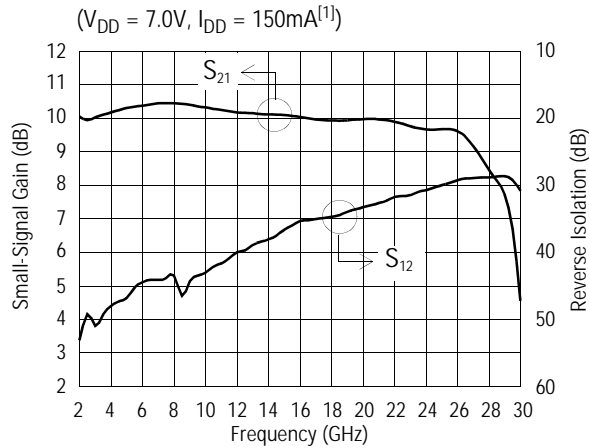


**Figure 2.**  
**Bond Pad Locations**

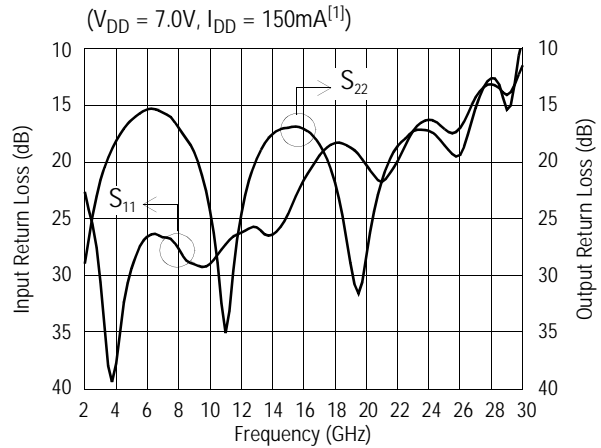
Notes:  
 All dimensions in microns.  
 Rectangular Pad Dim:  $75 \times 75 \mu\text{m}$ .  
 Octagonal Pad Dim:  $90 \mu\text{m}$  dia.  
 All other dimensions  $\pm 5 \mu\text{m}$   
 (unless otherwise noted).  
 Chip thickness:  $127 \pm 15 \mu\text{m}$ .



**Figure 3.**  
**Assembly Diagram**  
**(For 2.0–26.5 GHz Operation)**



**Figure 4.**  
Typical Gain and Reverse Isolation  
vs. Frequency



**Figure 5.**  
Typical Input and Out Return Loss  
vs. Frequency

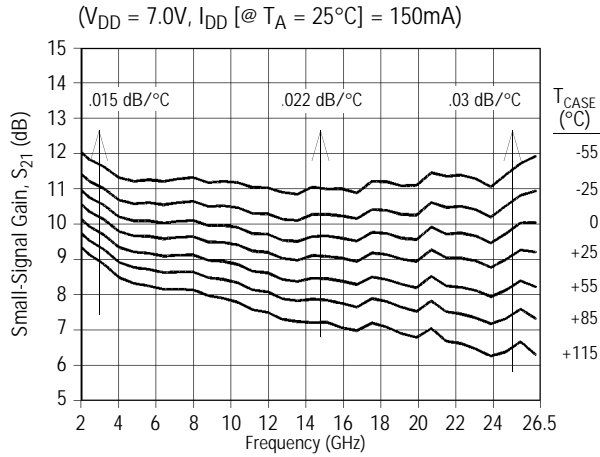
### Typical S-Parameters<sup>[1]</sup>

( $T_{\text{chuck}} = 25^{\circ}\text{C}$ ,  $V_{\text{DD}} = 7.0\text{V}$ ,  $I_{\text{DD}} = 150\text{ mA}$ ,  $Z_{\text{in}} = Z_{\text{out}} = 50\Omega$ )

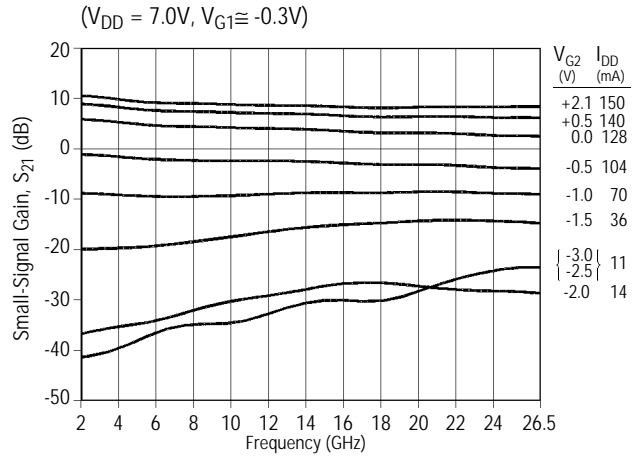
Freq. (GHz)	S <sub>11</sub>			S <sub>12</sub>			S <sub>21</sub>			S <sub>22</sub>		
	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang
2.0	-22.6	0.074	-174.1	-53.1	0.0022	167.3	10.1	3.183	123.6	-28.9	0.036	77.3
3.0	-30.6	0.030	130.4	-51.0	0.0028	120.1	10.0	3.173	102.1	-21.6	0.083	64.1
4.0	-37.8	0.013	-19.8	-48.0	0.0040	95.0	10.2	3.225	78.2	-18.2	0.124	45.4
5.0	-29.4	0.034	-79.9	-46.8	0.0046	67.1	10.3	3.275	53.5	-16.3	0.153	23.4
6.0	-26.6	0.047	-113.8	-44.4	0.0060	36.0	10.4	3.303	28.1	-15.4	0.170	2.5
7.0	-26.6	0.047	-137.0	-44.1	0.0062	1.0	10.4	3.330	2.3	-15.7	0.165	-19.5
8.0	-27.7	0.041	-152.6	-43.4	0.0067	-27.5	10.5	3.331	-23.8	-17.0	0.141	-40.7
9.0	-29.0	0.035	-149.8	-44.3	0.0061	-31.8	10.4	3.312	-50.2	-19.2	0.110	-59.7
10.0	-29.0	0.036	-140.8	-43.0	0.0071	-53.6	10.3	3.282	-76.4	-24.3	0.061	-76.8
11.0	-27.3	0.043	-138.1	-41.6	0.0083	-74.8	10.2	3.253	-102.5	-35.1	0.018	-32.6
12.0	-26.2	0.049	-141.9	-40.0	0.0100	-96.9	10.2	3.227	-128.8	-24.6	0.059	21.0
13.0	-25.8	0.052	-148.5	-38.9	0.0113	-120.9	10.2	3.218	-155.4	-19.7	0.103	2.8
14.0	-26.4	0.048	-143.0	-38.1	0.0125	-145.6	10.1	3.204	177.8	-17.6	0.132	-21.2
15.0	-24.6	0.059	-131.7	-36.6	0.0148	-169.9	10.1	3.197	150.4	-17.0	0.141	-44.8
16.0	-21.6	0.083	-133.7	-35.3	0.0172	160.9	10.0	3.177	122.5	-17.1	0.140	-67.4
17.0	-19.4	0.107	-143.5	-35.0	0.0177	130.6	10.0	3.149	94.4	-18.5	0.119	-91.8
18.0	-18.3	0.121	-158.7	-34.7	0.0184	105.0	9.9	3.138	65.9	-21.8	0.081	-116.0
19.0	-18.7	0.116	-172.6	-33.9	0.0201	80.2	9.9	3.140	36.8	-28.9	0.036	-121.7
20.0	-20.3	0.097	-179.5	-33.3	0.0217	50.7	10.0	3.151	6.6	-28.5	0.038	-57.0
21.0	-21.8	0.082	-168.3	-32.7	0.0233	22.5	10.0	3.150	-24.9	-21.7	0.082	-59.1
22.0	-19.9	0.101	-155.3	-31.7	0.0259	-8.4	9.9	3.126	-57.5	-18.6	0.117	-81.5
23.0	-17.3	0.137	-158.8	-31.4	0.0268	-39.5	9.8	3.076	-91.0	-17.3	0.137	-103.3
24.0	-16.3	0.153	-169.9	-30.7	0.0291	-71.5	9.7	3.045	-125.5	-17.3	0.137	-123.8
25.0	-17.1	0.139	-175.4	-30.0	0.0317	-106.2	9.7	3.045	-162.2	-18.5	0.118	-135.3
26.0	-17.0	0.141	-165.0	-29.2	0.0345	-145.5	9.6	3.027	157.2	-19.4	0.107	-122.5
26.5	-15.7	0.163	-161.1	-29.0	0.0356	-166.7	9.5	2.970	135.4	-17.6	0.132	-114.2
27.0	-14.3	0.192	-162.7	-28.9	0.0357	171.7	9.2	2.876	112.9	-15.3	0.173	-116.0
28.0	-13.2	0.220	-175.7	-28.8	0.0362	126.3	8.5	2.648	65.8	-12.6	0.233	-138.1
29.0	-14.1	0.197	-176.9	-28.6	0.0371	73.0	7.7	2.433	10.3	-15.4	0.170	-144.7
30.0	-11.5	0.266	-171.6	-30.8	0.0287	4.8	4.6	1.689	-61.1	-8.7	0.369	-123.6

Notes:

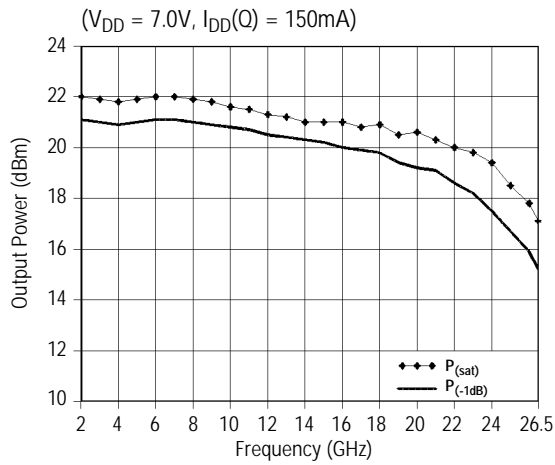
<sup>[1]</sup>Data Obtained from on-wafer measurements.



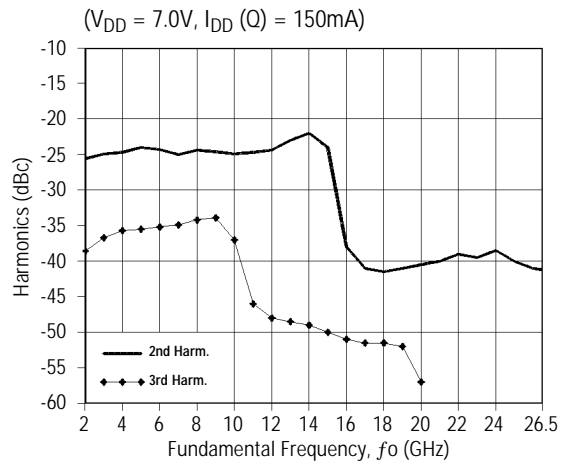
**Figure 6.**  
Typical Small-Signal Gain  
vs. Temperature



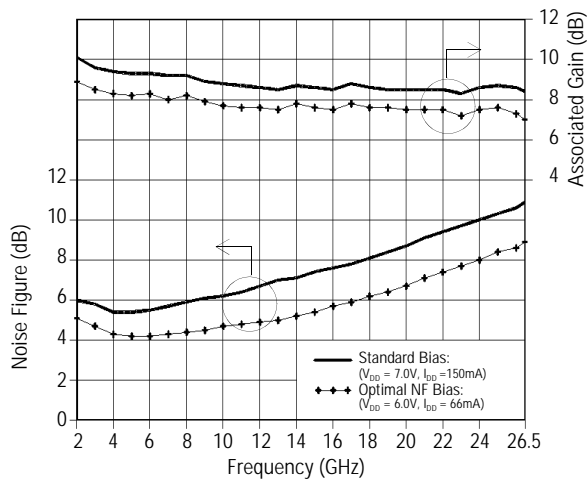
**Figure 7.**  
Typical Gain  
vs. Second Gate Control Voltage



**Figure 8.**  
Typical 1 dB Gain Compression  
and Saturated Output Power



**Figure 9.**  
Typical Second and Third  
Harmonics vs. Fundamental  
Frequency at  $P_{out} = +17$  dBm



**Figure 10.**  
Typical Noise Figure  
Performance

Notes:

All data measured on individual devices mounted in an 83040 Series Modular Microcircuit Package @  $T_A = 25^\circ C$  (except where noted).

This data sheet contains a variety of typical and guaranteed performance data. The information supplied should not be interpreted as a complete list of circuit specifications. In this data sheet the term *typical* refers to the 50th percentile performance. For additional information contact your local Agilent Technologies' sales representative.

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