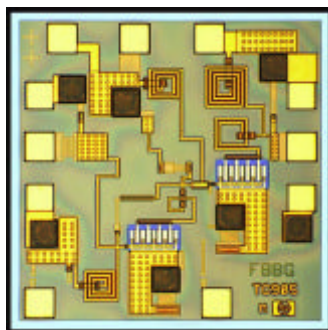




# Agilent HMMC-5618

## 6-20 GHz Medium Power Amplifier

### Data Sheet



Chip Size:  $920 \times 920 \mu\text{m}$  ( $36.2 \times 36.2$  mils)  
 Chip Size Tolerance:  $\pm 10 \mu\text{m}$  ( $\pm 0.4$  mils)  
 Chip Thickness:  $127 \pm 15 \mu\text{m}$  ( $5.0 \pm 0.6$  mils)  
 Pad Dimensions:  $80 \times 80 \mu\text{m}$  ( $3.2 \times 3.2$  mils)

### Features

- High Efficiency:  
11% @  $P_{-1\text{dB}}$  Typical
- Output Power,  $P_{-1\text{dB}}$ :  
18 dBm Typical
- High Gain:  
14 dB Typical
- Flat Gain Response:  
 $\pm 0.5$  dB Typical
- Low Input/Output VSWR:  
<1.7:1 Typical
- Single Supply Bias:  
5 volts (@ 115 mA typ.)  
with Optional Gate Bias

### Description

The HMMC-5618 6-20 GHz MMIC is an efficient two-stage medium-power amplifier that is designed to be used as a cascadable intermediate gain block for EW applications. In communication systems, it can be used as an amplifier for a local oscillator or as a transmit amplifier. It is fabricated using a PHEMT integrated circuit structure that provides exceptional efficiency and flat gain performance. During typical operation, with a single 5-volt DC power supply, each gain stage is biased for Class-A operation for optimal power output with minimal distortion. The RF input and RF output has matching circuitry for use in 50 ohm environments.

The backside of the chip is both RF and DC ground. This helps simplify the assembly process and reduces assembly related performance variations and costs.

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

| Symbol           | Parameters/Conditions              | Min. | Max. | Units |
|------------------|------------------------------------|------|------|-------|
| $V_{D1}, V_{D2}$ | Drain Supply Voltage               |      | 5.5  | Volts |
| $V_{G1}$         | Optional Gate Supply Voltage       | -5   | +1   | Volts |
| $V_{G2}$         | Optional Gate Supply Voltage       | -10  | +1   | Volts |
| $I_{D1}$         | Drain Supply Current               |      | 70   | mA    |
| $I_{D2}$         | Drain Supply Current               |      | 84   | mA    |
| $P_{in}$         | RF Input Power <sup>[2]</sup>      |      | 20   | dBm   |
| $T_{ch}$         | Channel Temperature <sup>[3]</sup> |      | 160  | °C    |
| $T_A$            | Backside Ambient Temperature       | -55  | +100 | °C    |
| $T_{st}$         | Storage Temperature                | -65  | +150 | °C    |
| $T_{max}$        | Max. Assembly Temperature          |      | 300  | °C    |

<sup>[1]</sup>Absolute maximum ratings for continuous operation unless otherwise noted.

<sup>[2]</sup>Operating at this power level for extended (continuous) periods is not recommended.

<sup>[3]</sup>Refer to DC Specifications/Physical Properties table for de-rating information.



## DC Specifications/Physical Properties<sup>[1]</sup>

| Symbol            | Parameters/Conditions                                                                                                                               | Min. | Typ. | Max. | Units                        |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------------------------------|
| $V_{D1}, V_{D2}$  | Drain Supply Voltage                                                                                                                                | 3.0  | 5.0  | 5.5  | Volts                        |
| $I_{D1}$          | Stage-One Drain Supply Current<br>( $V_{D1} = 5V$ , $V_{G1} = \text{Open or Ground}$ )                                                              |      | 50   |      | mA                           |
| $I_{D2}$          | Stage-Two Drain Supply Current<br>( $V_{D2} = 5V$ , $V_{G2} = \text{Open or Ground}$ )                                                              |      | 65   |      | mA                           |
| $I_{D1} + I_{D2}$ | Total Drain Supply Current<br>( $V_{D1} = V_{D2} = 5V$ , $V_{G1} = V_{G2} = \text{Open or Ground}$ )                                                |      | 115  | 140  | mA                           |
| $V_{P1}$          | Optional Input-Stage Gate Supply Pinch-off Voltage<br>( $V_{D1} = 5V$ , $I_{D1} < 3 \text{ mA}$ : Input Stage OFF <sup>[2]</sup> )                  | -4   | -2.8 |      | Volts                        |
| $I_{G1}$          | Gate Supply Current (Input Stage OFF <sup>[2]</sup> )                                                                                               |      | 0.9  |      | mA                           |
| $V_{P2}$          | Optional Output-Stage Gate Supply Pinch-off Voltage<br>( $V_{D2} = 5V$ , $I_{D2} < 3.6 \text{ mA}$ : Output Stage OFF <sup>[2]</sup> )              | -7.5 | -5.3 |      | Volts                        |
| $I_{G2}$          | Gate Supply Current (Output Stage OFF <sup>[2]</sup> )                                                                                              |      | 1.7  |      | mA                           |
| $\theta_{ch-bs}$  | Thermal Resistance <sup>[3]</sup><br>(Channel-to-Backside at $T_{ch} = 150^\circ\text{C}$ )                                                         |      | 87   |      | $^\circ\text{C}/\text{Watt}$ |
| $T_{ch}$          | Channel Temperature <sup>[4]</sup> ( $T_A = 100^\circ\text{C}$ , MTTF = $10^6$ hrs,<br>( $V_{D1} = V_{D2} = 5V$ , $V_{G1} = V_{G2} = \text{Open}$ ) |      | 150  |      | $^\circ\text{C}$             |

<sup>[1]</sup>Backside ambient operating temperature  $T_A = 25^\circ\text{C}$  unless otherwise noted.

<sup>[2]</sup>The specified FET stage is in the OFF state when biased with a gate voltage level that is sufficient to pinch off the drain current.

<sup>[3]</sup>Thermal resistance (in  $^\circ\text{C}/\text{Watt}$ ) at a channel temperature  $T(^\circ\text{C})$  can be *estimated* using the equation:

$$\theta(T) \approx 87 \times [T(^\circ\text{C}) + 273] / [150^\circ\text{C} + 273].$$

<sup>[4]</sup>De-rate MTTF by a factor of two for every  $8^\circ\text{C}$  above  $T_{ch}$ .

## RF Specifications

( $T_A = 25^\circ\text{C}$ ,  $V_{D1} = V_{D2} = 5V$ ,  $V_{G1} = V_{G2} = \text{Open or Ground}$ ,  $Z_0 = 50\Omega$ )

| Symbol                   | Parameters/Conditions                                   | Typ.      | 6-18 GHz |      | 5.9-20 GHz |      | Units                |
|--------------------------|---------------------------------------------------------|-----------|----------|------|------------|------|----------------------|
|                          |                                                         |           | Min.     | Max. | Min.       | Max. |                      |
| Gain                     | Small Signal Gain                                       | 14        | 12       |      | 11.5       |      | dB                   |
| $\Delta \text{Gain}$     | Gain flatness                                           | $\pm 0.5$ |          |      |            |      | dB                   |
| $\Delta S_{21}/\Delta T$ | Temperature Coefficient of Gain                         | -0.025    |          |      |            |      | dB/ $^\circ\text{C}$ |
| $(RL_{in})_{MIN}$        | Minimum Input Return Loss                               | 12        | 10       |      | 9          |      | dB                   |
| $(RL_{out})_{MIN}$       | Minimum Output Return Loss                              | 12        | 10       |      | 10         |      | dB                   |
| Isolation                | Reverse Isolation                                       | 40        |          |      |            |      | dB                   |
| $P_{-1dB}$               | Output Power<br>at 1dB Gain Compression                 | 18        | 17       |      | 17         |      | dBm                  |
| $P_{SAT}$                | Saturated Output Power<br>( $P_{in} = 10 \text{ dBm}$ ) | 20        | 18.5     |      | 18.5       |      | dBm                  |
| NF                       | Noise Figure                                            | 5.5       |          | 7    |            | 7    | dB                   |

## Applications

The HMMC-5618 is a GaAs MMIC medium-power amplifier designed for optimum Class-A efficiency and flat gain performance from 6 GHz to 20 GHz. It has applications as a cascadable gain stage for EW amplifier, buffer stages, LO-port driver, phased-array radar, and transmitter amplifiers used in commercial communication systems. The MMIC solution is a cost effective alternative to hybrid assemblies.

## Biasing and Operation

The MMIC amplifier is normally biased with a single positive drain supply connected to both  $V_{D1}$  and  $V_{D2}$  bond pads as shown in Figure 10. The recommended drain supply voltage is 3 to 5 volts. If desired, the first stage drain bonding pad can be biased separately to provide a small amount of gain slope control or bandwidth extension as demonstrated in Figure 2.

No ground wires are required because all ground connections are made with plated through-holes to the backside of the device.

Gate bias pads ( $V_{G1}$  and  $V_{G2}$ ) are also provided to allow adjustments in gain, RF output power,

and DC power dissipation, if necessary. No connection to the gate pads is needed for single drain-bias operation. However, for custom applications, the DC current flowing through the input and/or output gain stage may be adjusted by applying a voltage to the gate bias pad(s) as shown in Figure 10b. A negative gate-pad voltage will decrease the drain current. The gate-pad voltage is approximately zero volts during operation with no DC gate supply. Refer to the Absolute Maximum Ratings table for allowed DC and thermal conditions.

## Assembly Techniques

It is recommended that the RF input, RF output, and DC supply connections be made using 0.7 mil diameter gold wire. The device has been designed so that optimum performance is realized when the RF input and RF output bond-wire inductance is approximately 0.2 nH (0 mils) as demonstrated in Figures 4, 6, and 7.

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 #49, "HMMC-5618 (6-20 GHz) Amplifier" and PN #14, "HMMC-5618 Driven by an HMMC-5020."

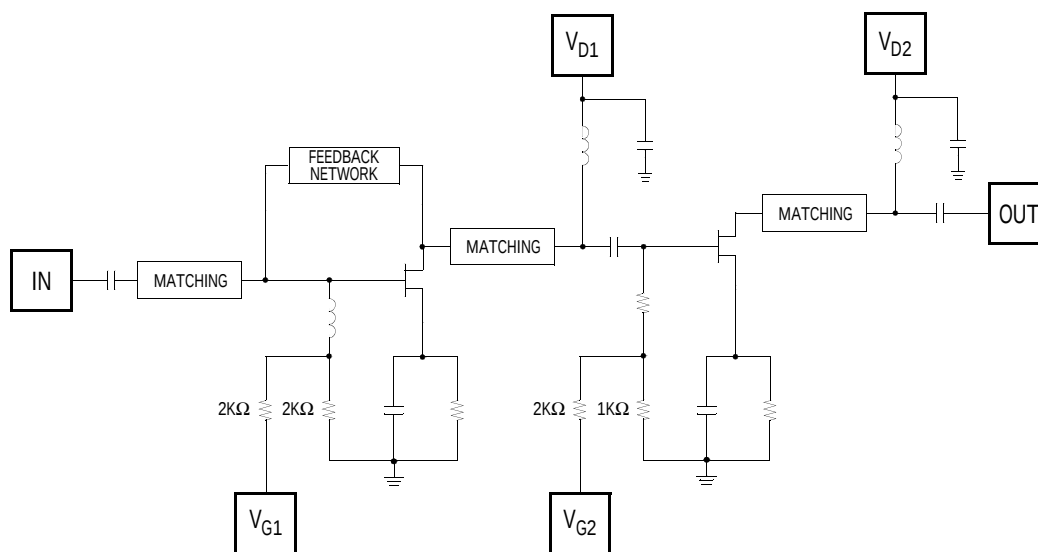


Figure 1.  
Simplified Schematic Diagram

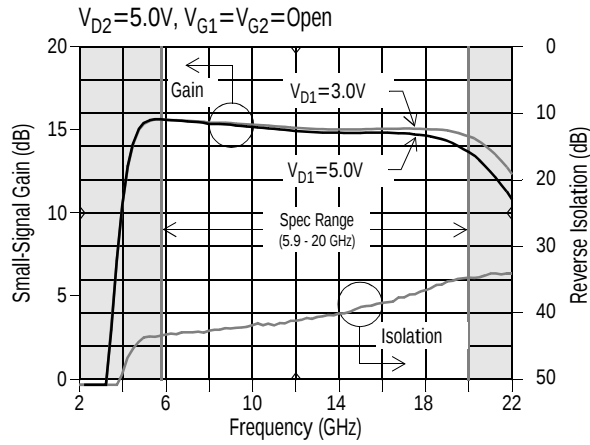


Figure 2.  
Gain and Isolation versus Frequency

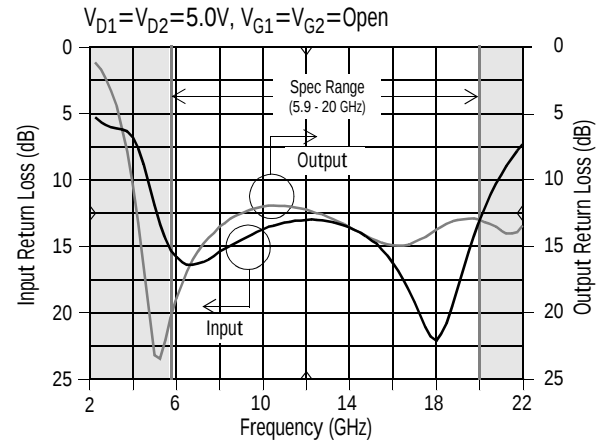


Figure 3.  
Input and Output Return Loss  
versus Frequency

### S-Parameters<sup>[1]</sup> ( $T_A = 25^\circ\text{C}$ , $V_{D1} = V_{D2} = 5.0\text{V}$ , $V_{G1} = V_{G2} = \text{Open}$ , $Z_0 = 50\Omega$ )

| Freq.<br>(GHz) | $S_{11}$ |       |        | $S_{12}$ |       |        | $S_{21}$ |        |        | $S_{22}$ |       |        |
|----------------|----------|-------|--------|----------|-------|--------|----------|--------|--------|----------|-------|--------|
|                | dB       | Mag   | Ang    | dB       | Mag   | Ang    | dB       | Mag    | Ang    | dB       | Mag   | Ang    |
| 2.0            | -4.8     | 0.574 | -140.8 | -71.2    | 0.000 | -73.5  | -43.0    | 0.0070 | 117.3  | -0.9     | 0.901 | -75.4  |
| 2.5            | -5.6     | 0.526 | -166.9 | -74.4    | 0.000 | -12.0  | -25.3    | 0.0544 | -113.7 | -1.6     | 0.835 | -99.7  |
| 3.0            | -6.0     | 0.501 | 166.4  | -73.6    | 0.000 | -41.3  | -8.0     | 0.3981 | -124.1 | -3.3     | 0.687 | -127.0 |
| 3.5            | -6.2     | 0.492 | 136.2  | -55.9    | 0.002 | -51.8  | 2.9      | 1.4008 | -159.1 | -6.1     | 0.498 | -156.7 |
| 4.0            | -6.7     | 0.461 | 99.3   | -49.4    | 0.003 | -94.9  | 10.4     | 3.3208 | 154.4  | -10.3    | 0.305 | 171.1  |
| 4.5            | -8.8     | 0.363 | 60.6   | -45.5    | 0.005 | -140.6 | 14.2     | 5.1331 | 104.5  | -16.7    | 0.147 | 133.8  |
| 5.0            | -11.9    | 0.255 | 30.7   | -43.8    | 0.006 | -179.4 | 15.4     | 5.9052 | 62.9   | -23.2    | 0.069 | 76.1   |
| 5.5            | -14.4    | 0.190 | 10.9   | -43.8    | 0.006 | 152.8  | 15.6     | 6.0539 | 31.6   | -22.0    | 0.079 | 21.3   |
| 6.0            | -15.8    | 0.163 | -3.8   | -43.4    | 0.007 | 132.6  | 15.6     | 6.0319 | 6.8    | -18.9    | 0.114 | -5.5   |
| 6.5            | -16.4    | 0.152 | -16.2  | -43.4    | 0.007 | 116.8  | 15.6     | 6.0062 | -14.1  | -16.8    | 0.144 | -19.6  |
| 7.0            | -16.3    | 0.153 | -27.4  | -43.1    | 0.007 | 101.8  | 15.5     | 5.9669 | -32.7  | -15.4    | 0.171 | -30.5  |
| 7.5            | -16.0    | 0.159 | -38.0  | -43.0    | 0.007 | 87.6   | 15.5     | 5.9318 | -49.7  | -14.3    | 0.193 | -39.4  |
| 8.0            | -15.4    | 0.171 | -48.2  | -42.8    | 0.007 | 79.1   | 15.4     | 5.8635 | -65.4  | -13.5    | 0.212 | -47.1  |
| 8.5            | -14.9    | 0.180 | -58.5  | -42.7    | 0.007 | 68.9   | 15.4     | 5.8567 | -80.0  | -12.9    | 0.227 | -54.4  |
| 9.0            | -14.5    | 0.189 | -67.5  | -42.5    | 0.008 | 58.9   | 15.3     | 5.8232 | -94.2  | -12.5    | 0.237 | -61.4  |
| 9.5            | -14.1    | 0.198 | -75.8  | -42.3    | 0.008 | 50.2   | 15.2     | 5.7757 | -107.8 | -12.2    | 0.246 | -67.8  |
| 10.0           | -13.7    | 0.206 | -83.6  | -42.0    | 0.008 | 41.0   | 15.2     | 5.7385 | -121.0 | -12.0    | 0.252 | -73.9  |
| 10.5           | -13.4    | 0.214 | -91.2  | -42.0    | 0.008 | 33.7   | 15.1     | 5.7043 | -133.8 | -11.9    | 0.254 | -79.6  |
| 11.0           | -13.2    | 0.219 | -98.3  | -42.0    | 0.008 | 27.5   | 15.1     | 5.6618 | -146.2 | -11.9    | 0.253 | -85.2  |
| 11.5           | -13.0    | 0.223 | -105.1 | -41.7    | 0.008 | 19.8   | 15.0     | 5.6180 | -158.4 | -12.0    | 0.250 | -90.0  |
| 12.0           | -13.0    | 0.224 | -111.4 | -41.3    | 0.009 | 13.9   | 14.9     | 5.5801 | -170.4 | -12.2    | 0.245 | -94.3  |
| 12.5           | -13.0    | 0.224 | -117.5 | -40.9    | 0.009 | 6.2    | 14.9     | 5.5525 | 177.7  | -12.5    | 0.238 | -98.2  |
| 13.0           | -13.1    | 0.221 | -123.2 | -40.8    | 0.009 | 1.0    | 14.9     | 5.5276 | 166.0  | -12.8    | 0.230 | -101.6 |
| 13.5           | -13.3    | 0.217 | -128.7 | -40.5    | 0.009 | -6.7   | 14.8     | 5.5138 | 154.2  | -13.1    | 0.221 | -104.3 |
| 14.0           | -13.5    | 0.210 | -134.1 | -40.2    | 0.010 | -12.5  | 14.8     | 5.5069 | 142.3  | -13.5    | 0.211 | -106.2 |
| 14.5           | -13.9    | 0.201 | -138.9 | -40.0    | 0.010 | -17.5  | 14.8     | 5.4997 | 130.5  | -13.9    | 0.201 | -107.1 |
| 15.0           | -14.5    | 0.188 | -143.4 | -39.2    | 0.011 | -25.3  | 14.8     | 5.5050 | 118.6  | -14.4    | 0.191 | -106.8 |
| 15.5           | -15.2    | 0.174 | -147.2 | -39.1    | 0.011 | -31.8  | 14.8     | 5.5089 | 106.3  | -14.7    | 0.184 | -105.4 |
| 16.0           | -16.2    | 0.155 | -150.0 | -38.6    | 0.012 | -38.9  | 14.8     | 5.5103 | 93.8   | -14.9    | 0.180 | -103.4 |
| 16.5           | -17.5    | 0.133 | -150.7 | -38.4    | 0.012 | -45.8  | 14.8     | 5.5013 | 80.9   | -14.9    | 0.180 | -100.3 |
| 17.0           | -19.2    | 0.110 | -147.8 | -37.8    | 0.013 | -52.1  | 14.8     | 5.4892 | 67.9   | -14.6    | 0.186 | -97.4  |
| 17.5           | -21.1    | 0.088 | -138.0 | -37.3    | 0.014 | -60.7  | 14.7     | 5.4475 | 54.4   | -14.3    | 0.194 | -95.6  |
| 18.0           | -22.1    | 0.079 | -117.7 | -36.7    | 0.015 | -69.6  | 14.7     | 5.4016 | 40.5   | -13.7    | 0.206 | -95.1  |
| 18.5           | -20.7    | 0.092 | -96.6  | -35.9    | 0.016 | -74.8  | 14.5     | 5.3231 | 26.1   | -13.3    | 0.217 | -96.0  |
| 19.0           | -18.2    | 0.123 | -83.9  | -35.4    | 0.017 | -85.0  | 14.3     | 5.2168 | 11.2   | -13.0    | 0.224 | -98.0  |
| 19.5           | -15.4    | 0.169 | -80.3  | -35.0    | 0.018 | -95.7  | 14.0     | 5.0371 | -4.3   | -12.9    | 0.226 | -99.4  |
| 20.0           | -13.0    | 0.224 | -81.8  | -34.8    | 0.018 | -105.6 | 13.7     | 4.8240 | -19.9  | -13.0    | 0.225 | -100.9 |
| 20.5           | -11.1    | 0.278 | -85.7  | -34.7    | 0.018 | -114.9 | 13.2     | 4.5580 | -36.4  | -13.3    | 0.217 | -99.8  |
| 21.0           | -9.6     | 0.332 | -91.2  | -34.2    | 0.020 | -126.3 | 12.5     | 4.2135 | -52.5  | -13.8    | 0.205 | -97.5  |
| 21.5           | -8.3     | 0.384 | -97.7  | -34.3    | 0.019 | -137.2 | 11.7     | 3.8489 | -68.9  | -14.0    | 0.199 | -90.2  |
| 22.0           | -7.3     | 0.432 | -284.7 | -34.2    | 0.020 | -328.3 | 10.8     | 3.4671 | -85.5  | -13.4    | 0.214 | -80.1  |

<sup>[1]</sup>Data obtained from on-wafer measurements.  
2-68

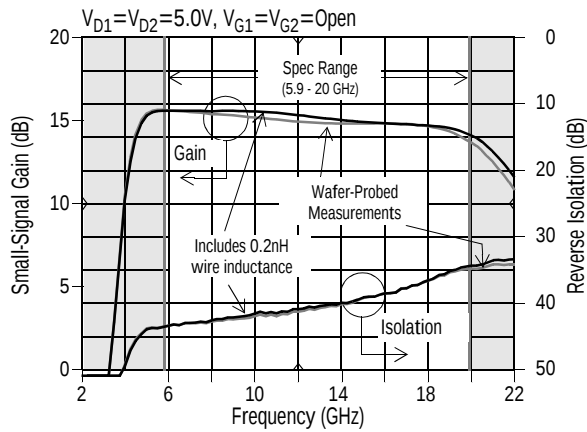


Figure 4.  
Effects of Input/Output Bond Wire  
Inductance on Gain and Isolation[1]

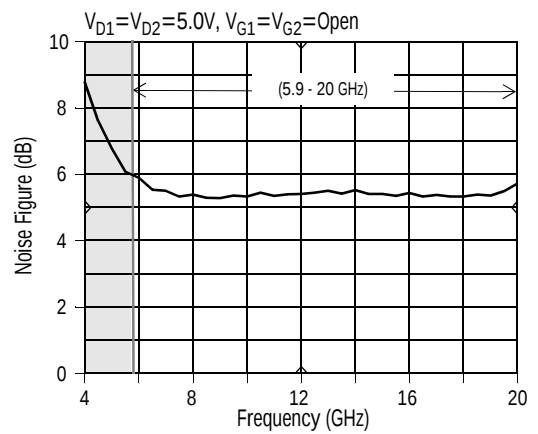


Figure 5.  
Noise Figure versus Frequency[2]

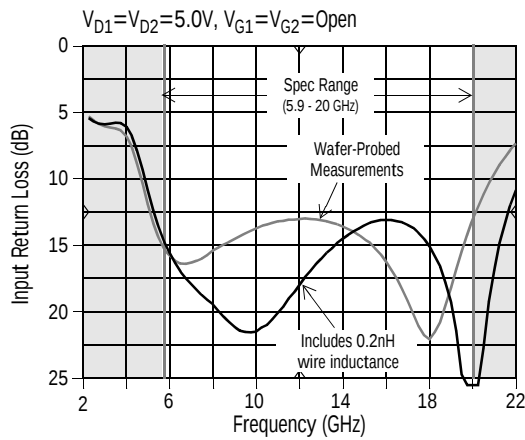


Figure 6.  
Effects of Input/Output Bond Wire  
Inductance on Input Return Loss[1]

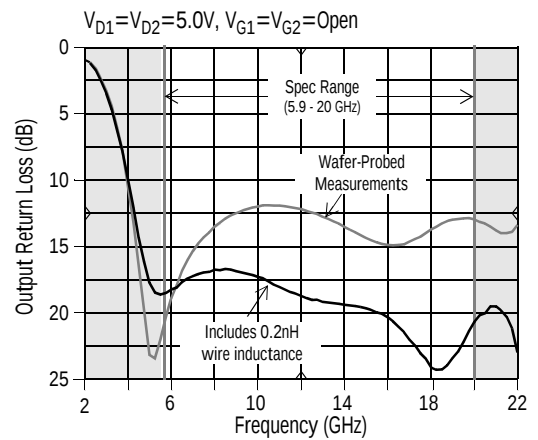


Figure 7.  
Effects of Input/Output Bond Wire  
Inductance on Output Return Loss[1]

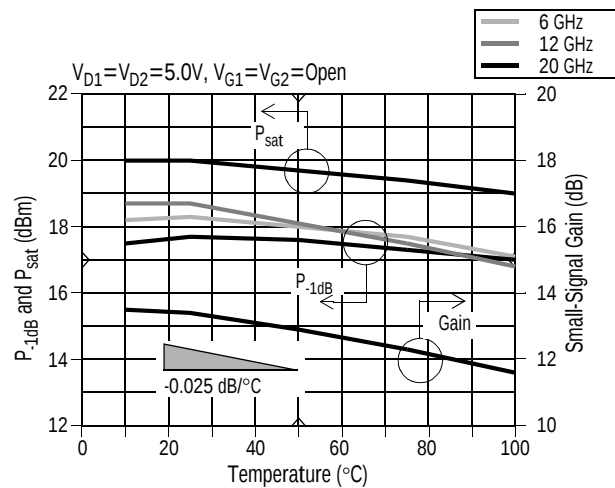


Figure 8.  
Power and Gain versus Backside Temperature[2]

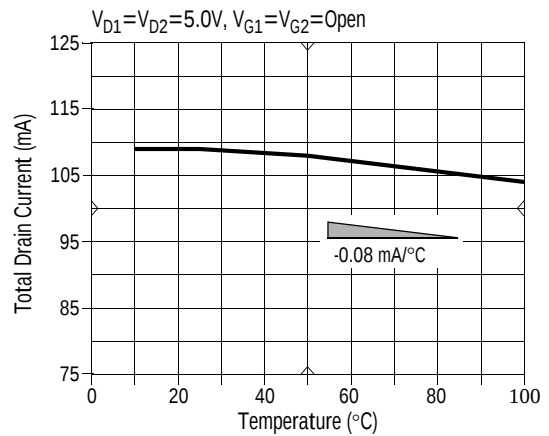


Figure 9.  
Drain Current versus Backside Temperature[2]

[1]Effect of 0.2nH inductance in the RF input and RF output bond wires is modeled from measured wafer-probe tests calibrated at the pads of the MMIC device.

[2]Wafer-probed measurements.

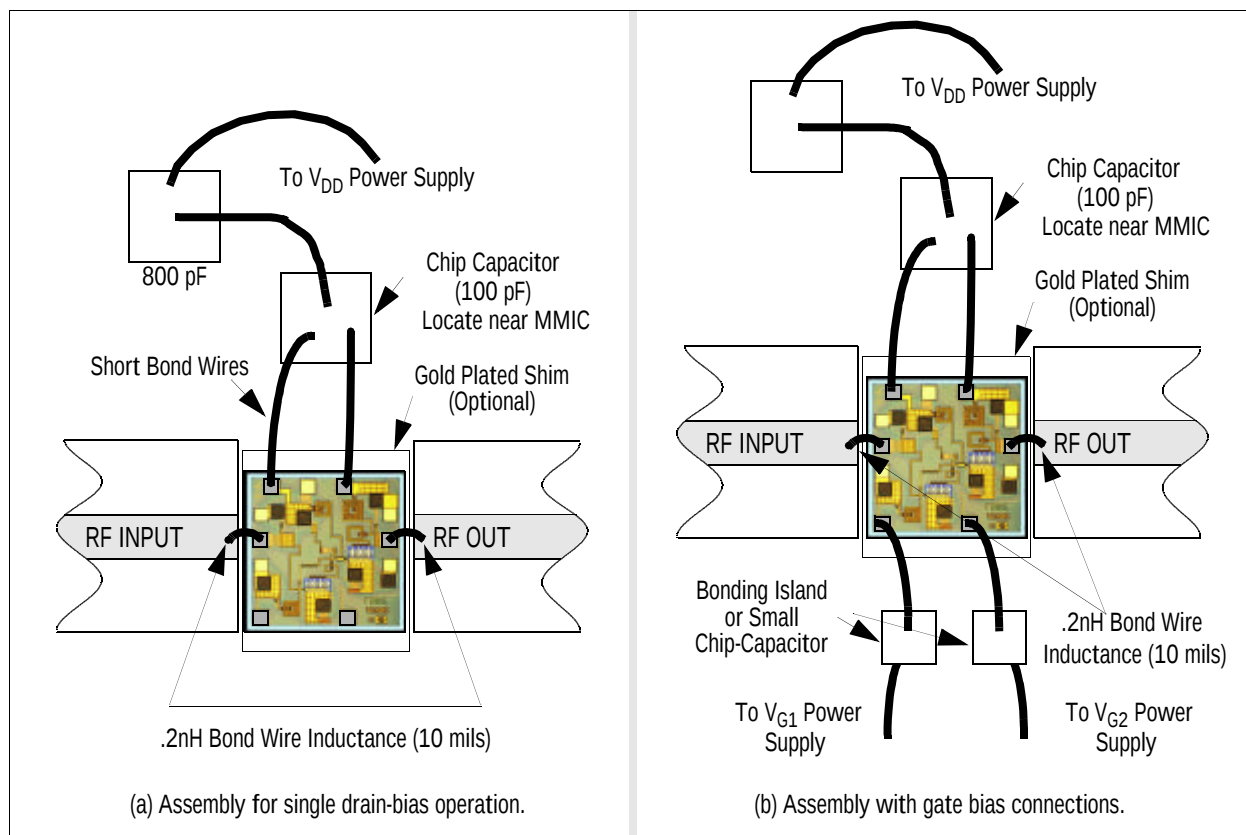


Figure 10.  
Assembly Diagrams

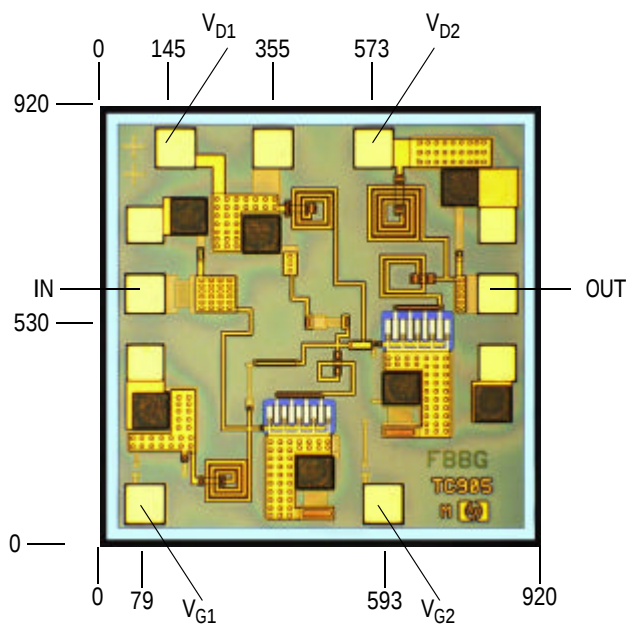


Figure 11.  
Bonding Pad Positions  
(Dimensions are in micrometers)

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.