

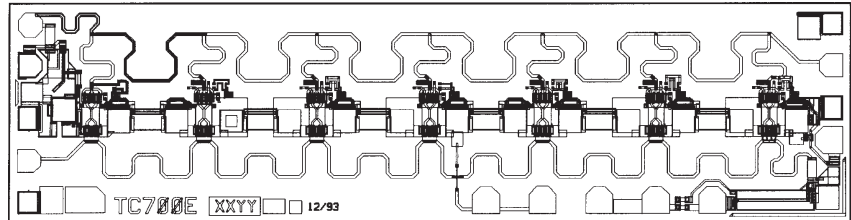
2–26.5 GHz GaAs MMIC Traveling Wave Amplifier

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



Chip Size: 2980 x 770 μm (117.3 x 30.3 mils)
 Chip Size Tolerance: $\pm 10 \mu\text{m}$ (± 0.4 mils)
 Chip Thickness: $127 \pm 15 \mu\text{m}$ (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. | $^{\circ}\text{C}$ | | +150 |
| T_{case} | Operating Case Temp. | $^{\circ}\text{C}$ | -55 | |
| T_{STG} | Storage Temperature | $^{\circ}\text{C}$ | -65 | +165 |
| T_{max} | Maximum Assembly Temp. (for 60 seconds maximum) | $^{\circ}\text{C}$ | | +300 |

Notes:

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

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 $\approx 0.4 \mu\text{m}$. The HMMC-5021/22/26 incorporates advanced MBE technology, Ti-Pt-Au gate metallization, silicon nitride passivation, and polyimide for scratch protection.

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 _D SOFF (V _{G1}) | First Gate Pinch-off Current (V _{DD} = 7.0 V, V _{G1} = -3.5 V, V _{G2} = open circuit) | mA | | 4 | |
| I _D SOFF (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 $V_{DD} = 7.0V$, $I_{DD} = 150\text{ mA}$ 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 auxiliary gate and drain contacts are used only for low-frequency performance extension below $\approx 1.0\text{ GHz}$. 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 $\approx +2.1\text{ V}$.

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 $22 \pm 1\text{ gram}$, stage temperature should be $150 \pm 2^\circ\text{C}$, and ultrasonic power and duration should be $64 \pm 1\text{ dB}$ and $76 \pm 8\text{ msec}$, 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.

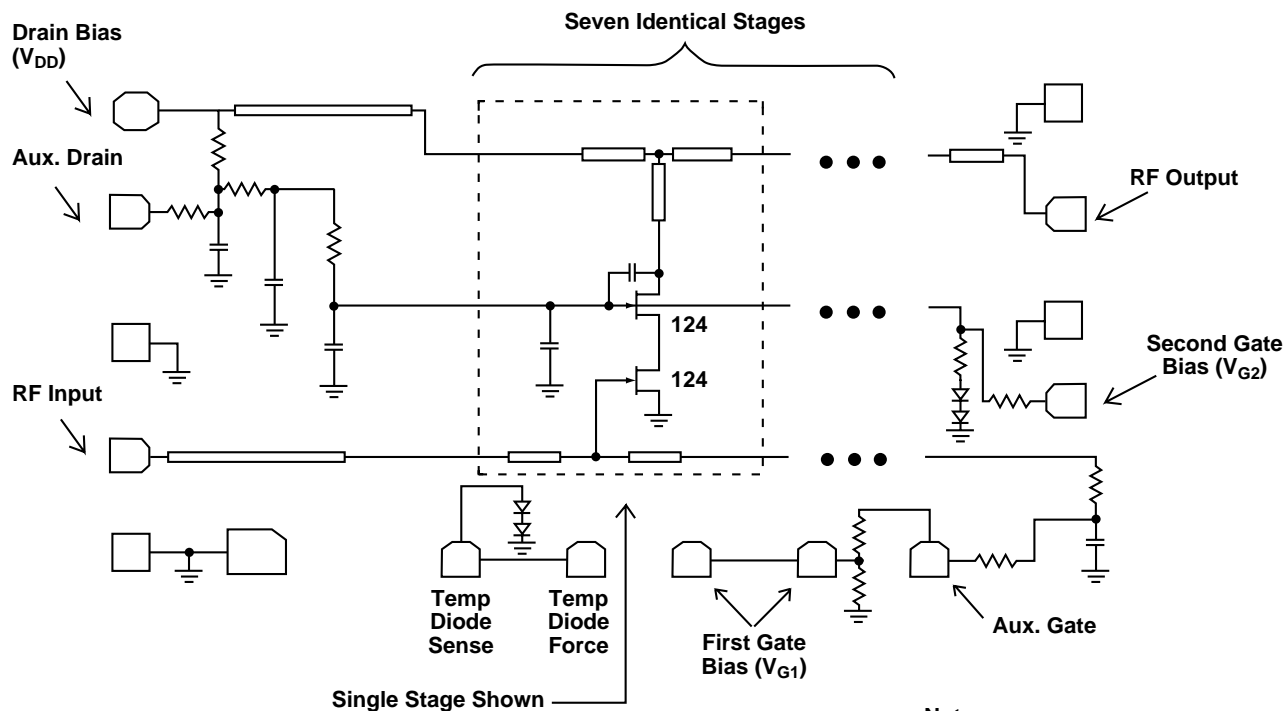


Figure 1. HMMC-5021/22/26 Schematic.

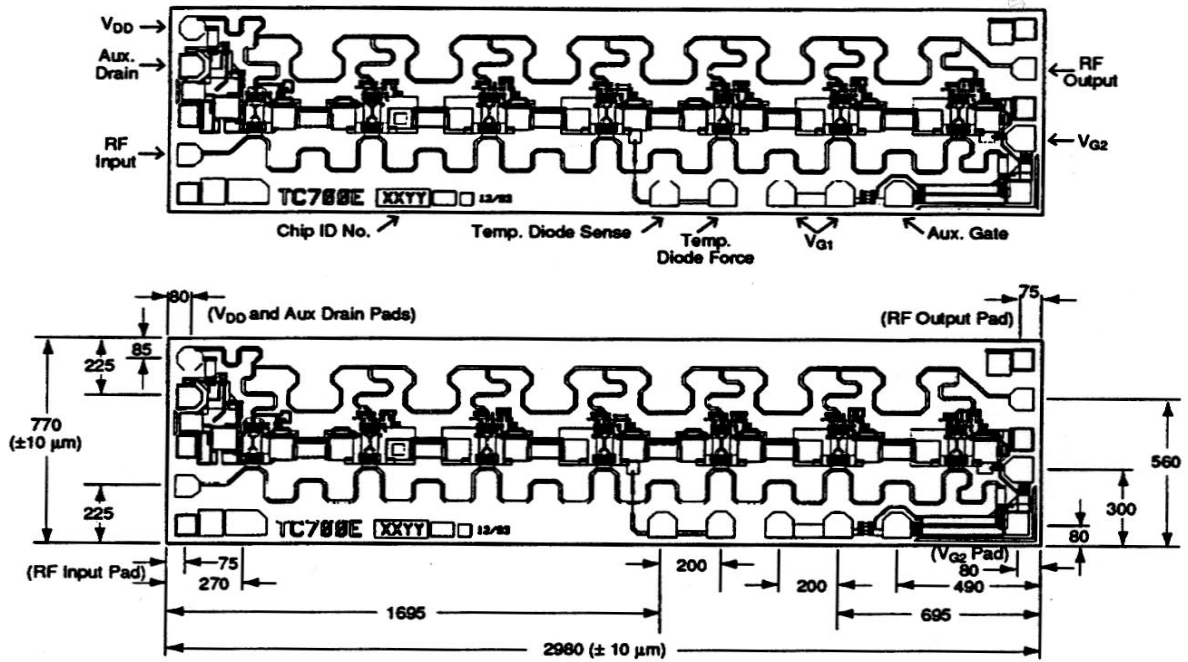
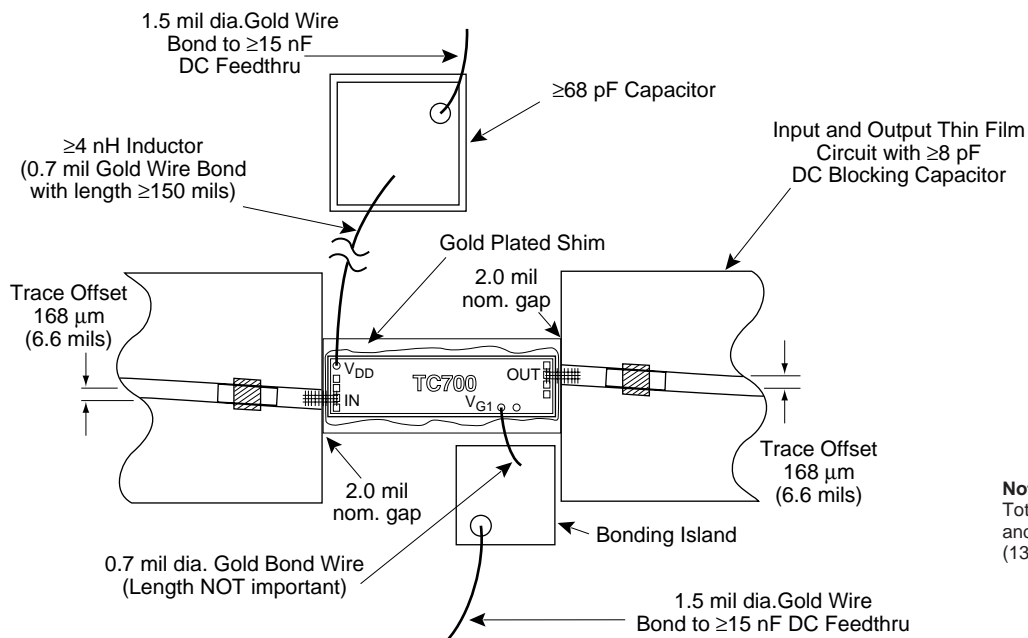


Figure 2. HMMC-5021/22/26 Bonding Pad Locations.

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



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

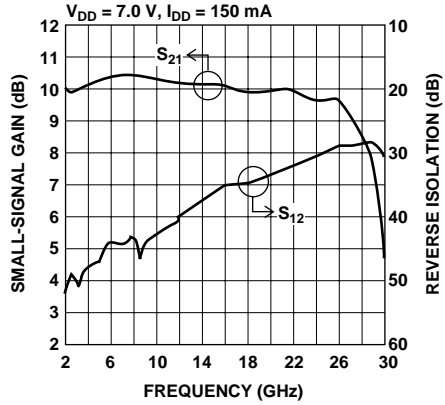


Figure 4. Typical Gain and Reverse Isolation vs. Frequency.

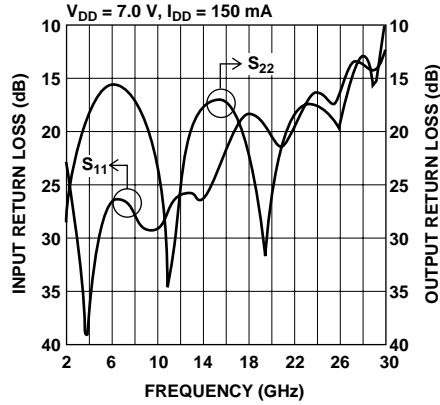


Figure 5. Typical Input and Output Return Loss vs. Frequency.

Typical Scattering Parameters^[1], ($T_{\text{chuck}} = 25^{\circ}\text{C}$, $V_{\text{DD}} = 7.0\text{ V}$, $I_{\text{DD}} = 150\text{ mA}$, $Z_{\text{in}} = Z_{\text{out}} = 50\ \Omega$)

| Freq. GHz | S_{11} | | | S_{21} | | | S_{12} | | | S_{22} | | |
|--------------|----------|-------|--------|----------|--------|--------|----------|-------|--------|----------|-------|--------|
| | 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

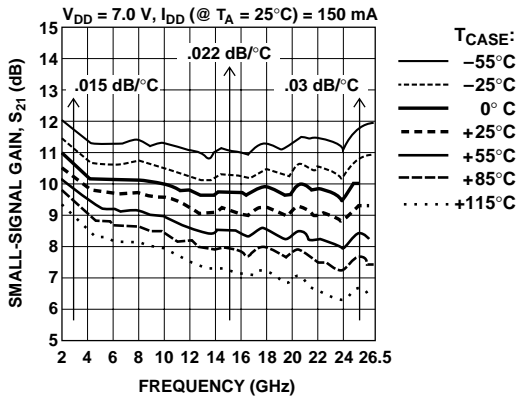


Figure 6. Typical Small-Signal Gain vs. Temperature.

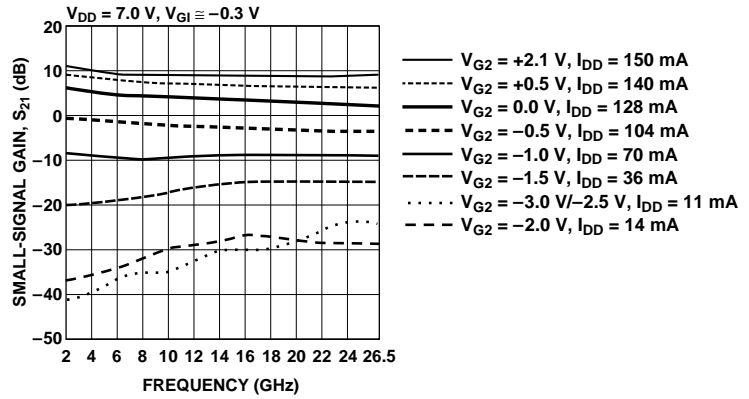


Figure 7. Typical Gain vs. Second Gate Control Voltage.

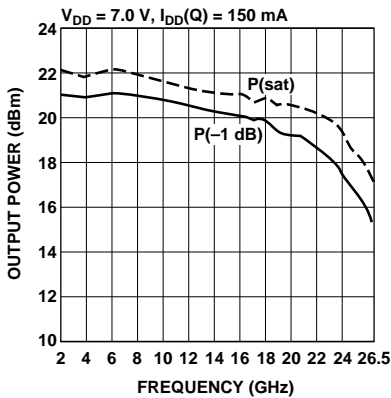


Figure 8. Typical 1 dB Gain Compression and Saturated Output Power.

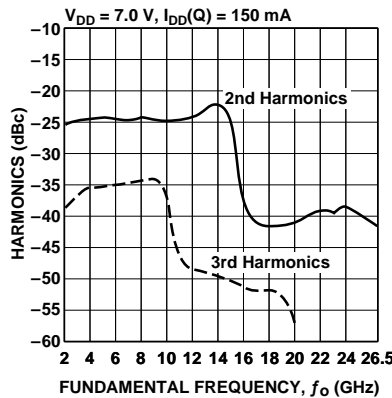


Figure 9. Typical Second and Third Harmonics vs. Fundamental Frequency at P_{OUT} = +17 dBm.

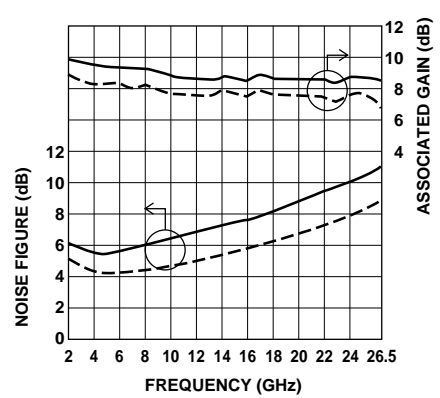


Figure 10. Typical Noise Figure Performance.
 — Standard Bias: V_{DD} = 7.0 V, I_{DD} = 150 mA
 - - - Optimal NF Bias: V_{DD} = 6.0 V, I_{DD} = 66 mA

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.