GaAs pHEMT MMIC
0.5 WATT POWER AMPLIFIER, DC - 30 GHz

Typical Applications
The HMC994A is ideal for:
• Test Instrumentation
• Military & Space
• Fiber Optics

Features
High P1dB Output Power: 28 dBm
High Psat Output Power: 30 dBm
High Gain: 14 dB
High Output IP3: 39 dBm
Supply Voltage: +10 V @ 250 mA
50 Ohm Matched Input/Output
Die Size: 2.75 x 1.45 x 0.1 mm

General Description
The HMC994A is a GaAs MMIC pHEMT Distributed Power Amplifier which operates between DC and 30 GHz. The amplifier provides 14 dB of gain, +39 dBm output IP3 and +28 dBm of output power at 1 dB gain compression while requiring 250 mA from a +10 V supply. The HMC994A exhibits a slightly positive gain slope from 2 to 20 GHz, making it ideal for EW, ECM, Radar and test equipment applications. With up to 39 dBm Output IP3 the HMC994A is ideal for high linearity applications in military and space as well as test equipment where high order modulations are used. The HMC994A amplifier I/Os are internally matched to 50 Ohms facilitating integration into Multi-Chip-Modules (MCMs). All data is taken with the chip connected via two 0.025 mm (1 mil) wire bonds of minimal length 0.31 mm (12 mils).

Functional Diagram

Electrical Specifications, $T_A = +25^\circ \text{C}$, $V_{dd} = +10 \text{ V}$, $V_{gg2} = +3.5 \text{ V}$, $I_{dd} = 250 \text{ mA}^*$

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>DC - 18</td>
<td>18 - 26</td>
<td>26 - 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>Gain</td>
<td>11.5</td>
<td>14.5</td>
<td>12</td>
<td>15</td>
<td>12.5</td>
<td>15.5</td>
<td>dB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain Flatness</td>
<td>±0.25</td>
<td>±0.5</td>
<td>±0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Gain Variation Over Temperature</td>
<td>0.004</td>
<td>0.005</td>
<td>0.01</td>
<td>dB/°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>13</td>
<td>22</td>
<td>22</td>
<td>dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>20</td>
<td>18</td>
<td>20</td>
<td>dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Power for 1 dB Compression (P1dB)</td>
<td>26</td>
<td>28</td>
<td>26</td>
<td>24.5</td>
<td>27.5</td>
<td>dBm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated Output Power (Psat)</td>
<td>30</td>
<td>30</td>
<td>29</td>
<td>dBm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Third Order Intercept (IP3) Pout / tone = +16dBm</td>
<td>39</td>
<td>36</td>
<td>36</td>
<td>dBm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise Figure</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
<td>dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Current (Idd) (Vdd= 10V, Vgg1= -0.6V Typ.)</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>mA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td>V</td>
</tr>
</tbody>
</table>

* Adjust Vgg1 between -2 to 0 V to achieve 250 mA typical, Vgg1 typical = -0.6 V
**HMC994A**

**GaAs pHEMT MMIC**

**0.5 WATT POWER AMPLIFIER, DC - 30 GHz**

**Gain & Return Loss**

**Low Frequency Gain & Return Loss**

**Gain vs. Temperature**

**Gain vs. Vdd**

**Gain vs. Idc**

**Input Return Loss vs. Temperature**

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106
Phone: 781-329-4700 • Order online at www.analog.com
Application Support: Phone: 1-800-ANALOG-D
**HMC994A**

**GaAs pHEMT MMIC**

**0.5 WATT POWER AMPLIFIER, DC - 30 GHz**

**Input Return Loss vs. Vdd**

**Input Return Loss vs. Idd**

**Output Return Loss vs. Temperature**

**Output Return Loss vs. Vdd**

**Output Return Loss vs. Idd**

**Reverse Isolation vs. Temperature**

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106
Phone: 781-329-4700 • Order online at www.analog.com
Application Support: Phone: 1-800-ANALOG-D
GaAs pHEMT MMIC
0.5 WATT POWER AMPLIFIER, DC - 30 GHz

**Noise Figure vs. Temperature**

**Noise Figure vs Idd**

**Low Frequency P1dB vs. Temperature**

**P1dB vs. Temperature**

**Low Frequency P1dB vs. Vdd**

**P1dB vs. Vdd**
HMC994A

GaAs pHEMT MMIC

0.5 WATT POWER AMPLIFIER, DC - 30 GHz

P1dB vs. Idd

Psat vs Temperature

Psat vs Vdd

Psat vs Idd

Power Compression @ 16 GHz

Gain & Power vs. Idd @ 16 GHz

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106
Phone: 781-329-4700 • Order online at www.analog.com
Application Support: Phone: 1-800-ANALOG-D

Downloaded from Arrow.com.
**HMC994A**

GaAs pHEMT MMIC

*0.5 WATT POWER AMPLIFIER, DC - 30 GHz*

---

**Gain & Power vs Vdd @ 16 GHz**

- Gain (dB), P1dB (dBm), Psat (dBm)
- **Frequency (GHz):** 1, 2, 3, 4, 5, 6, 7, 8
- Values: 10, 15, 20, 25, 30

**Power Dissipation @ 85C**

- **Input Power (dBm):** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
- **Power Dissipation (W):** 0, 0.3, 0.6, 0.9, 1.2, 1.5

**PAE @ Psat vs Temperature**

- **Frequency (GHz):** 1, 2, 3, 4, 5, 6, 7, 8
- **Temperature:** +25C, +85C, -55C
- Values: 0, 5, 10, 15, 20, 25, 30

**Low Frequency OIP3 vs Temperature**

- **Frequency (GHz):** 1, 2, 3, 4, 5, 6, 7, 8
- **Temperature:** +25C, +85C, -55C
- **OIP3 (dBm):** 10, 15, 20, 25, 30, 35, 40

**OIP3 vs. Temperature**

- **Frequency (GHz):** 1, 2, 3, 4, 5, 6, 7, 8
- **Temperature:** +25C, +85C, -55C
- **OIP3 (dBm):** 10, 15, 20, 25, 30, 35, 40

**Low Frequency OIP3 vs Vdd**

- **Frequency (GHz):** 1, 2, 3, 4, 5, 6, 7, 8
- **Input Power (dBm):** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
- **OIP3 (dBm):** 10, 15, 20, 25, 30, 35, 40

---

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106

Phone: 781-329-4700 • Order online at www.analog.com

Application Support: Phone: 1-800-ANALOG-D
HMC994A

GaAs pHEMT MMIC

0.5 WATT POWER AMPLIFIER, DC - 30 GHz

OIP3 vs Vdd
@ Pout/tone = +16dBm

OIP3 vs Idd
@ Pout/tone = +16dBm

Output IM3 @ Vdd=8V

Output IM3 @ Vdd=10V

Output IM3 @ Vdd=11V

Second Harmonics vs. Temperature
@ Pout = +14 dBm
GaAs pHEMT MMIC
0.5 WATT POWER AMPLIFIER, DC - 30 GHz

Second Harmonics vs. Vdd
@ Pout = +14 dBm

Second Harmonics vs. Pout

OIP2 vs. Temperature
@ Pout/tone = +16dBm

OIP2 vs. Vdd
@ Pout/tone = +16dBm

OIP2 vs. Idd
@ Pout/tone = +16dBm

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106
Phone: 781-329-4700 • Order online at www.analog.com
Application Support: Phone: 1-800-ANALOG-D

Downloaded from Arrow.com.
HMC994A

GaAs pHEMT MMIC
0.5 WATT POWER AMPLIFIER, DC - 30 GHz

**Igg1 vs. Input Power**

![Graph of Igg1 vs. Input Power](image1)

**Igg2 vs. Input Power**

![Graph of Igg2 vs. Input Power](image2)

**Idd vs. Vgg1**

![Graph of Idd vs. Vgg1](image3)

Representative of a Typical Device

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106
Phone: 781-329-4700 • Order online at www.analog.com
Application Support: Phone: 1-800-ANALOG-D
HMC994A
v04.0918

GaAs pHEMT MMIC
0.5 WATT POWER AMPLIFIER, DC - 30 GHz

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Bias Voltage (Vdd)</td>
<td>12V</td>
</tr>
<tr>
<td>Gate Bias Voltage (Vgg1)</td>
<td>-3 to 0 Vdc</td>
</tr>
<tr>
<td>Gate Bias Voltage (Vgg2)</td>
<td>2.5V min up to (Vdd - 5.5V)</td>
</tr>
<tr>
<td>RF Input Power (RFIN)</td>
<td>25 dBm</td>
</tr>
<tr>
<td>Output Load VSWR</td>
<td>7:1</td>
</tr>
<tr>
<td>Continuous Pdiss (T= 85 °C)</td>
<td>3.62 W</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65 to 150 °C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-55 to 85 °C</td>
</tr>
<tr>
<td>ESD Sensitivity (HBM)</td>
<td>Class 0B - Passed 150V</td>
</tr>
</tbody>
</table>

Reliability Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Temperature to Maintain 1 Million Hour MTTF</td>
<td>175 °C</td>
</tr>
<tr>
<td>Thermal Resistance (channel to die bottom)</td>
<td>24.8 °C/W</td>
</tr>
</tbody>
</table>

Stresses at or above those listed in the Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only, functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating condition for extended periods may affect product reliability.

Electrostatic Sensitive Device
Observe Handling Precautions

Outline Drawing

Die Packaging Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard GP-1 (Gel Pack)</td>
<td>[2]</td>
</tr>
<tr>
<td>Alternate GP-1 (Gel Pack)</td>
<td>[2]</td>
</tr>
</tbody>
</table>

NOTES:

1. ALL DIMENSIONS IN INCHES [MILLIMETERS]
2. DIE THICKNESS IS 0.004 (0.100)
3. TYPICAL BOND PAD IS 0.004 (0.100) SQUARE
4. BOND PAD METALIZATION: GOLD
5. BACKSIDE METALLIZATION: GOLD
6. BACKSIDE METAL IS GROUND
7. NO CONNECTION REQUIRED FOR UNLABELED BOND PADS
8. OVERALL DIE SIZE IS ±.002

[1] Refer to the “Packaging Information” section on our website for die packaging dimensions.
[2] For alternate packaging information contact Analog Devices Inc.
**HMC994A**

**GaAs pHEMT MMIC**

**0.5 WATT POWER AMPLIFIER, DC - 30 GHz**

## Pad Descriptions

<table>
<thead>
<tr>
<th>Pad Number</th>
<th>Function</th>
<th>Description</th>
<th>Interface Schematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RFIN</td>
<td>This pad is DC coupled and matched to 50 Ohms. Blocking capacitor is required.</td>
<td><img src="image1" alt="RFIN" /></td>
</tr>
<tr>
<td>2</td>
<td>VGG2</td>
<td>Gate control 2 for amplifier. Attach bypass capacitors per application circuit herein. For nominal operation +3.5V should be applied to Vgg2.</td>
<td><img src="image2" alt="Vgg2" /></td>
</tr>
<tr>
<td>3</td>
<td>ACG1</td>
<td>Low frequency termination. Attach bypass capacitor per application circuit herein.</td>
<td><img src="image3" alt="ACG1" /></td>
</tr>
<tr>
<td>4</td>
<td>ACG2</td>
<td>Low frequency termination. Attach bypass capacitor per application circuit herein.</td>
<td><img src="image4" alt="ACG2" /></td>
</tr>
<tr>
<td>5</td>
<td>RFOUT &amp; VDD</td>
<td>RF output for amplifier. Connect DC bias (Vdd) network to provide drain current (Idd). See application circuit herein.</td>
<td><img src="image5" alt="RFOUT &amp; VDD" /></td>
</tr>
<tr>
<td>6</td>
<td>ACG3</td>
<td>Low frequency termination. Attach bypass capacitors per application circuit herein.</td>
<td><img src="image6" alt="ACG3" /></td>
</tr>
<tr>
<td>7</td>
<td>ACG4</td>
<td>Low frequency termination. Attach bypass capacitors per application circuit herein.</td>
<td><img src="image7" alt="ACG4" /></td>
</tr>
<tr>
<td>8</td>
<td>VGG1</td>
<td>Gate control 1 for amplifier. Attach bypass capacitor per application circuit herein. Please follow “MMIC Amplifier Biasing Procedure” application note.</td>
<td><img src="image8" alt="Vgg1" /></td>
</tr>
<tr>
<td>Die Bottom</td>
<td>GND</td>
<td>Die bottom must be connected to RF/DC ground.</td>
<td><img src="image9" alt="GND" /></td>
</tr>
</tbody>
</table>
**Application Circuit**

**NOTE 1:** Drain Bias (Vdd) must be applied through a broadband bias tee with low series resistance and capable of providing 500 mA.

**NOTE 2:** Optional capacitors to be used if part is to be operated below 200MHz.
HMC994A

GaAs pHEMT MMIC
0.5 WATT POWER AMPLIFIER, DC - 30 GHz

Assembly Diagram

= 100pF & 0.01 uF
integrated into one case

= 0.01 uF

= 100 pF
Mounting & Bonding Techniques for Millimeterwave GaAs MMICs

The die should be attached directly to the ground plane eutectically or with conductive epoxy (see HMC general Handling, Mounting, Bonding Note).

50 Ohm Microstrip transmission lines on 0.127mm (5 mil) thick alumina thin film substrates are recommended for bringing RF to and from the chip (Figure 1). If 0.254mm (10 mil) thick alumina thin film substrates must be used, the die should be raised 0.150mm (6 mils) so that the surface of the die is coplanar with the surface of the substrate. One way to accomplish this is to attach the 0.102mm (4 mil) thick die to a 0.150mm (6 mil) thick molybdenum heat spreader (moly-tab) which is then attached to the ground plane (Figure 2).

Microstrip substrates should be placed as close to the die as possible in order to minimize bond wire length. Typical die-to-substrate spacing is 0.076mm to 0.152 mm (3 to 6 mils).

Handling Precautions

Follow these precautions to avoid permanent damage.

Storage: All bare die are placed in either Waffle or Gel based ESD protective containers, and then sealed in an ESD protective bag for shipment. Once the sealed ESD protective bag has been opened, all die should be stored in a dry nitrogen environment.

Cleanliness: Handle the chips in a clean environment. DO NOT attempt to clean the chip using liquid cleaning systems.

Static Sensitivity: Follow ESD precautions to protect against ESD strikes.

Transients: Suppress instrument and bias supply transients while bias is applied. Use shielded signal and bias cables to minimize inductive pick-up.

General Handling: Handle the chip along the edges with a vacuum collet or with a sharp pair of bent tweezers. The surface of the chip may have fragile air bridges and should not be touched with vacuum collet, tweezers, or fingers.

Mounting

The chip is back-metallized and can be die mounted with AuSn eutectic preforms or with electrically conductive epoxy. The mounting surface should be clean and flat.

Eutectic Die Attach: A 80/20 gold tin preform is recommended with a work surface temperature of 255 °C and a tool temperature of 265 °C. When hot 90/10 nitrogen/hydrogen gas is applied, tool tip temperature should be 290 °C. DO NOT expose the chip to a temperature greater than 320 °C for more than 20 seconds. No more than 3 seconds of scrubbing should be required for attachment.

Epoxy Die Attach: Apply a minimum amount of epoxy to the mounting surface so that a thin epoxy fillet is observed around the perimeter of the chip once it is placed into position. Cure epoxy per the manufacturer’s schedule.

Wire Bonding

RF bonds made with two 1 mil wires are recommended. These bonds should be thermosonically bonded with a force of 40-60 grams. DC bonds of 0.001” (0.25 mm) diameter, thermosonically bonded, are recommended. Ball bonds should be made with a force of 40-50 grams and wedge bonds at 18-22 grams. All bonds should be made with a nominal stage temperature of 150 °C. A minimum amount of ultrasonic energy should be applied to achieve reliable bonds. All bonds should be as short as possible, less than 12 mils (0.31 mm).