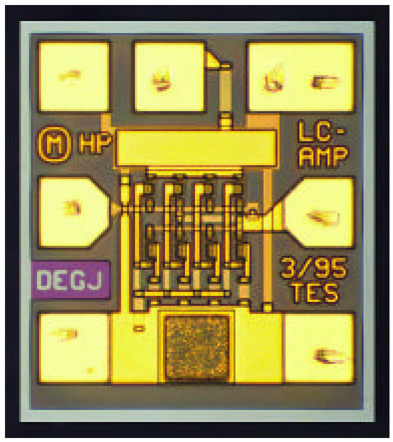
Agilent HMMC-5220 DC–15 GHz HBT Series–Shunt Amplifier

Data Sheet



Features

- **High Bandwidth, F_{-1dB}: 16 GHz Typical**
- **Moderate Gain: 10 dB ± 1 dB @ 1.5 GHz**
- **P_{-1dB} @ 1.5 GHz: 12.5 dBm Typical**
- **Low I / f Noise Corner: <20 kHz Typical**
- **Single Supply Operation: >4.75 volts @ 44 mA Typ.**
- **Low Power Dissipation: 190 mW Typ. for chip**

Chip Size:	410 × 460 µm (16.1 × 18.1 mils)
Chip Size Tolerance:	± 10 µm (± 0.4 mils)
Chip Thickness:	127 ± 15 µm (5.0 ± 0.6 mils)
Pad Dimensions:	70 × 70 µm (2.8 × 2.8 mils), or larger

Description

The HMMC-5220 is a DC to 15 GHz, 10 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 MWTC'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[1]

Symbol	Parameters / Conditions	Min.	Max.	Units
V_{CC}	V_{CC} Pad Voltage		8.0	Volts
V_{PAD}	Output Pad Voltage		3.5	Volts
P_{in}	RF Input Power		13	dBm
T_J	Junction Temperature		+150	°C
T_{op}	Operating Temperature	–55	+85	°C
T_{st}	Storage Temperature	–65	+165	°C
T_{max}	Max. Assembly Temperature		+300	°C

Notes:

1. 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_J) is not exceeded. T_A=25°C except for T_{op}, T_{st}, and T_{max}.

DC Specifications / Physical Properties[1]

(Typicals are for V_{CC} = + 5V, R_{out} = 64Ω)

Symbol	Parameters / Conditions	Min.	Typ.	Max.	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
$\theta_{J\text{-}bs}$	Thermal Resistance[1] (Junction-to-Backside at T_J = 150°C)[2]		210		°C / Watt

Notes:

1. Backside ambient operating temperature $T_A = T_{op}$ = 25°C unless otherwise noted.
2. Thermal resistance (in °C / Watt) at a junction temperature T(°C) can be *estimated* using the equation:
   $\theta(T) \cong \theta(T_J)$ [T(°C)+273] / [T_J(°C)+273] where $\theta(T_J$=150°C) = $\theta_{J\text{-}bs}$.

RF Specifications

(T_A = 25°C, V_{CC} = + 5V, R_{out} = 64Ω, 50Ω system)

Symbol	Parameters / Conditions	Min.	Typ.	Max.	Units
BW	Operating Bandwidth (f_{-3db})	15			GHz
BW	Operating Bandwidth (f_{-1db})		16		GHz
S21	Small Signal Gain (@1.5 GHz)	9	10	11	dB
Δ Gain	Small Signal Gain Flatness (DC–4 GHz)		±0.2		dB
	Small Signal Gain Flatness (DC–15 GHz)		±1		dB
TC	Temperature Coefficient of Gain (DC–10 GHz)		0.004		dB / °C
	Temperature Coefficient of Gain (10–15 GHz)		0.02		dB / °C
(RL_{in})MIN	Minimum Input Return Loss (DC–10 GHz)		–15		dB
	Minimum Input Return Loss (10–15 GHz)		–12		dB
(RL_{out})MIN	Minimum Output Return Loss		–15		dB
Isolation	Reverse Isolation		–15		dB
Pf_{-1dB}	Output Power at 1dB Gain Compression:				dBm
	(@ 1.5 GHz)		12.5		
	(@ 5 GHz)		12.1		
	(@ 10 GHz)		10.7		
	(@ 15 GHz)		7.7		
P_{SAT}	Saturated Output Power (@ 1.5 GHz)		13		dBm
NF	Noise Figure (1 GHz)		6.0		dB

Applications

The HMMC-5220 can be used for a variety of applications requiring moderate amounts of gain and low power dissipation in a 50 ohm system.

Biasing and Operation

The HMMC-5220 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:

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

where V_{supply} is in volts. If R_{out} is greater than 300 ohms, 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.

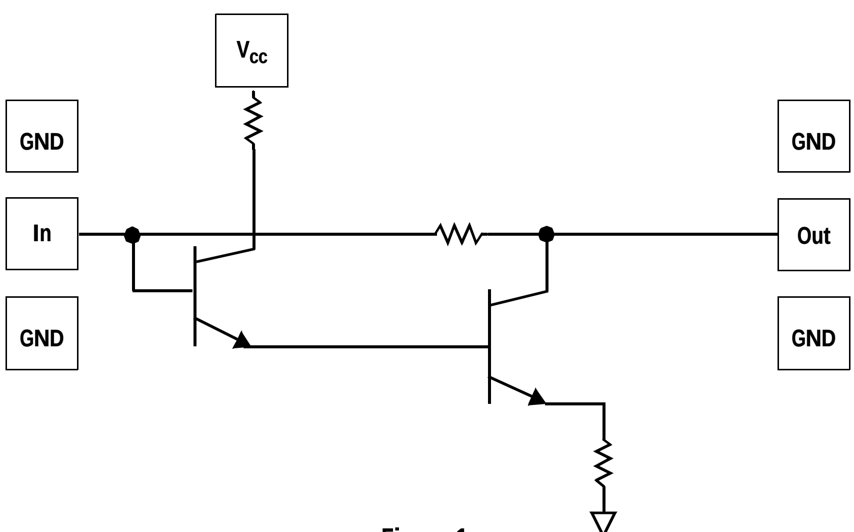


Figure 1.
Simplified Schematic Diagram

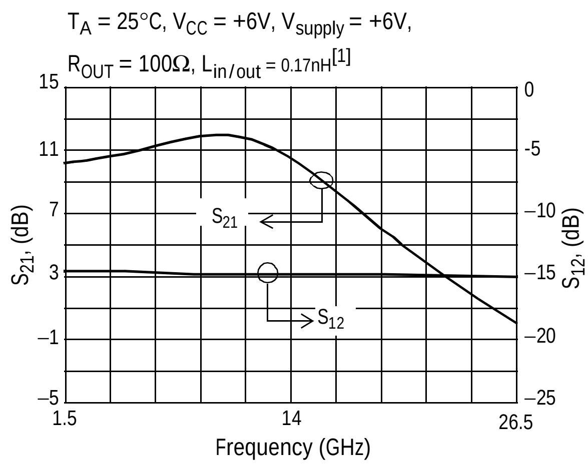


Figure 2.
Typical S_{21} and S_{12} Response

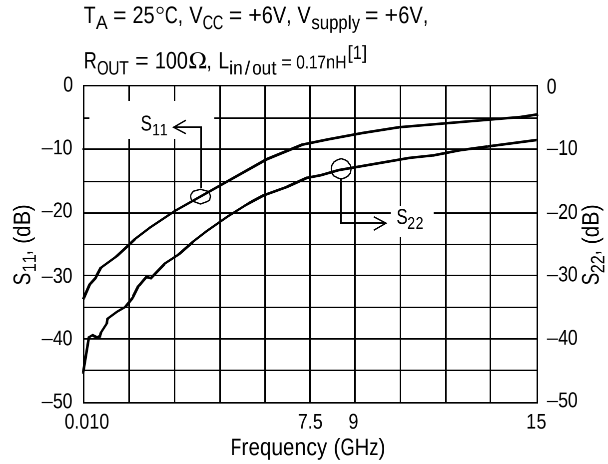


Figure 3.
Typical S_{11} and S_{22} Response

S–Parameters[1] (T_A = 25°C, V_{CC} = + 6V, R_{OUT} = 100Ω,$L_{in/out}$=0.17nH)

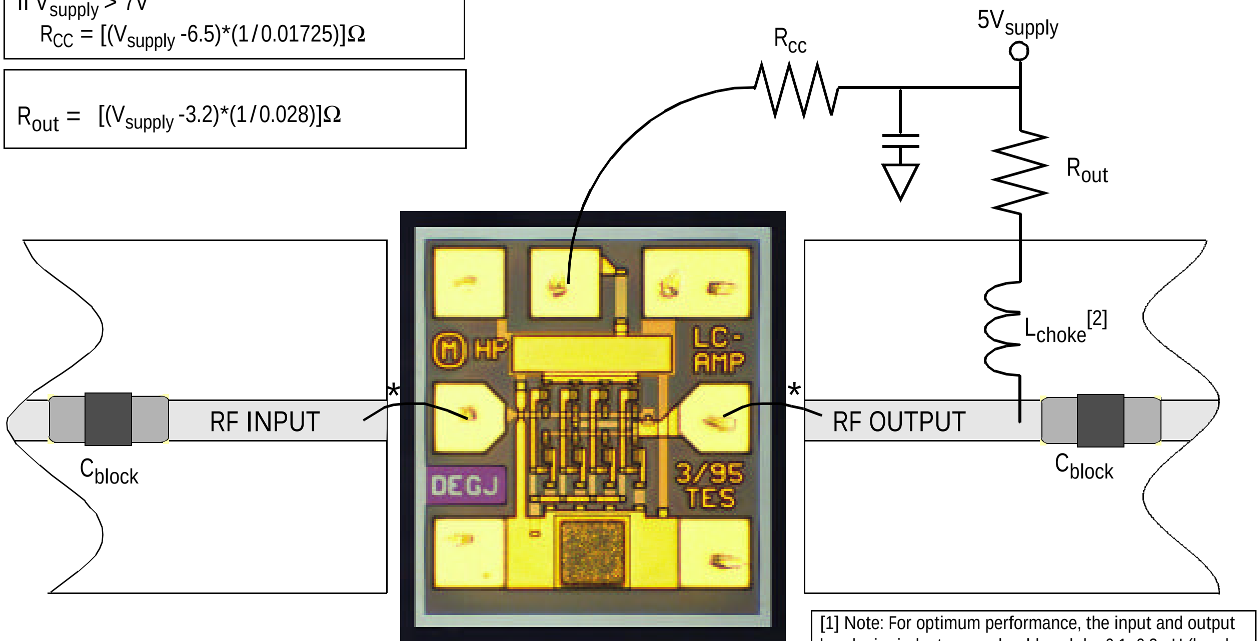
Freq. (GHz)	S_{11}			S_{12}			S_{21}			S_{22}		
	dB	mag	ang	dB	mag	ang	dB	mag	ang	dB	mag	ang
1.0	–36.815	0.014	101.711	–14.556	0.187	–2.816	10.176	3.227	170.043	–43.856	0.006	93.948
2.0	–30.190	0.031	82.146	–14.582	0.187	–5.700	10.239	3.251	160.475	–39.221	0.011	–135.294
3.0	–26.991	0.045	61.919	–14.597	0.186	–8.470	10.389	3.307	150.592	–36.219	0.015	–130.656
4.0	–24.274	0.061	44.654	–14.618	0.186	–11.254	10.591	3.385	140.439	–33.911	0.020	–126.347
5.0	–22.219	0.077	27.802	–14.655	0.185	–14.136	10.834	3.481	129.786	–30.311	0.031	–133.404
6.0	–20.339	0.096	10.215	–14.682	0.184	–16.941	11.111	3.594	118.664	–27.968	0.040	–137.582
7.0	–18.556	0.118	–7.488	–14.734	0.183	–19.616	11.398	3.714	106.865	–25.668	0.052	–144.575
8.0	–16.771	0.145	–26.532	–14.774	0.183	–22.309	11.661	3.828	94.261	–23.403	0.068	–148.075
9.0	–15.138	0.175	–45.766	–14.847	0.181	–24.923	11.851	3.914	80.955	–21.089	0.088	–154.839
10.0	–13.526	0.211	–64.903	–14.868	0.181	–27.421	11.934	3.951	66.934	–19.412	0.107	–163.460
11.0	–11.968	0.252	–84.115	–14.920	0.179	–29.846	11.847	3.912	52.329	–17.932	0.127	–171.353
12.0	–10.710	0.291	–102.350	–14.971	0.178	–32.213	11.548	3.779	37.679	–16.642	0.147	–179.061
13.0	–9.561	0.333	–119.990	–14.952	0.179	–34.429	11.094	3.587	23.434	–15.406	0.170	173.818
14.0	–8.683	0.368	–135.642	–14.945	0.179	–36.859	10.444	3.328	9.757	–14.556	0.187	165.440
15.0	–7.974	0.399	–149.914	–14.914	0.180	–39.544	9.671	3.045	–2.929	–13.709	0.206	160.213
16.0	–7.375	0.180	–162.569	–14.909	0.180	–42.062	8.804	2.756	–14.573	–13.120	0.221	154.272
17.0	–6.925	0.181	–173.902	–14.858	0.181	–44.635	7.905	2.484	–25.264	–12.511	0.237	148.463
18.0	–6.487	0.181	176.146	–14.860	0.181	–47.629	6.979	2.233	–35.066	–12.065	0.249	144.169
19.0	–6.186	0.182	167.583	–14.814	0.182	–50.721	6.072	2.012	–43.983	–11.609	0.263	140.531
20.0	–5.864	0.181	159.638	–14.867	0.181	–53.627	5.168	1.813	–52.137	–11.189	0.276	137.557
21.0	–5.596	0.180	152.696	–14.896	0.180	–56.776	4.299	1.640	–59.775	–10.681	0.292	134.679
22.0	–5.344	0.179	146.514	–14.935	0.179	–59.179	3.476	1.492	–66.862	–10.236	0.308	131.609
23.0	–5.101	0.179	140.907	–14.965	0.179	–62.349	2.671	1.360	–73.357	–9.840	0.322	128.416
24.0	–4.873	0.178	135.780	–15.003	0.178	–64.663	1.883	1.242	–79.769	–9.355	0.341	125.665
25.0	–4.641	0.177	131.066	–15.047	0.177	–67.789	1.157	1.142	–85.664	–8.945	0.357	122.834
26.0	–4.452	0.177	126.675	–15.027	0.177	–70.387	0.439	1.052	–91.318	–8.647	0.370	120.272

Notes:

1. S–parameter data obtained from on wafer device measurement plus simulation of input and output wire bond inductance.

If $4.75V \le V_{supply} \le 7V$
$R_{CC} = 0$
If $V_{supply} > 7V$
$R_{CC} = [(V_{supply} - 6.5)*(1/0.01725)]\Omega$

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

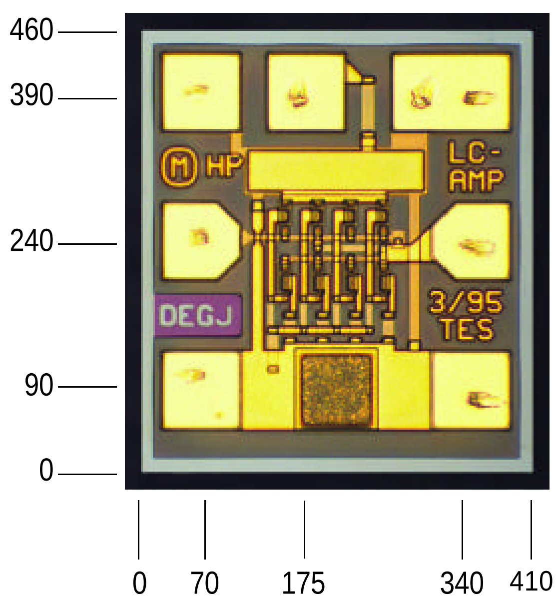


Note: Blocking Cap required on input and output.

Figure 4.
Assembly Diagram

[1] Note: For optimum performance, the input and output bond wire inductances should each be 0.1–0.3 nH (bond wire has about 20 pH/mil of inductance).

[2] L_{choke} is optional if R_{out} is greater than 300Ω, however, gain will be reduced by about 0.5 dB.



Note:
All dimensions in microns.

Figure 5.
Bonding Pad Positions

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.

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