6–20 GHz Amplifier

Technical Data

HMMC-5618

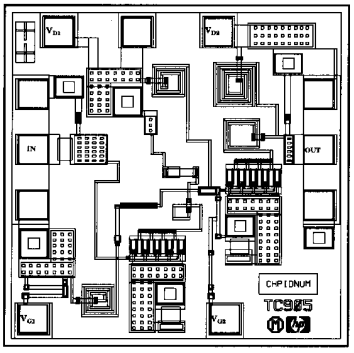
Features

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

Description

The HMMC-5618 6–20 GHz MMIC is an efficient two-stage 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. The MMIC is a cost effective alternative to hybrid (discrete-FET) amplifiers that require complex tuning and assembly processes.



Chip Size: 920 x 920 µm (36.2 x 36.2 mils)
Chip Size Tolerance: ± 10 µm (± 0.4 mils)
Chip Thickness: 127 ± 15 µm (5.0 ± 0.6 mils)
Pad Dimensions: 80 x 80 µm (3.2 x 3.2 mils)

Absolute Maximum Ratings[1]

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

Notes:
1. Absolute maximum ratings for continuous operation unless otherwise noted.
2. Operating at this power level for extended (continuous) periods is not recommended.
3. Refer to *DC Specifications/Physical Properties* table for derating information.

HMMC-5618 DC Specifications/Physical Properties[1]

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

Notes:
1. Backside ambient operating temperature T_A = 25°C unless otherwise noted.
2. 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.
3. Thermal resistance (in °C/Watt) at a channel temperature T (°C) can be estimated using his equation: $\theta(T) \cong 87 \times [T(°C) + 273] / [150°C + 273]$.
4. Derate MTTF by a factor of two for every 8°C above T_{ch}.

HMMC-5618 RF Specifications, T_A = 25°C, $V_{D1} = V_{D2}$ = 5 V, $V_{G1} = V_{G2}$ = Open or Ground, Z_O = 50 Ω

Symbol	Parameters and Test Conditions	Units	Typ.	6–18 GHz		5.9–20 GHz	
				Min.	Max.	Min.	Max.
Gain	Small Signal Gain	dB	14	12		11.5	
Δ Gain	Gain Flatness	dB	±0.5				
$\Delta S_{21}/\Delta T$	Temperature Coefficient of Gain	dB/°C	-0.025				
$(RL_{in})_{MIN}$	Minimum Input Return Loss	dB	12	10		9	
$(RL_{out})_{MIN}$	Minimum Output Return Loss	dB	12	10		10	
Isolation	Reverse Isolation	dB	40				
P_{-1dB}	Output Power @ 1 dB Gain Compression	dBm	18	17		17	
P_{sat}	Saturated Output Power (P_{in} = 10 dBm)	dBm	20	18.5		18.5	
NF	Noise Figure	dB	5.5		7		7

HMMC-5618 Applications

The HMMC-5618 is a GaAs MMIC 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 amplifiers, buffer stages, LO drives, 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 8a. 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 8b. 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

Solder die attach using a fluxless gold-tin (AuSn) solder preform is the recommended assembly method. A conductive epoxy such as ABLEBOND® 71-1LM1 or ABLEBOND® 36-2 may also be used for die attaching provided the Maximum Thermal Ratings are not exceeded. The device should be attached to an electrically conductive surface to complete the DC and RF ground paths. The backside metallization on the device is gold.

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 as demonstrated in Figures 4, 6, and 7. Therefore, mesh or multiple-wire bonds are not necessary. It is, however, recommended that the RF wires be as short as possible to minimize assembly related performance variations.

Thermosonic wedge is the preferred method for wire bonding to the gold bond pads. Wires can be attached using a guided-wedge at an ultrasonic power level of roughly 64 dB for a duration of 76 ± 8 msec with a stage temperature of 150 ± 2°C.

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.

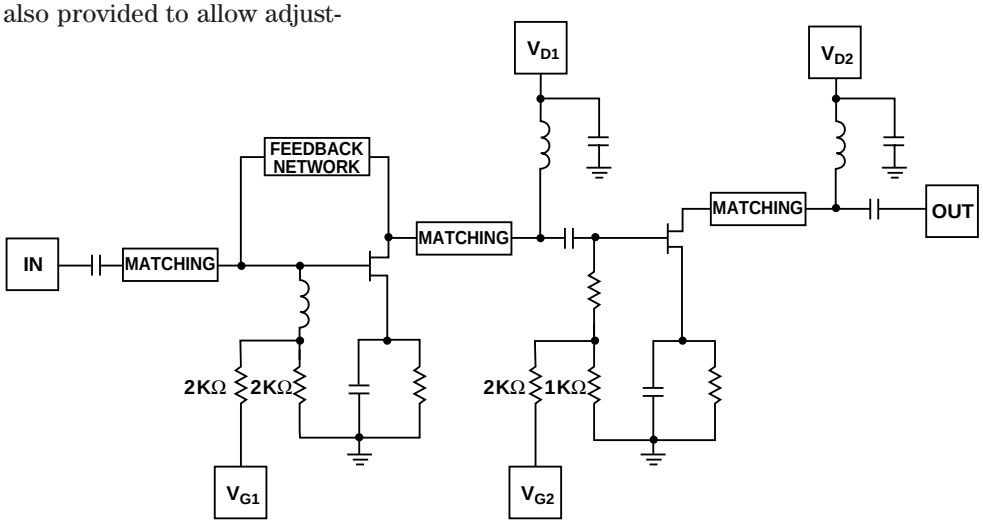


Figure 1. HMMC-5618 Simplified Schematic.

HMMC-5618 Typical Scattering Parameters[1],

($T_A = 25°C, V_{D1} = V_{D2} = 5.0\,V, V_{G1} = V_{G2} = Open, Z_o = 50\,\Omega$

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

Note:

1. Data obtained from on-wafer measurements.

HMMC-5618 Typical Performance

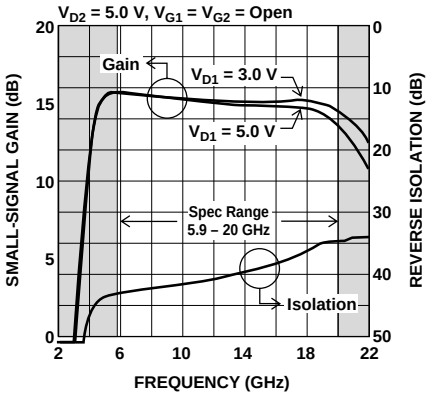


Figure 2. Gain and Isolation vs. Frequency.[1]

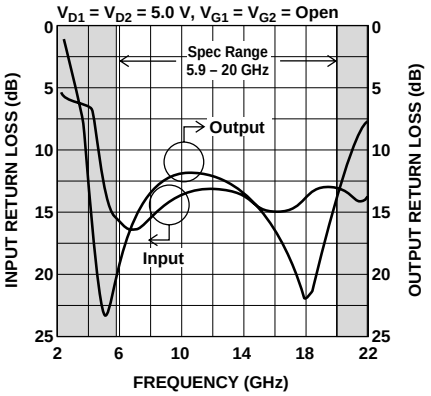


Figure 3. Input and Output Return Loss vs. Frequency.[1]

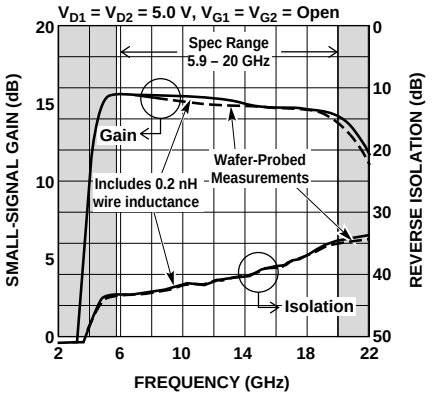


Figure 4. Effects of Input/Output Bond Wire Inductance on Gain and Isolation.[2]

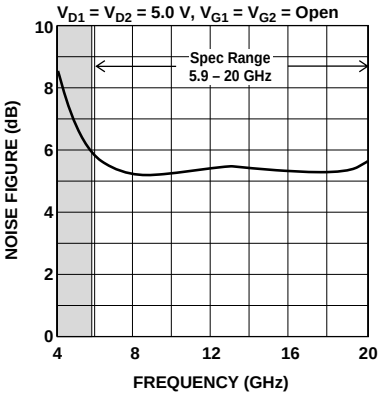


Figure 5. Noise Figure vs. Frequency.[1]

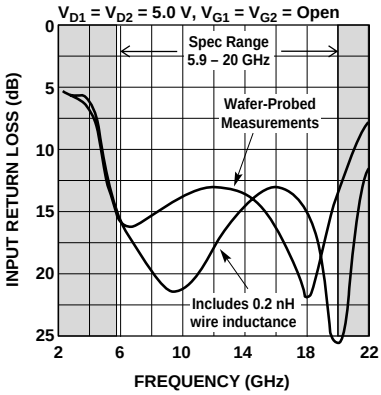


Figure 6. Effects of Input/ Output Bond Wire Inductance on Input Return Loss.[2]

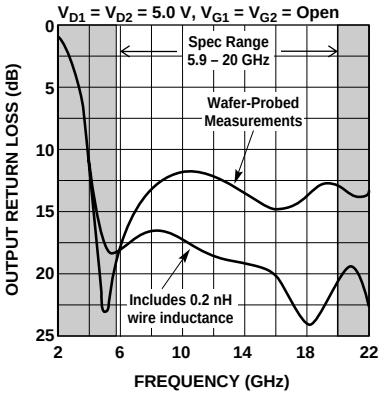


Figure 7. Effects of Input/Output Bond Wire Inductance on Output Return Loss.[2]

Notes:
1. Wafer-probed measurements.
2. Effect of 0.2 nH 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.

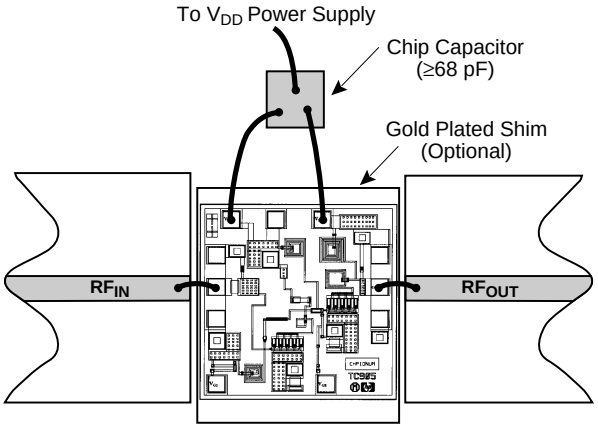


Figure 8a. Assembly for single drain-bias operation.

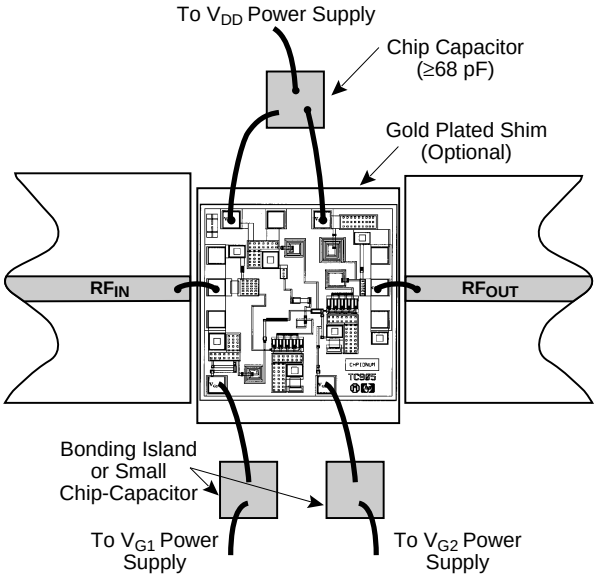


Figure 8b. Assembly with gate bias connections.

Figure 8. HMMC-5618 Assembly Diagrams.

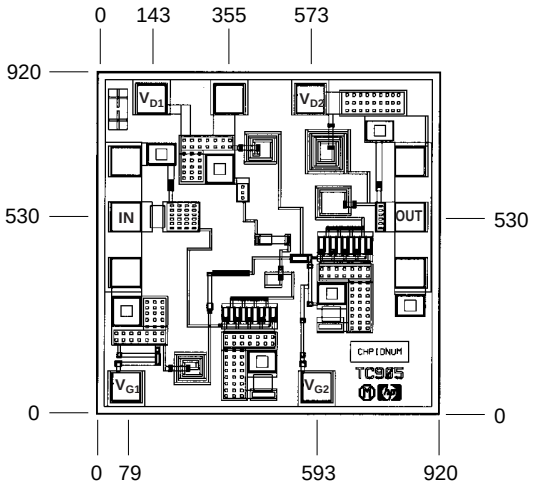


Figure 9. HMMC-5618 Bonding Pad Positions. (Dimensions are in micrometers.)

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 HP sales representative.