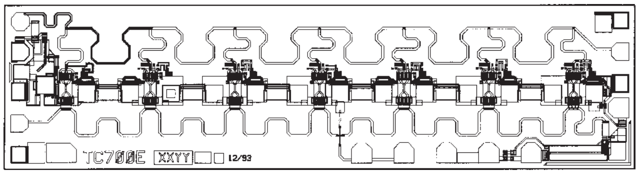
Avago HMMC-5021 (2–22 GHz), HMMC-5026 (2–26.5 GHz)

GaAs MMIC Traveling Wave Amplifiers

AVAGO TECHNOLOGIES

Data Sheet



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

Description

The HMMC-5021/26 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 MESFET cascode stages provide a flat gain response, making the HMMC-5021/26 an ideal wideband gain block. Optical lithography is used to produce gate lengths of ≈0.4 µm. The HMMC-5021/26 incorporates advanced MBE technology, Ti-Pt-Au gate metallization, silicon nitride passivation, and polyimide for scratch protection.

Absolute Maximum Ratings[1]

Symbol	Parameters/Conditions	Units	Min.	Max.
V_{DD}	Positive Drain Voltage	V		8.0
I_{DD}	Total Drain Current	mA		250
V_{G1}	First Gate Voltage	V	-5	0
I_{G1}	First Gate Current	mA	-9	+5
V_{G2}[2]	Second Gate Voltage	V	-2.5	+3.5
I_{G2}	Second Gate Current	mA	-7	
P_{DC}	DC Power Dissipation	watts		2.0
P_{in}	CW Input Power	dBm		23
T_{ch}	Operating Channel Temp.	°C		+150
T_{case}	Operating Case Temp.	°C	-55	
T_{stg}	Storage Temperature	°C	-65	+165
T_{max}	Max. Assembly Temp. (for 60 seconds max.)	°C		300

Notes:
1. Operation in excess of any one of these conditions may result in permanent damage to this device. T_A = 25°C except for T_{ch}, T_{STG}, and T_{max}.
2. Minimum voltage on V_{G2} must not violate the following: V_{G2}(min) > V_{DD} - 9 volts.

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_{-1dB}: 18 dBm
  P_{sat}: 20 dBm
  26.5 GHz: P_{-1dB}: 15 dBm
  P_{sat}: 17 dBm

DC Specifications/Physical Properties[1] (Applies to all part numbers)

Symbol	Parameters and Test Conditions	Units	Min.	Typ.	Max.
I_{DSS}	Saturated Drain Current (V_{DD} = 7.0 V, V_{G1} = 0 V, V_{G2} = open circut)	mA	115	180	250
V_p	First Gate Pinch-Off Voltage (V_{DD} = 7.0 V, I_{DD} = 16 mA, V_{G2} = open circut)	V	-3.5	-1.5	-0.5
V_{G2}	Secong Gate Self-Bias Voltage (V_{DD} = 7.0 V, V_{G1} = 0 V)	V		2.1	
I_{DSOFF}	First Gate Pinch-Off Current (V_{DD} = 7.0V, V_{G1} = -3.5V, V_{G2} = open circut)	mA		4	
I_{DSOFF}	Second Gate Pinch-Off Current (V_{DD} = 5.0 V, V_{G1} = 0 V, V_{G2} = -3.5V)	mA		8	
$\theta_{ch\text{-}bs}$	Thermal Resistance ($T_{backside}$ = 25°C)	°C/W		36	

Notes:
1. Measured in wafer form withT_{chuck} = 25°C. (Except $\theta_{ch\text{-}bs}$.)

HMMC-5021, -5026 RF Specifications, V_{DD} = 7.0 V, I_{DD}(Q) = 150 mA, Z_{in} = Z_o = 50 Ω[1]

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

Notes:
1. Small-signal data measured in wafer form with T_{chuck} = 25°C. Large-signal data measured on individual devices mounted in an HP83040 Series Modular Microcircuit Package @ T_A = 25°C.
2. 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-5021/26 series of traveling wave amplifiers are designed for use as general purpose wideband gain blocks in commu-nication systems and microwave instrumentation. They are ideally suited for broadband applications requiring a flat gain re-sponse and excellent port matches over a 2 to 26.5 GHz frequency range. Dynamic gain control and low-frequency extension capabilities are de-signed 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-5021/26 are V_{DD} = 7.0V, I_{DD} = 150 mA for best overall performance. To achieve this drain current level, V_{G1} is typi-cally 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-5021/26 is a DC coupled amplifier. External cou-pling 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 con-tacts are provided when perfor-mance below 1 GHz in 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 ≈ +2.1V. Applying an external bias be-tween 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 consid-erations, die attach and bonding methods are critical factors in successful GaAs MMIC perfor-mance and reliability. Avago application note #54, "GaAs MMIC ESD, Die Attach and Bonding Guidelines" provides basic infor-mation 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," AN# 47, "HMMC-5021/22/26 2–26.5 GHz GaAs MMIC Distributed Amplifier Conversion Guide," and AN# 1053, "Designing with HMMC-5021/22/26 and HMMC-5027 GaAs MMIC Amplifiers."

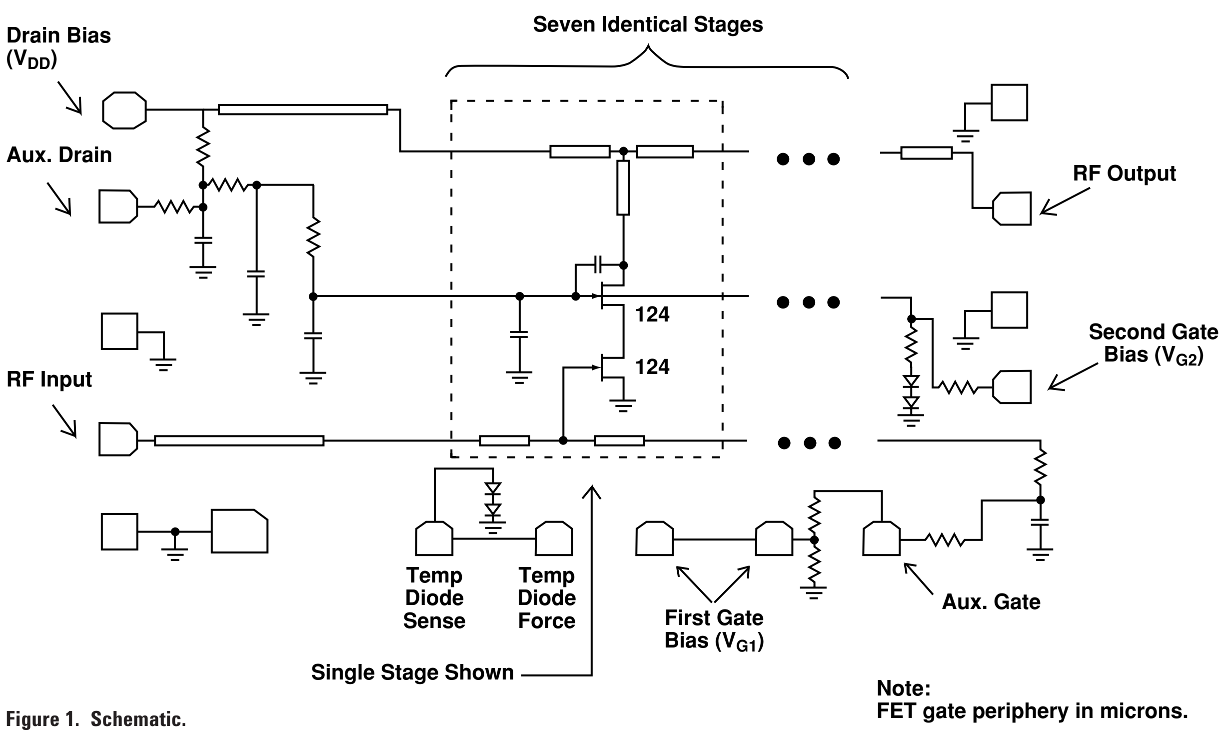
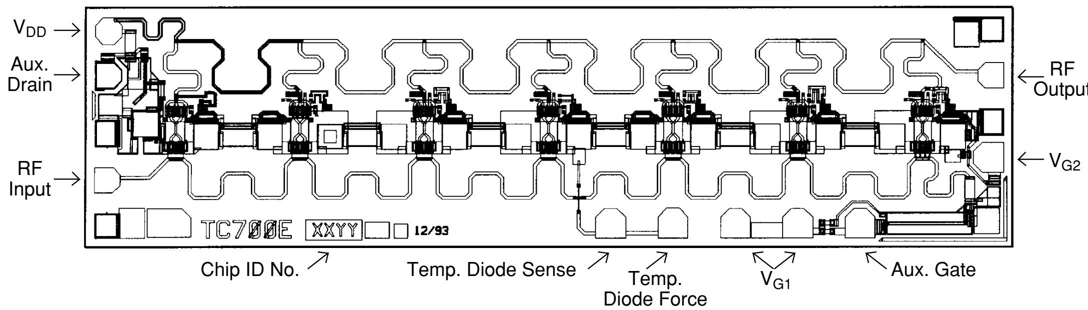
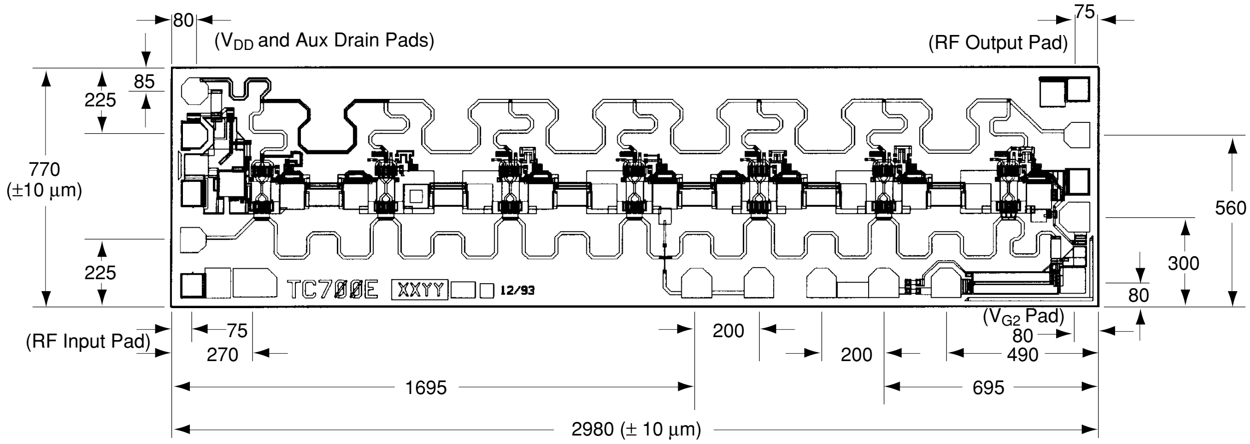


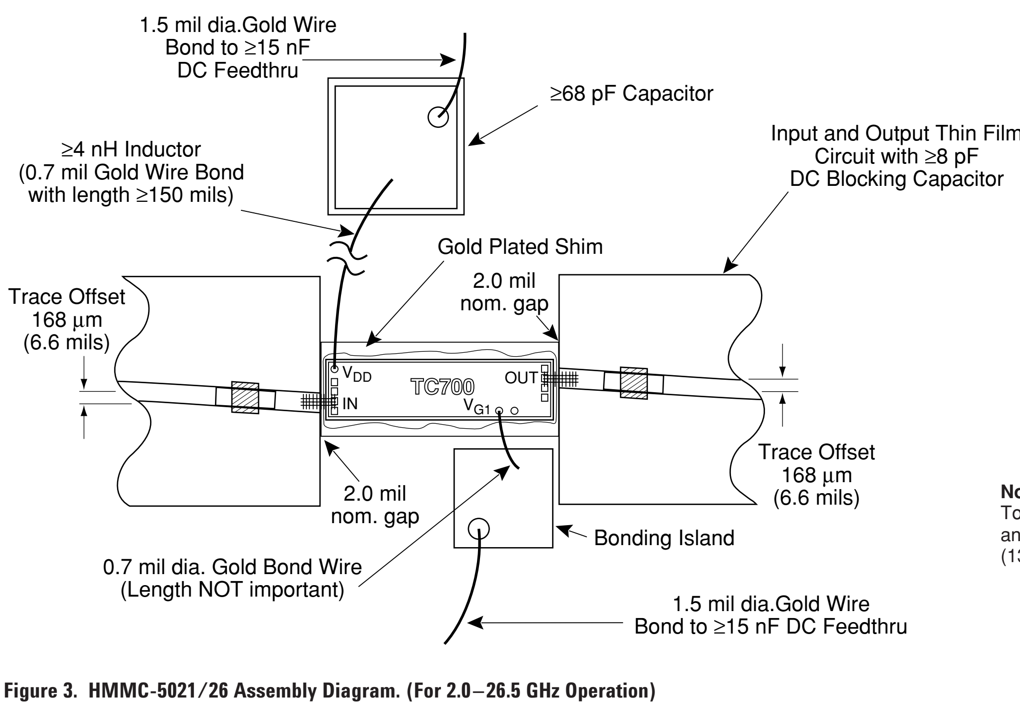
Figure 1. Schematic.





Notes:
All dimensions in microns.
Rectangular Pad Dim: 75 x 75 µm.
Octagonal Pad Dim: 90 µm dia.
All other dimensions ±5 µm
(unless otherwise noted).
Chip thickness: 127 ± 15 µm.

Figure 2. HMMC-5021/26 Bonding Pad Locations.



Note:
Total offset between RF input and RF output pad is 335 µm (13.2 mils).

Figure 3. HMMC-5021/26 Assembly Diagram. (For 2.0–26.5 GHz Operation)

HMMC-5021/26 Typical Performance

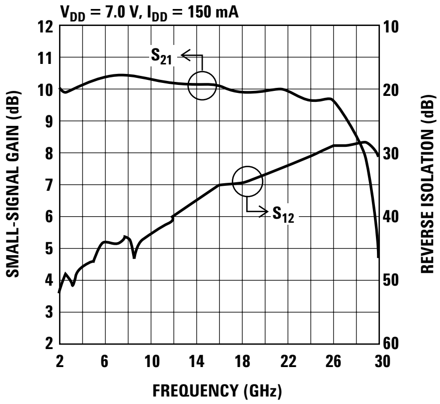


Figure 4. Typical Gain and Reverse Isolation vs. Frequency.

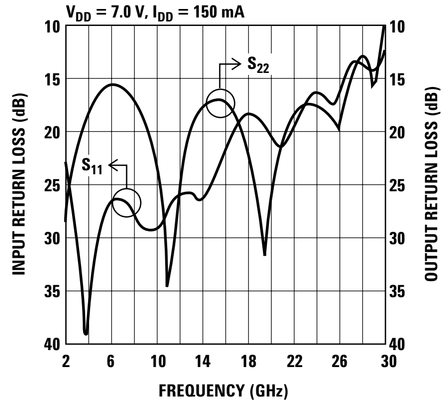


Figure 5. Typical Input and Output Return Loss vs. Frequency.

Typical Scattering Parameters[1], (T_{chuck} = 25°C, V_{DD} = 7.0 V, I_{DD} = 150 mA, Z_{in} = Z_{out} = 50Ω

Freq.		S_{11}			S_{21}			S_{12}			S_{22}	
GHz	**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

Note:

1. Data obtained from on-wafer measurements.

HMMC-5021/26 Typical Temperature Performance

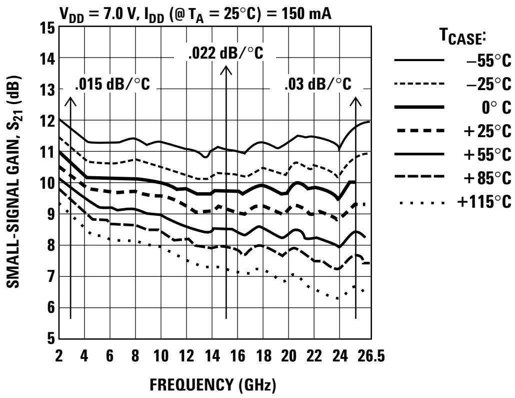


Figure 6. Typical Small-Signal Gain vs. Temperature.

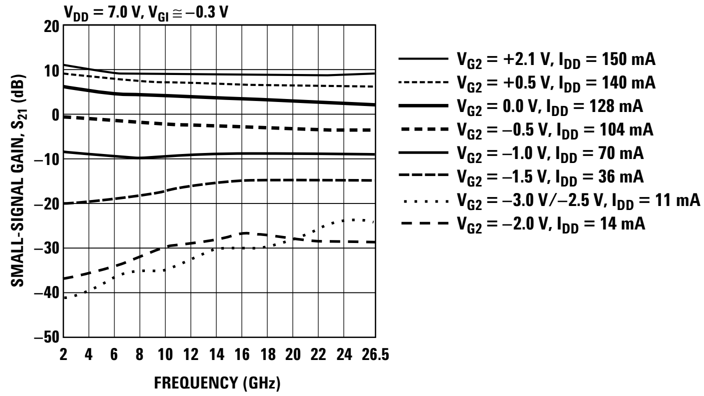


Figure 7. Typical Gain vs. Second Gate Control Voltage.

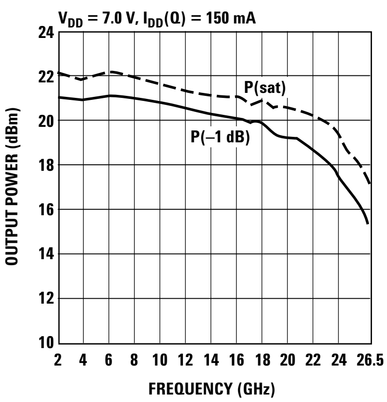


Figure 8. Typical 1 dB Gain Compression and Saturated Output Power.

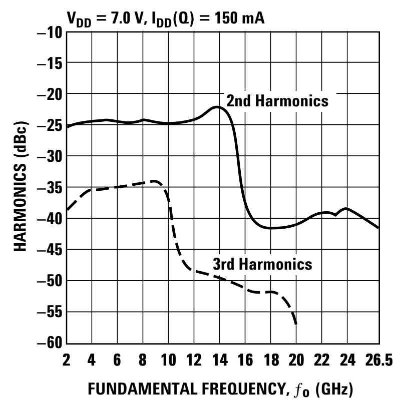


Figure 9. Typical Second and Third Harmonics vs. Fundamental Frequency at P_{OUT} = +17 dBm.

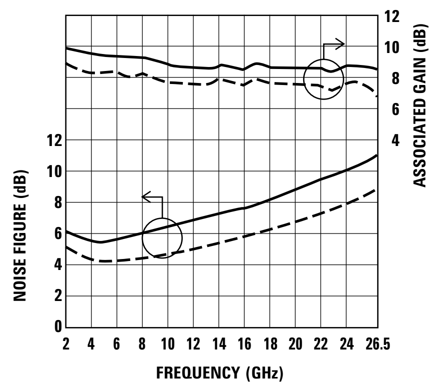


Figure 10. Typical Noise Figure Performance.

Standard Bias: V_{DD} = 7.0 V, I_{DD} = 150 mA
Optimal NF Bias: V_{DD} = 6.0 V, I_{DD} = 66 mA

Note:

1. **All data measured on individual devices mounted in an HP83040 Series Modular Microcircuit Package @ T_A = 25°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 Avago Technologies' sales representative.

For product information and a complete list of distributors, please go to our web site:
www.avagotech.com

Obsoletes 5965-5449E
5988-1893EN March 12, 2007