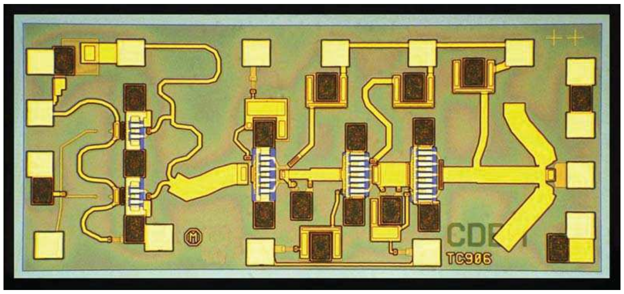
Agilent HMMC-5040 20–40 GHz Amplifier

1GG6-4066

Data Sheet



Chip size:	1720 x 760 µm (67.7 x 29.9 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 (3.1 x 3.1 mils)

Features

- **Large bandwidth:**
  20 to 44 GHz typical
  21 to 40 GHz specified
- **High gain: 22 dB typical**
- **Saturated output power:**
  21 dB typical
- **Supply bias:**
  ≤ 4.5 volts @ ≤ 300 mA

Description

The HMMC-5040 is a high-gain broad-band MMIC amplifier designed for both military applications and commercial communication systems. This four stage amplifier has input and output matching circuitry for use in 50 ohm environments. It is fabricated using a PHEMT integrated circuit structure that provides exceptional broadband performance. 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. This MMIC is a cost effective alternative to hybrid (discrete-FET) amplifiers that require complex tuning and assembly processes.

Absolute maximum ratings[1]

Symbol	Parameters/conditions	Minimum	Maximum	Units
$V_{1,2\text{-}3\text{-}4}$	Drain supply voltages		5	Volts
$V_{G1,2,3\text{-}4}$	Gate supply voltages	–3.0	0.5	Volts
I_{DD}	Total drain current		400	mA
P_{in}	RF input power		21	dBm
T_{ch}	Channel temperature[2]		160	°C
T_A	Backside ambient temperature	–55	+75	°C
T_{st}	Storage temperature	–65	+165	°C
T_{max}	Maximum assembly temperature		300	°C

[1] Absolute maximum ratings for continuous operation unless otherwise noted.

[2] Refer to *DC specifications/physical properties* table for derating information.

DC specifications/physical properties[1]

Symbol	Parameters/conditions	Minimum	Typical	Maximum	Units
$V_{D1,2\text{-}3\text{-}4}$	Drain supply operating voltages	2	4.5	5	Volts
I_{D1}	First stage drain supply current (V_{DD} = 4.5 V, V_{G1} ≅ –0.6 V)		55		mA
$I_{D2\text{-}3\text{-}4}$	Total drain supply current for stage 2, 3, and 4 (V_{DD} = 4.5 V, V_{GG} ≅ –0.6 V)		245		mA
$V_{G1,2,3\text{-}4}$	Gate supply operating voltages (I_{DD} ≅ 300 mA)		–0.6		Volts
V_P	Pinch-off voltage (V_{DD} = 4.5 V, I_{DD} ≤ 10 mA)	–2	–1.2	–0.8	Volts
θch–bs	Thermal resistance[2] (channel-to-backside at T_{ch} = 160°C)		62		°C/Watt
T_{ch}	Channel temperature[3] (T_A = 75°C, MTTF > 10^6 hrs, V_{DD} = 4.5 V, I_{DD} = 300 mA)		160		°C

[1] Backside ambient operating temperature T_A = 25°C unless otherwise noted.

[2] Thermal resistance (°C/Watt) at a channel temperature T (°C) can be *estimated* using the equation: $_q$(T) ≅ 62 ¥ [T(°C)+273] / [160°C+273].

[3] Derate MTTF by a factor of two for every 8°C above T_{ch}.

RF specifications

(T_A = 25°C, Z_0 = 50 Ω, V_{DD} = 4.5 V, I_{DD} = 300 mA)

		Broadband specifications			Narrow band performance			
Symbol	**Parameters/conditions**	**Minimum**	**Typical**	**Maximum**		**Typical**		**Units**
BW	Operating bandwidth	21	20-44	40	21-24	27-29	37-40	GHz
Gain	Small signal gain	20	22		25	23	22	dB
ΔGain	Small signal gain flatness		±1.5		±1	±0.75	±0.3	dB
$(RL_{in})_{MIN}$	Minimum input return loss	8	10		9	10	14	dB
$(RL_{out})_{MIN}$	Minimum output return loss	8	10		10	11	12	dB
Isolation	Reverse isolation		54		54	54	54	dB
$P_{-1\ dB}$	Output power at 1 dB gain compression		18		18	18	18	dBm
P_{SAT}	Saturated output power at 3 dB gain compression	20	21		21	21	21	dBm

Applications

The HMMC-5040 broadband amplifier is designed for both military (35 GHz) applications and wireless communication systems that operate at 23, 28, and 38 GHz. It is also suitable for use as a frequency multiplier due to excellent below-band input return loss and high gain.

Biasing and operation

The recommended DC bias condition is with all drains connected to single 4.5 volt supply and all gates connected to an adjustable negative voltage supply as shown in Figure 12. The gate voltage is adjusted for a total drain supply current of typically up to 300 mA. Figures 4, 5, 8, and 9 can be used to help estimate the minimum drain voltage and current necessary for a given RF gain and output power.

The second, third, and fourth stage DC drain bias lines are connected internally (Figure 1) and therefore require only a single bond wire. An additional bond wire is needed for the first stage DC drain bias, V_{D1}.

Only the third and fourth stage DC gate bias lines are connected internally. A total of three DC gate bond wires are required: one for V_{G1}, one for V_{G2}, and one for the V_{G3}-to-V_{G4} connection.

The RF input has matching circuitry that creates a 50 ohm DC and RF path to ground. A DC blocking capacitor should be used in the RF input transmission line. Any DC voltage applied to the RF input must be maintained below 1 volt. The RF output is AC-coupled.

No ground wires are needed since ground connections are made with plated through-holes to the backside of the device.

The HMMC-5040 can also be used to double, triple, or quadruple the frequency of input signals. Many bias schemes may be used to generate and amplify desired harmonics within the device. The information given here is intended to be used by the customer as a starting point for such applications. Optimum conversion efficiency is obtained with approximately 14 dBm input drive level.

As a *doubler*, the device can multiply an input signal in the 10 to 20 GHz frequency range up to 20 to 40 GHz with conversion gain for output frequencies exceeding 30 GHz. Similarly, 5 to 10 GHz signals can be quadrupled to 20 to 40 GHz with some conversion loss. Frequency doubling or quadrupling is accomplished by operating the first gain stage at pinch-off ($V_{G1} = V_P \cong 1.2$ volts). Stages 2, 3, and 4 are biased for normal amplification. The assembly diagram shown in Figure 13 can be used.

To operate the device as a frequency *tripler* the drain voltage can be reduced to approximately 2.5 volts and the gate voltage can be set at about –0.4 volts or adjusted to minimize second harmonics if needed. Either of Figures 12 and 13 can be used.

Contact your local Agilent Technologies sales representative for additional information concerning multiplier performance and operating conditions.

Assembly techniques

It is recommended that the RF input and output connections be made using either 500 lines/inch (or equivalent) gold wire mesh. The RF connections should be kept as short as possible to minimize inductance. The DC bias supply wires can be 0.7 mil diameter gold.

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 #46, "HMMC-5040 20-40 GHz Amplifier"

AN #50, "HMMC-5040 As a 20-40 GHz Multiplier"

PN #3, "HMMC-5040 and HMMC-5032 Demo, 20-32 GHz High Gain Medium Power Amp."

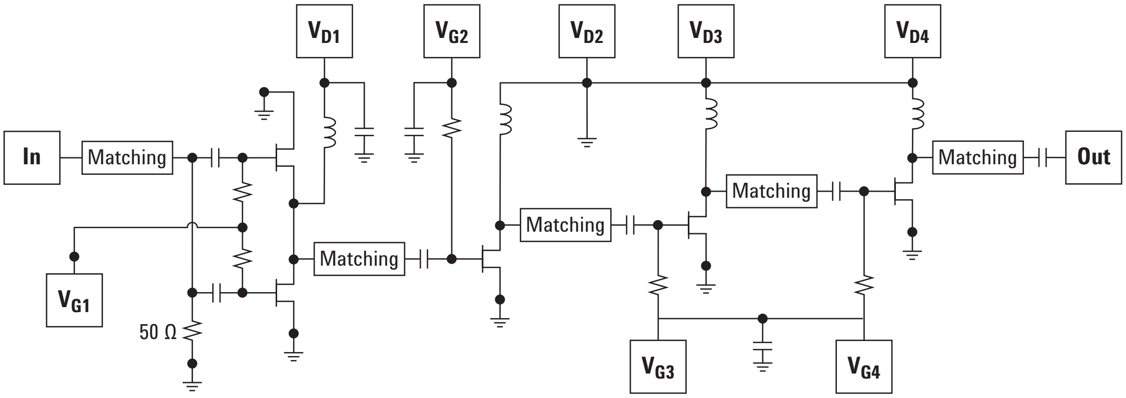
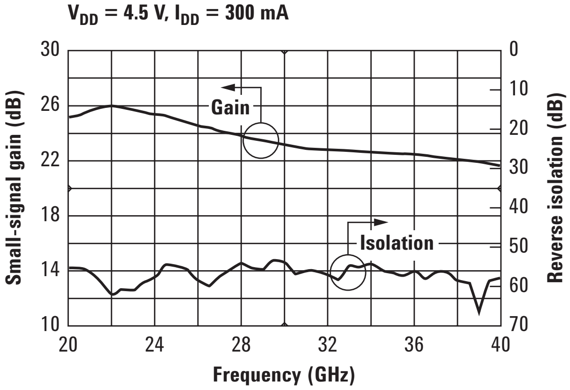


Figure 1. Simplified schematic diagram



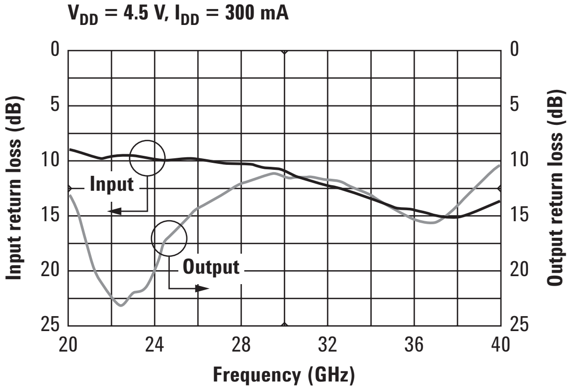
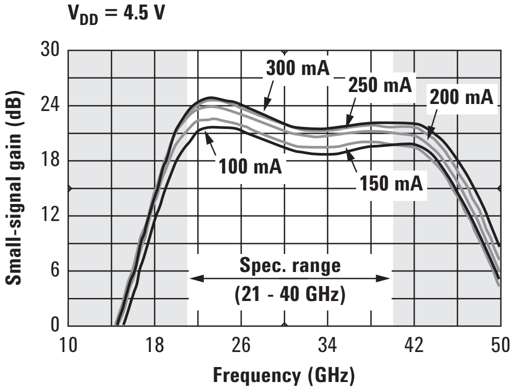


Figure 2. Typical gain and isolation vs. frequency[1]

Figure 3. Typical input and output return loss vs. frequency[1]



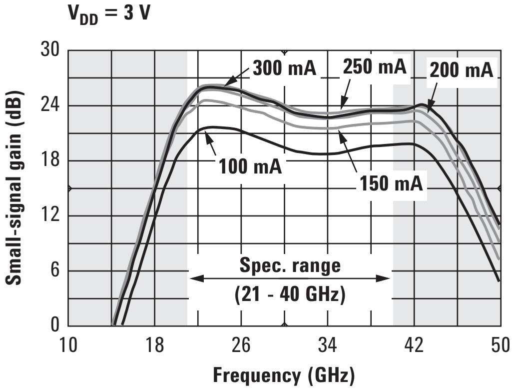


Figure 4. Broadband gain as a function of drain current vs. frequency with V_{DD} = 4.5 V[1]

Figure 5. Broadband gain as a function of drain current vs. frequency with V_{DD} = 3 V[1]

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[1] Wafer-probed measurements

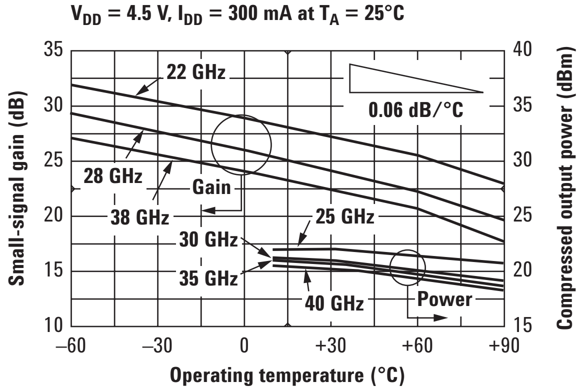

Figure 6. Small-signal gain[1] and compressed power[2] vs. temperature

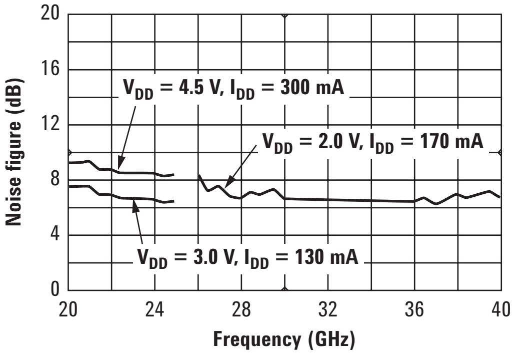

Figure 7. Noise figure vs. frequency

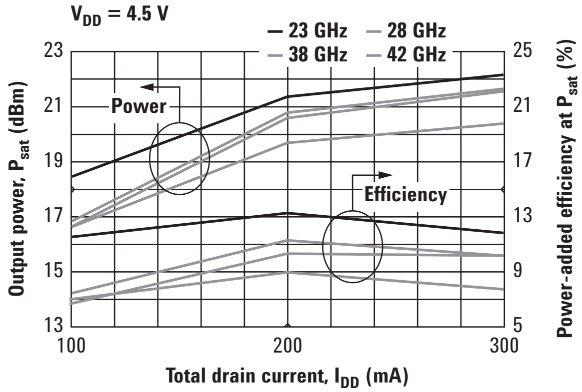

Figure 8. Output power[2] and efficiency vs. drain current with V_{DD} = 4.5 V

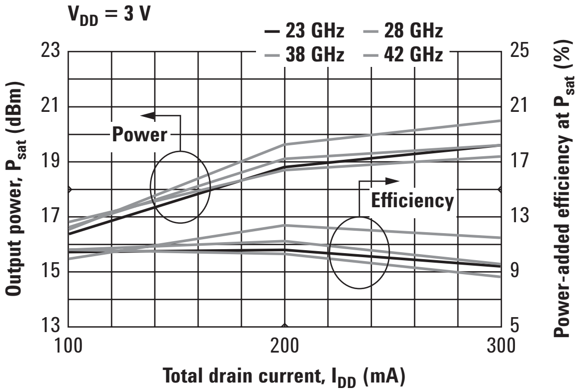

Figure 9. Output power[2] and efficiency vs. drain current with V_{DD} = 3 V

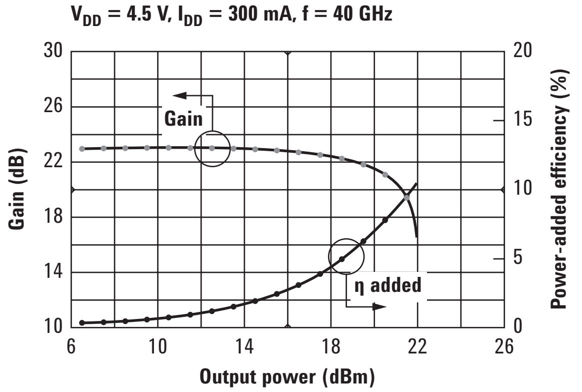

Figure 10. Gain compression and efficiency characteristics[3]

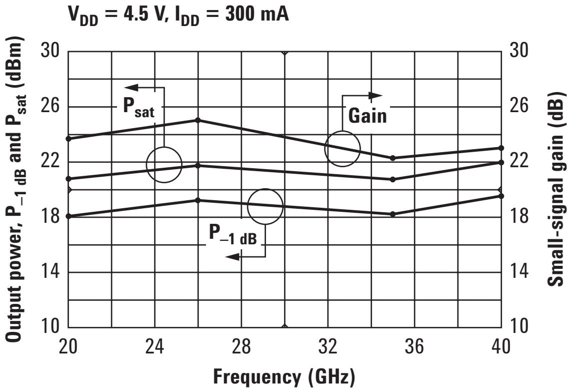

Figure 11. Output power and gain vs. frequency characteristics[3]

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[1] Measurements taken on a device mounted in a connectorized package calibrated at the connector terminals

[2] Output power into 50 ohms with 2 dBm input power

[3] Wafer-probed measurements

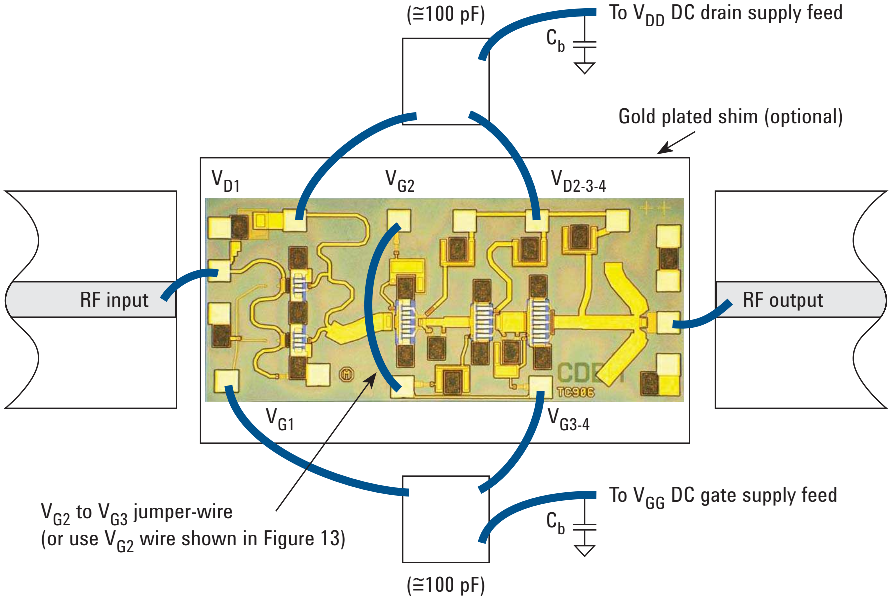


Figure 12. Single drain and single gate supply assembly for tripler and standard amplifier applications.

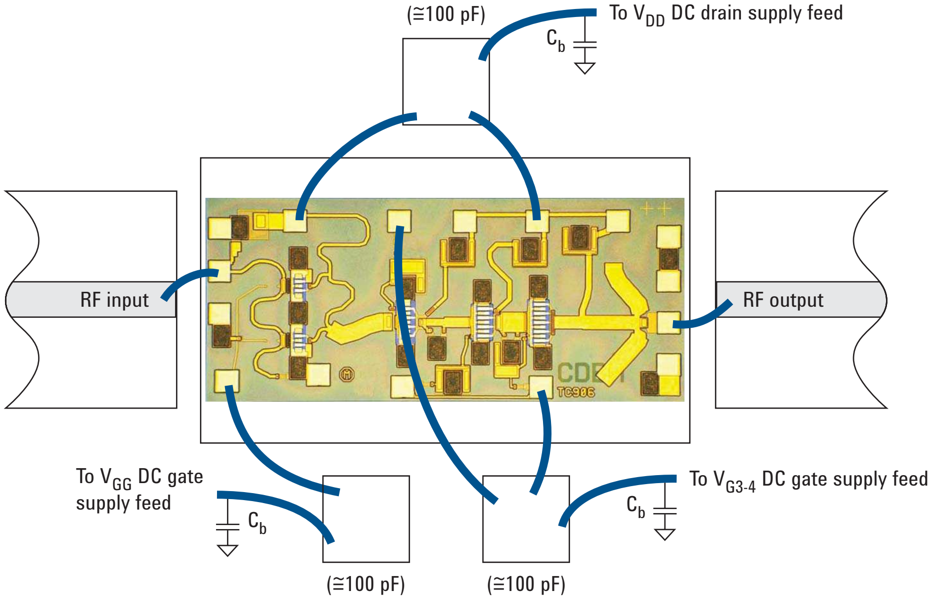
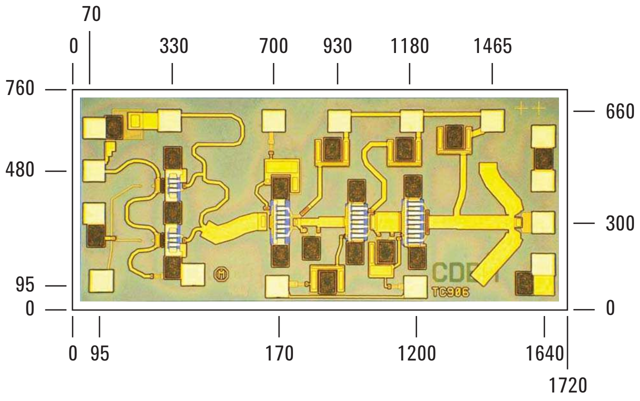


Figure 13. Separate first-stage gate bias supply for any multiplier or amplifier application. This diagram shows an optional variation to the V_{G2} jumper-wire bonding scheme presented in Figure 12.



Note: All dimensions in micrometers.

Figure 14. Bonding pad locations

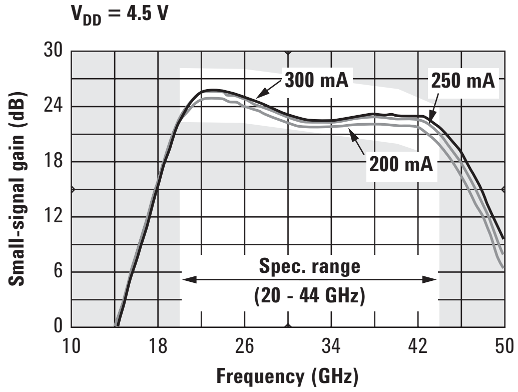


Figure 15. 1GG6-4066 broadband gain as a function of drain current vs. frequency with V_{DD} = 4.5 V[1]

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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