HEWLETT® PACKARD

2–26.5 GHz GaAs MMIC Traveling Wave Amplifier

Technical Data

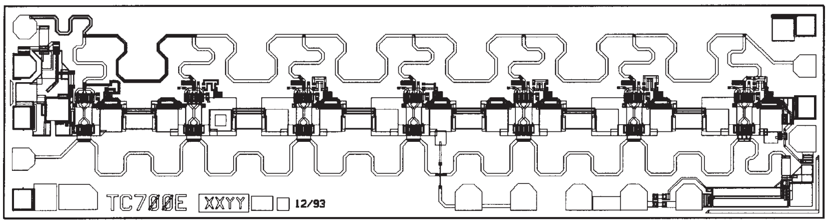
HMMC-5021 (2-22 GHz)
HMMC-5022 (2-22 GHZ)
HMMC-5026 (2-26.5 GHz)

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

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 MESFET 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.



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 75 µm (2.95 x 2.95 mils), or larger

Absolute Maximum Ratings

Symbol	Parameters/Conditions	Units	Min.	Max.[1]
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}	Maximum Assembly Temp. (for 60 seconds maximum)	°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.

HMMC-5021/22/26 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 circuit)	mA	115	180	250
V_p	First Gate Pinch-off Voltage (V_{DD} = 7.0 V, I_{DD} = 16 mA, V_{G2} = open circuit)	V	-3.5	-1.5	-0.5
V_{G2}	Second Gate Self-Bias Voltage (V_{DD} = 7.0 V, V_{G1} = 0 V)	V		2.1	
I_{DSOFF} (V_{G1})	First Gate Pinch-off Current (V_{DD} = 7.0 V, V_{G1} = -3.5 V, V_{G2} = open circuit)	mA		4	
I_{DSOFF} (V_{G2})	Second Gate Pinch-Off Current (V_{DD} = 5.0 V, V_{G1} = 0 V, V_{G2} = -3.5 V)	mA		8	
θ_{ch-bs}	Thermal Resistance ($T_{backside}$ = 25°C)	°C/W		36	

Note:
1. Measured in wafer form with T_{chuck} = 25°C. (Except θ_{ch-bs}.)

HMMC-5021/22/26 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				2.0–26.5 GHz		
			HMMC-5021	HMMC-5022			HMMC-5026		
			Typ.	Min.	Typ.	Max.	Min.	Typ.	Max.
BW	Guaranteed Bandwidth	GHz	2-22	2		22	2		26.5
S_{21}	Small Signal Gain	dB	10	8.0	10	12	7.5	9.5	12
ΔS_{21}	Small Signal Gain Flatness	dB	± 0.5		± 0.5	± 1.0		± 0.75	± 1.0
$RL_{in(min)}$	Minimum Input Return Loss	dB	16	10	16		10	14	
$RL_{out(min)}$	Minimum Output Return Loss	dB	13	10	13		10	13	
Isolation	Minimum Reverse Isolation	dB	32	20	32		20	30	
P_{-1dB}	Output Power at 1 dB Gain Comp.	dBm	18	15	18		12	15	
P_{sat}	Saturated Output Power	dBm	20	17	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		-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		-34	-20
NF	Noise Figure	dB	8		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-5021/22/26 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} = 150 mA 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 auxiliary gate and drain contacts are used only for low-frequency performance extension below ≈ 1.0 GHz. When used, these contacts must be AC coupled only. (Do not attempt to 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 ≈ +2.1 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

Solder die-attach using a fluxless AuSu solder preform is the recommended assembly method. Gold thermosonic wedge bonding with 0.7 mil diameter Au wire is recommended for all bonds. Tool force should be 22 ± 1 gram, stage temperature should be 150 ± 2°C, and ultrasonic power and duration should be 64 ± 1 dB and 76 ± 8 msec, respectively. The bonding pad and chip backside metallization is gold.

For more detailed information see HP application note #999, "GaAs MMIC Assembly and Handling Guidelines."

GaAs MMICs are ESD sensitive. Proper precautions should be used when handling these devices.

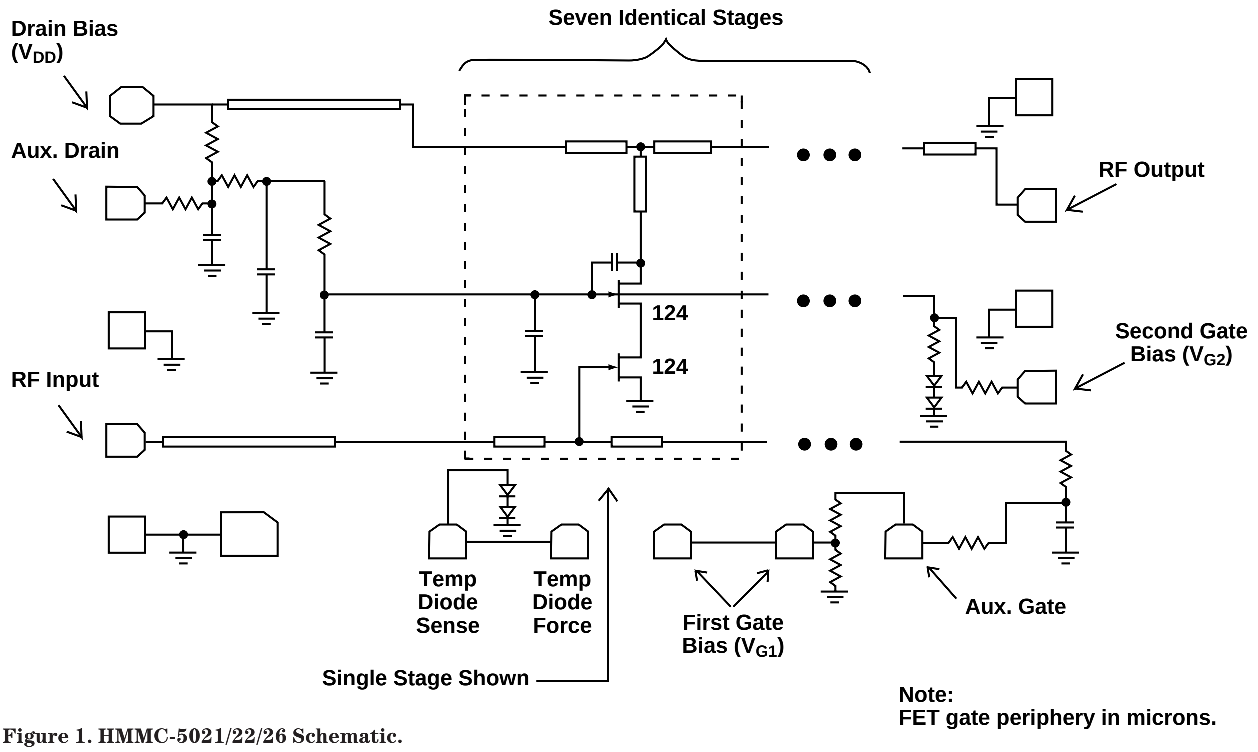


Figure 1. HMMC-5021/22/26 Schematic.

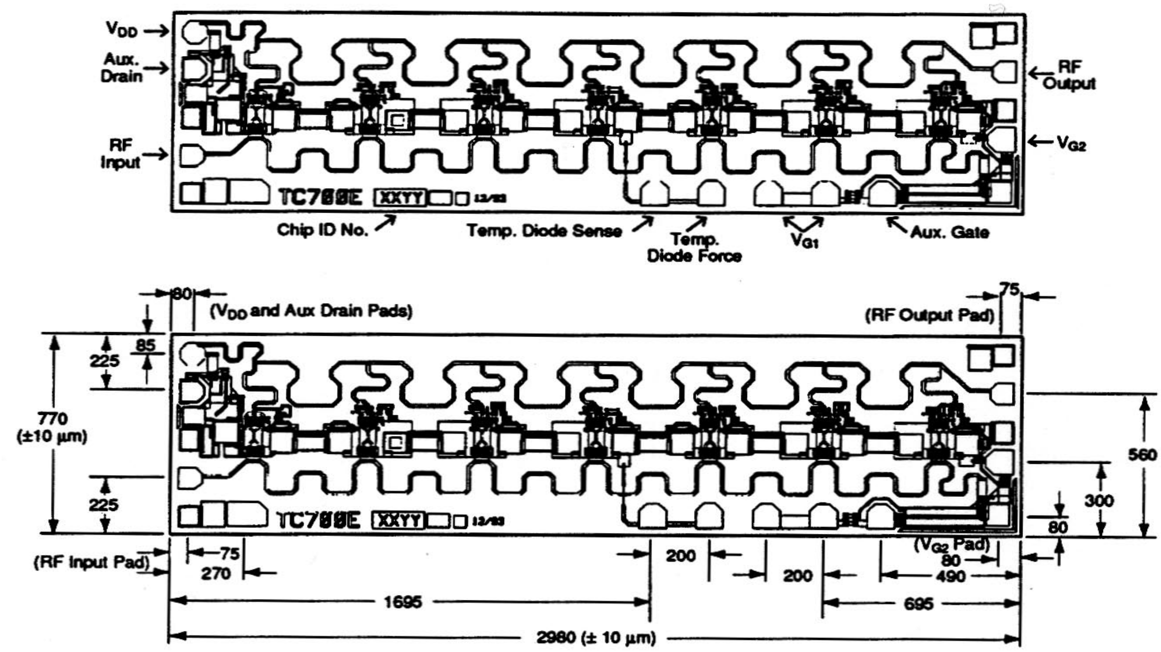
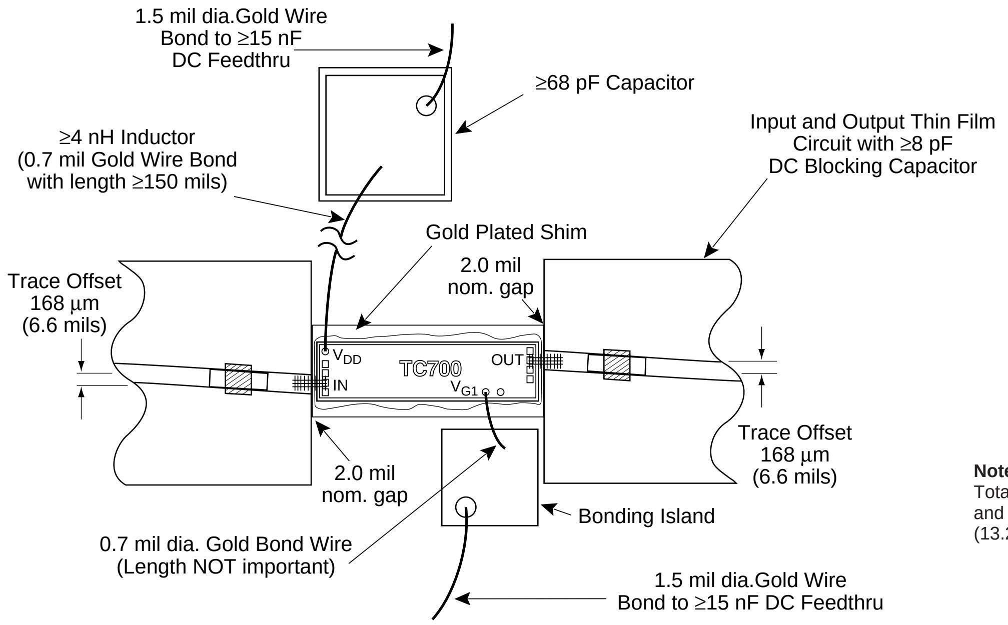


Figure 2. HMMC-5021/22/26 Bonding Pad Locations.

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.



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

Figure 3. HMMC-5021/22/26 Assembly Diagram.

HMMC-5021/22/26 Typical Performance

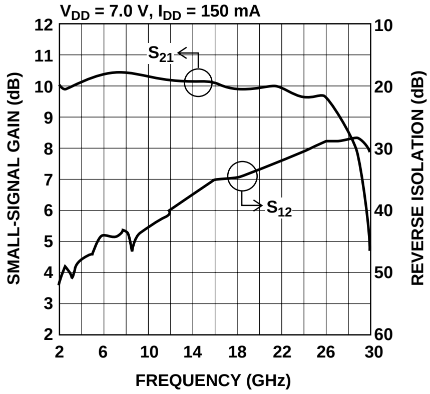


Figure 4. Typical Gain and Reverse Isolation vs. Frequency.

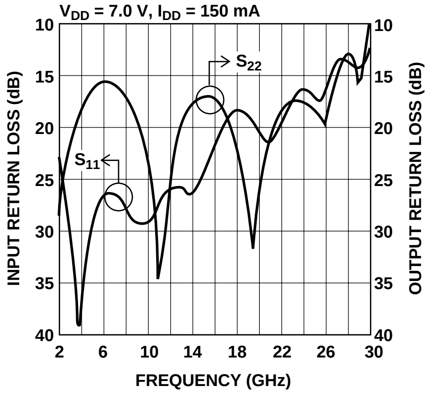


Figure 5. Typical Input and Output Return Loss vs. Frequency.

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

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-5021/22/26 Typical Temperature Performance

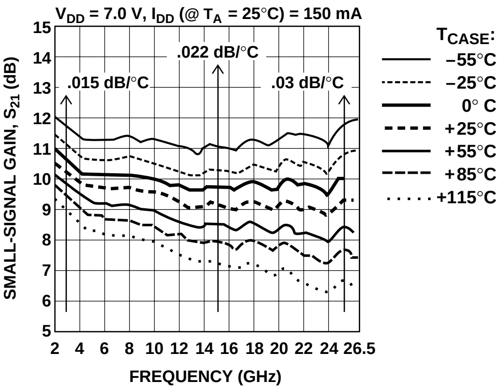


Figure 6. Typical Small-Signal Gain vs. Temperature.

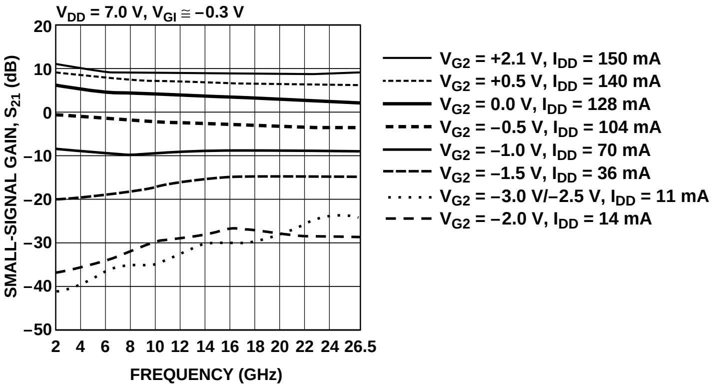


Figure 7. Typical Gain vs. Second Gate Control Voltage.

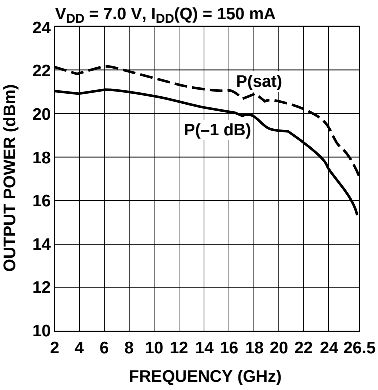


Figure 8. Typical 1 dB Gain Compression and Saturated Output Power.

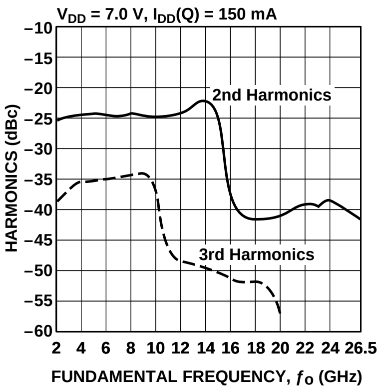


Figure 9. Typical Second and Third Harmonics vs. Fundamental Frequency at P_{OUT} = +17 dBm.

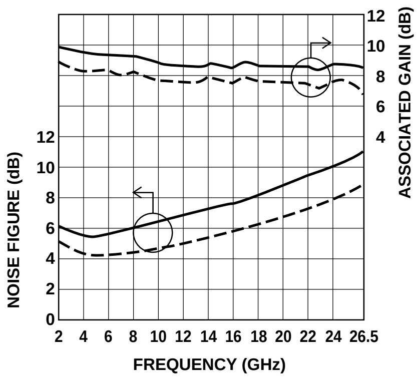


Figure 10. Typical Noise Figure Performance.

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 HP sales representative.