

# Agilent HMMC-5200

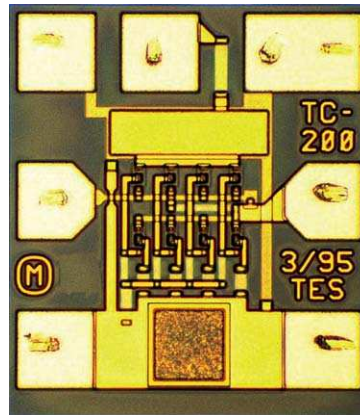
## DC–20 GHz HBT Series Shunt Amplifier

### 1GC1-8000

#### Data Sheet

#### Features

- **High bandwidth,  $F_{-1\text{ dB}}$ :**  
21 GHz typical
- **Moderate gain:**  
9.5 dB  $\pm$ 1 dB @ 1.5 GHz
- **$P_{-1\text{ dB}}$  @ 1.5 GHz:**  
12.5 dBm typical
- **Low 1/f noise corner:**  
< 20 kHz typical
- **Single supply operation:**  
> 4.75 volts @ 44 mA typical
- **Low power dissipation:**  
190 mW typical for chip



Chip size: 410 x 460  $\mu\text{m}$  (16.1 x 18.1 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: 70 x 70  $\mu\text{m}$  (2.8 x 2.8 mils) or larger

#### Description

The HMMC-5200 is a DC to 20 GHz, 9.5 dB gain, feedback amplifier designed to be used as a cascadable gain block for a variety of applications. The device consists of a modified Darlington feedback pair which reduces the sensitivity to process variations and provides 50 ohm input/output port matches. Furthermore, this amplifier is fabricated using WPTC's Heterojunction Bipolar Transistor (HBT) process which provides excellent process uniformity, reliability and 1/f noise performance. The device requires a single positive supply voltage and generally operates Class-A for good distortion performance.

#### Absolute maximum ratings<sup>1</sup>

| Symbol           | Parameters/conditions        | Minimum | Maximum | Units              |
|------------------|------------------------------|---------|---------|--------------------|
| $V_{\text{CC}}$  | VDC pad voltage              |         | 8.0     | Volts              |
| $V_{\text{PAD}}$ | Output pad voltage           |         | 3.5     | Volts              |
| $P_{\text{in}}$  | RF input power, continuous   |         | +6      | dBm                |
| $T_{\text{J}}$   | Junction temperature         |         | +150    | $^{\circ}\text{C}$ |
| $T_{\text{op}}$  | Operating temperature        | -55     | +85     | $^{\circ}\text{C}$ |
| $T_{\text{st}}$  | Storage temperature          | -65     | +165    | $^{\circ}\text{C}$ |
| $T_{\text{max}}$ | Maximum assembly temperature |         | +300    | $^{\circ}\text{C}$ |

<sup>1</sup> Operation in excess of any one of these ratings may result in permanent damage to this device. For normal operation, all combined bias and thermal conditions should be chosen such that the maximum junction temperature ( $T_{\text{J}}$ ) is not exceeded.  $T_{\text{A}} = 25^{\circ}\text{C}$  except for  $T_{\text{op}}$ ,  $T_{\text{st}}$ , and  $T_{\text{max}}$ .



## DC specifications/physical properties<sup>1</sup>

(Typicals are for  $V_{CC} = +5\text{ V}$ ,  $R_{OUT} = 64\ \Omega$ )

| Symbol            | Parameters/conditions  | Minimum | Typical | Maximum | Units                        |
|-------------------|--|---------|---------|---------|------------------------------|
| $V_{CC}$          | Supply voltage   | 4.75    | 6.0     |         | Volts                        |
| $I_{C1}$          | Stage-one supply current   | 14.5    | 17      | 20      | mA                           |
| $I_{C2}$          | Stage-two supply current   | 26      | 29      | 32      | mA                           |
| $I_{C1} + I_{C2}$ | Total supply current   |         | 46      |         | mA                           |
| $\theta_{J-bs}$   | Thermal resistance <sup>1</sup><br>(junction-to-backside at $T_J = 150^\circ\text{C}$ ) <sup>2</sup> |         | 340     |         | $^\circ\text{C}/\text{Watt}$ |

1 Backside ambient operating temperature  $T_A = T_{op} = 25^\circ\text{C}$  unless otherwise noted.

2 Thermal resistance ( $^\circ\text{C}/\text{Watt}$ ) at a junction temperature  $T$  ( $^\circ\text{C}$ ) can be *estimated* using the equation:  $\theta(T) \cong \theta(T_J) [T(^\circ\text{C})+273] / [T_J(^\circ\text{C})+273]$  where  $\theta(T_J = 150^\circ\text{C}) = \theta_{J-bs}$ .

## RF specifications

( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = +5\text{ V}$ ,  $R_{out} = 64\ \Omega$ ,  $50\ \Omega$  system)

| Symbol              | Parameters/conditions                              | Minimum | Typical   | Maximum | Units                |
|---------------------|--|---------|-----------|---------|----------------------|
| BW                  | Operating bandwidth ( $f_{-3\text{ dB}}$ )         | 20      |           |         | GHz                  |
| BW                  | Operating bandwidth ( $ff_{-1\text{ dB}}$ )        |         | 21        |         | GHz                  |
| $S_{21}$            | Small signal gain (@ 1.5 GHz)                      | 8.5     | 9.7       | 10.5    | dB                   |
| $\Delta$ Gain       | Small signal gain flatness (DC to 5 GHz)           |         | $\pm 0.2$ |         | dB                   |
|                     | Small signal gain flatness (DC to 20 GHz)          |         | $\pm 1$   |         | dB                   |
| TC                  | Temperature coefficient of gain (DC to 13 GHz)     |         | 0.004     |         | dB/ $^\circ\text{C}$ |
|                     | Temperature coefficient of gain (13 to 20 GHz)     |         | 0.02      |         | dB/ $^\circ\text{C}$ |
| $(RL_{in})_{MIN}$   | Minimum input return loss (DC to 15 GHz)           |         | -15       |         | dB                   |
|                     | Minimum input return loss (15 to 20 GHz)           |         | -12       |         | dB                   |
| $(RL_{out})_{MIN}$  | Minimum output return loss                         |         | -15       |         | dB                   |
| Isolation           | Reverse isolation                                  |         | -15       |         | dB                   |
| $Pf_{-1\text{ dB}}$ | Output power at 1 dB gain compression: (@ 1.5 GHz) |         | 12.5      |         | dBm                  |
|                     | (@ 5 GHz)  |         | 12.5      |         | dBm                  |
|                     | (@ 10 GHz)   |         | 11.7      |         | dBm                  |
|                     | (@ 15 GHz)   |         | 10.6      |         | dBm                  |
|                     | (@ 20 GHz)   |         | 8.0       |         | dBm                  |
| $P_{SAT}$           | Saturated output power (@ 1.5 GHz)                 |         | 13        |         | dBm                  |
| NF                  | Noise figure: (@ 1 GHz)                            |         | 6.5       |         | dB                   |
|                     | (@ 6 GHz)  |         | 6.8       |         | dB                   |
|                     | (@ 10 GHz)   |         | 7         |         | dB                   |
|                     | (@ 15 GHz)   |         | 7.5       |         | dB                   |
|                     | (@ 16 GHz)   |         | 8         |         | dB                   |
|                     | (@ 18 GHz)   |         | 8.5       |         | dB                   |

### Applications

The HMMC-5200 can be used for a variety of applications requiring moderate amounts of gain and low power dissipation in a 50 Ω system.

### Biasing and operation

The HMMC-5200 can be operated from a single positive supply. This supply must be connected to two points on the chip, namely the  $V_{CC}$  pad and the output pad. The supply voltage may be directly connected to the  $V_{CC}$  pad as long as the voltage is between +4.75 to +7 volts; however, if the supply is higher than +7 volts, a series resistor ( $R_{CC}$ ) should be used to reduce the voltage to the  $V_{CC}$  pad. See the bonding diagram for the equation used to select  $R_{CC}$ . In the case of the output pad, the supply voltage must be connected to the output transmission line through a

resistor and an inductor. The required value of the resistor is given by the equation:

$$R_{out} = 35.7 V_{supply} - 114.3 \Omega$$

where  $V_{supply}$  is in volts. If  $R_{out}$  is greater than 300 Ω, the inductor may be omitted, however, the amplifier's gain may be reduced by ~0.5 dB. Figure 4 shows a recommended bonding strategy.

The chip contains a backside via to provide a low inductance ground path; therefore, the ground pads on the IC should not be bonded.

The voltage at the IN and OUT pads of the IC will be approximately 3.2 volts; therefore, DC blocking caps should be used at these ports.

### Assembly techniques

It is recommended that the RF input and RF output connections be made using 0.7 mil diameter gold wire. The chip is designed to operate with 0.1-0.3 nH of inductance at the RF input and output. This can be accomplished by using 10 mil bond wire lengths on the RF input and output. The bias supply wire can be a 0.7 mil diameter gold wire attached to the  $V_{CC}$  bonding pad.

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.

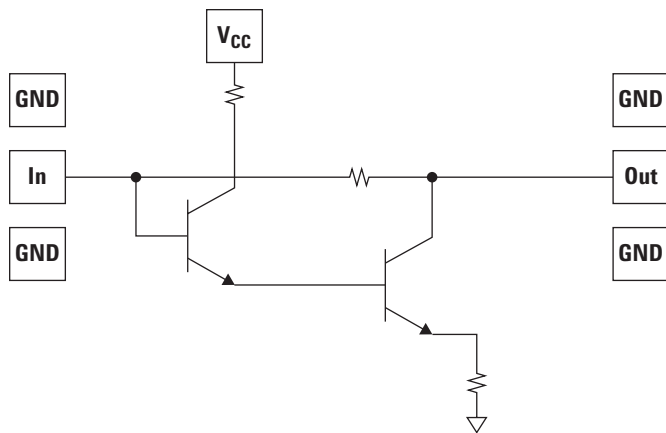


Figure 1. Simplified schematic diagram

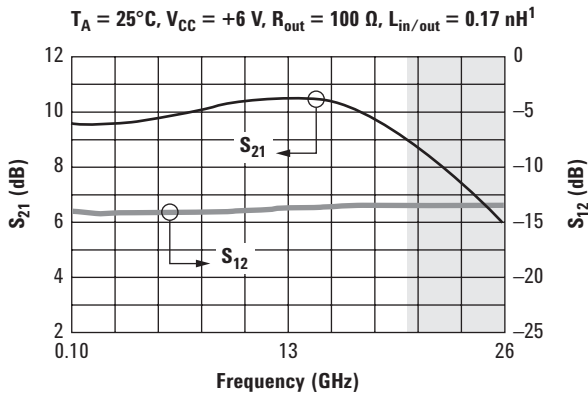


Figure 2. Typical  $S_{21}$  and  $S_{12}$  response

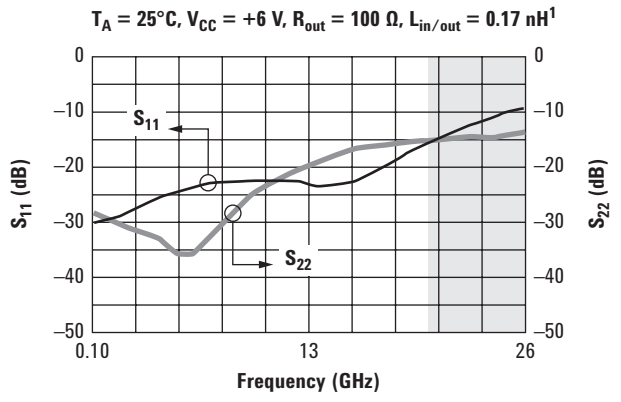


Figure 3. Typical  $S_{11}$  and  $S_{22}$  response

**S-Parameters<sup>1</sup> ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = +6\text{ V}$ ,  $R_{out} = 100\ \Omega$ ,  $L_{in/out} = 0.17\text{ nH}$ )**

| Frequency<br>(GHz) | S11   |       |        | S12   |       |       | S21  |       |       | S22   |       |         |
|--------------------|-------|-------|--------|-------|-------|-------|------|-------|-------|-------|-------|---------|
|                    | dB    | mag   | ang    | dB    | mag   | ang   | dB   | mag   | ang   | dB    | mag   | ang     |
| 0.0                | -30.4 | 0.030 | 28.9   | -14.1 | 0.197 | 0.0   | 9.5  | 3.013 | 179.9 | -28.4 | 0.038 | -1.5    |
| 1.0                | -29.5 | 0.033 | 24.9   | -14.1 | 0.195 | -2.0  | 9.5  | 2.999 | 171.5 | -29.3 | 0.034 | -7.049  |
| 2.0                | -28.7 | 0.037 | 27.3   | -14.2 | 0.194 | -4.1  | 9.5  | 2.992 | 163.2 | -30.8 | 0.029 | -15.233 |
| 3.0                | -27.2 | 0.043 | 33.5   | -14.2 | 0.195 | -6.2  | 9.5  | 3.009 | 155.0 | -31.5 | 0.026 | -23.9   |
| 4.0                | -25.6 | 0.052 | 32.4   | -14.1 | 0.195 | -8.3  | 9.6  | 3.036 | 146.7 | -33.6 | 0.022 | -42.7   |
| 5.0                | -24.8 | 0.058 | 33.3   | -14.1 | 0.195 | -10.4 | 9.7  | 3.062 | 138.2 | -35.8 | 0.016 | -72.8   |
| 6.0                | -24.0 | 0.063 | 31.1   | -14.1 | 0.196 | -12.6 | 9.8  | 3.097 | 129.6 | -36.6 | 0.015 | -109.3  |
| 7.0                | -23.1 | 0.070 | 27.1   | -14.1 | 0.197 | -14.7 | 9.9  | 3.135 | 120.9 | -34.1 | 0.020 | -143.3  |
| 8.0                | -22.6 | 0.074 | 21.9   | -14.0 | 0.197 | -16.9 | 10.0 | 3.181 | 112.0 | -30.1 | 0.031 | -166.4  |
| 9.0                | -22.5 | 0.074 | 15.7   | -14.0 | 0.198 | -19.1 | 10.1 | 3.225 | 102.9 | -26.9 | 0.045 | 176.1   |
| 10.0               | -22.3 | 0.076 | 8.55   | -14.0 | 0.199 | -21.4 | 10.2 | 3.266 | 93.5  | -24.4 | 0.060 | 164.4   |
| 11.0               | -22.4 | 0.076 | -0.36  | -13.9 | 0.200 | -23.6 | 10.3 | 3.298 | 83.9  | -22.5 | 0.075 | 154.2   |
| 12.0               | -22.5 | 0.075 | -13.5  | -13.9 | 0.201 | -25.8 | 10.4 | 3.322 | 74.2  | -20.9 | 0.090 | 147.9   |
| 13.0               | -22.8 | 0.072 | -27.9  | -13.8 | 0.203 | -28.2 | 10.4 | 3.338 | 64.4  | -19.5 | 0.105 | 141.1   |
| 14.0               | -23.2 | 0.069 | -47.1  | -13.8 | 0.204 | -30.6 | 10.4 | 3.332 | 54.2  | -18.3 | 0.121 | 134.2   |
| 15.0               | -22.9 | 0.071 | -69.7  | -13.7 | 0.205 | -33.1 | 10.3 | 3.306 | 44.0  | -17.5 | 0.133 | 128.4   |
| 16.0               | -22.5 | 0.075 | -93.4  | -13.6 | 0.207 | -35.7 | 10.2 | 3.253 | 33.7  | -16.7 | 0.145 | 122.0   |
| 17.0               | -20.8 | 0.091 | -115.1 | -13.6 | 0.208 | -37.9 | 10.0 | 3.181 | 23.5  | -16.0 | 0.158 | 118.6   |
| 18.0               | -19.2 | 0.109 | -134.4 | -13.5 | 0.210 | -40.8 | 9.7  | 3.085 | 13.4  | -15.5 | 0.167 | 112.3   |
| 19.0               | -17.4 | 0.134 | -149.6 | -13.4 | 0.212 | -43.8 | 9.4  | 2.975 | 3.5   | -15.3 | 0.172 | 109.7   |
| 20.0               | -15.8 | 0.161 | -161.7 | -13.4 | 0.213 | -46.8 | 9.0  | 2.844 | -6.0  | -15.2 | 0.172 | 106.0   |
| 21.0               | -14.4 | 0.190 | -172.3 | -13.4 | 0.213 | -49.8 | 8.6  | 2.706 | -15.4 | -14.9 | 0.179 | 105.1   |
| 22.0               | -13.1 | 0.220 | 178.7  | -13.4 | 0.213 | -52.9 | 8.1  | 2.560 | -24.4 | -14.9 | 0.178 | 104.0   |
| 23.0               | -12.0 | 0.250 | 170.7  | -13.4 | 0.212 | -55.6 | 7.6  | 2.416 | -33.0 | -14.7 | 0.183 | 103.0   |
| 24.0               | -11.0 | 0.281 | 163.3  | -13.4 | 0.212 | -58.3 | 7.1  | 2.272 | -41.3 | -14.5 | 0.187 | 104.9   |
| 25.0               | -10.1 | 0.313 | 157.0  | -13.5 | 0.211 | -61.2 | 6.5  | 2.134 | -49.2 | -14.2 | 0.193 | 105.7   |
| 26.0               | -9.29 | 0.343 | 150.8  | -13.4 | 0.212 | -63.9 | 6.0  | 1.997 | -56.9 | -13.8 | 0.203 | 106.8   |

<sup>1</sup> S-parameter data obtained from on-wafer device measurement plus simulation of input and output wire bond inductance.

If  $4.75 \text{ V} \leq V_{\text{supply}} \leq 7 \text{ V}$

$R_{\text{CC}} = 0$   
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If  $V_{\text{supply}} > 7 \text{ V}$

$$R_{\text{CC}} = [(V_{\text{supply}} - 6.5) * (1/0.01725)] \Omega$$

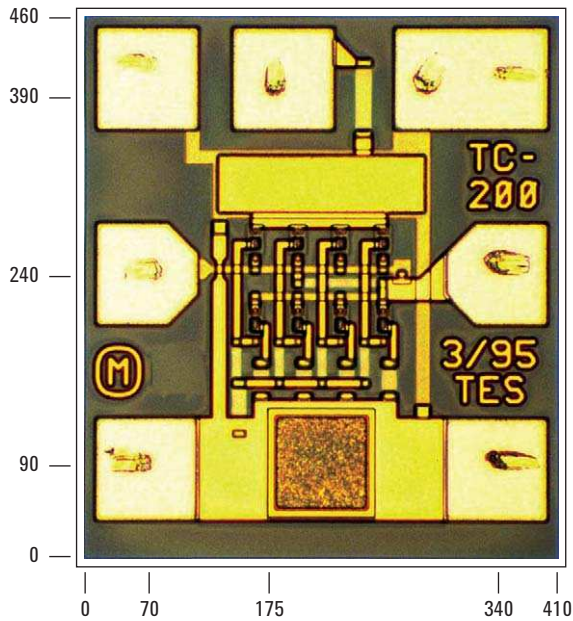
$R_{\text{out}} =$

$$[(V_{\text{supply}} - 3.2) * (1/0.028)] \Omega$$

**Note: Blocking Cap required on input and output.**

- 1 For optimum performance, the input and output bond wire inductances should each be 0.1f–0.3 nH (bond wire has about 20 pH/mil of inductance).
- 2  $L_{\text{choke}}$  is optional if  $R_{\text{out}}$  is greater than 300  $\Omega$ , however, gain will be reduced by about 0.5 dB.

**Figure 4. Assembly diagram**



Note: All dimensions in microns.

Figure 5. Bonding pad locations

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