FEATURES

High saturated output power (P_{SAT}): 25 dBm
High output third-order intercept (IP3): 35 dBm
High gain: 22 dB (24 GHz to 27 GHz)
High output power for 1 dB compression (P_{1dB}): 24 dBm
DC supply: 5 V at 225 mA
Compact 24-lead, 4 mm × 4 mm LCC package

APPLICATIONS

Point-to-point radios
Point-to-multipoint radios
VSAT and SATCOM

GENERAL DESCRIPTION

The HMC1131 is a gallium arsenide (GaAs), pseudomorphic high electron mobility transfer (pHEMT), monolithic microwave integrated circuit (MMIC), driver amplifier that operates from 24 GHz to 35 GHz. The HMC1131 provides 22 dB of gain at the 24 GHz to 27 GHz range, 35 dBm output IP3, and 24 dBm of output power at 1 dB gain compression, while requiring 225 mA from a 5 V supply. The HMC1131 is capable of supplying 25 dBm of saturated output power and is housed in a compact, 4 mm × 4 mm ceramic leadless chip carrier (24-lead LCC). The HMC1131 is an ideal driver amplifier for a wide range of applications, including point-to-point radios, from 24 GHz to 35 GHz.
**HMC1131* Product Page Quick Links**

Last Content Update: 08/30/2016

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**Comparable Parts**
View a parametric search of comparable parts

**Evaluation Kits**
- HMC1131 Evaluation Board

**Documentation**

**Application Notes**
- AN-1363: Meeting Biasing Requirements of Externally Biased RF/Microwave Amplifiers with Active Bias Controllers
- Broadband Biasing of Amplifiers General Application Note
- MMIC Amplifier Biasing Procedure Application Note
- Thermal Management for Surface Mount Components General Application Note

**Data Sheet**
- HMC1131: GaAs, pHEMT, MMIC, Medium Power Amplifier, 24 GHz to 35 GHz Data Sheet

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**Reference Materials**

**Press**
- Medium-Power Driver Amplifier Delivers High Gain and Output Power for Easy Integration in Communications Systems

**Design Resources**
- HMC1131 Material Declaration
- PCN-PDN Information
- Quality And Reliability
- Symbols and Footprints

**Discussions**
View all HMC1131 EngineerZone Discussions

**Sample and Buy**
Visit the product page to see pricing options

**Technical Support**
Submit a technical question or find your regional support number

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TABLE OF CONTENTS

Features .......................................................... 1
Applications......................................................... 1
Functional Block Diagram ..................................... 1
General Description ............................................. 1
Revision History ................................................. 2
Electrical Specifications ....................................... 3
  24 GHz to 27 GHz Frequency Range ..................... 3
  27 GHz to 35 GHz Frequency Range ..................... 3
Absolute Maximum Ratings ................................. 4
ESD Caution ....................................................... 4
Pin Configuration and Function Descriptions .......... 5
  Interface Schematics .......................................... 6
Typical Performance Characteristics .................... 7
Applications Information ...................................... 11
Evaluation PCB .................................................. 12
Typical Application Circuit .................................. 13
Outline Dimensions ........................................... 14
Ordering Guide .................................................. 14

REVISION HISTORY

9/15—Rev. 0 to Rev. A
Changes to Features Section and General Description Section........ 1
Change to Gain Parameter, Table 1 ............................. 3

7/15—Revision 0: Initial Version
ELECTRICAL SPECIFICATIONS

24 GHz TO 27 GHz FREQUENCY RANGE

T<sub>A</sub> = 25°C, V<sub>DD1</sub> = V<sub>DD2</sub> = V<sub>DD3</sub> = V<sub>DD4</sub> = 5 V, I<sub>DD</sub> = 225 mA, unless otherwise stated. Adjust V<sub>G1</sub> and V<sub>G2</sub> between −2 V to 0 V to achieve I<sub>DD</sub> = 225 mA typical.

<table>
<thead>
<tr>
<th>Table 1. Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY RANGE</td>
<td></td>
<td>24</td>
<td>27</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>GAIN</td>
<td></td>
<td>18</td>
<td>22</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Gain Variation Over Temperature</td>
<td></td>
<td>0.031</td>
<td></td>
<td>dB/°C</td>
</tr>
<tr>
<td>RETURN LOSS Input</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>OUTPUT</td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>OUTPUT</td>
<td>P&lt;sub&gt;1dB&lt;/sub&gt;</td>
<td>20</td>
<td>23</td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td></td>
<td>P&lt;sub&gt;SAT&lt;/sub&gt;</td>
<td>27</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>OUTPUT</td>
<td>IP3</td>
<td>34</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>SUPPLY CURRENT</td>
<td>I&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>225</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>4</td>
<td>5</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

1 Measurement taken at P<sub>OUT</sub>/tone = 10 dBm.
2 The amplifier operates over the full voltage ranges shown. V<sub>G1</sub> and V<sub>G2</sub> are adjusted to achieve I<sub>DD</sub> = 225 mA at 5 V.

27 GHz TO 35 GHz FREQUENCY RANGE

T<sub>A</sub> = 25°C, V<sub>DD1</sub> = V<sub>DD2</sub> = V<sub>DD3</sub> = V<sub>DD4</sub> = 5 V, I<sub>DD</sub> = 225 mA, unless otherwise stated. Adjust V<sub>G1</sub> and V<sub>G2</sub> between −2 V to 0 V to achieve I<sub>DD</sub> = 225 mA typical.

<table>
<thead>
<tr>
<th>Table 2. Parameter</th>
<th>Symbol</th>
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<th>Max</th>
<th>Unit</th>
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<td></td>
<td>27</td>
<td>35</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>GAIN</td>
<td></td>
<td>18</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Gain Variation Over Temperature</td>
<td></td>
<td>0.031</td>
<td></td>
<td>dB/°C</td>
</tr>
<tr>
<td>RETURN LOSS Input</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>OUTPUT</td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>OUTPUT</td>
<td>P&lt;sub&gt;1dB&lt;/sub&gt;</td>
<td>21</td>
<td>24</td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td></td>
<td>P&lt;sub&gt;SAT&lt;/sub&gt;</td>
<td>25</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>OUTPUT</td>
<td>IP3</td>
<td>35</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>SUPPLY CURRENT</td>
<td>I&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>225</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>4</td>
<td>5</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

1 Measurement taken at P<sub>OUT</sub>/tone = 10 dBm.
2 The amplifier operates over the full voltage ranges shown. V<sub>G1</sub> and V<sub>G2</sub> are adjusted to achieve I<sub>DD</sub> = 225 mA at 5 V.
ABSOLUTE MAXIMUM RATINGS

Table 3.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Bias Voltage (Vdd)</td>
<td>5.5 V</td>
</tr>
<tr>
<td>RF Input Power (RFIN)</td>
<td>12 dBm</td>
</tr>
<tr>
<td>Channel Temperature</td>
<td>175°C</td>
</tr>
<tr>
<td>Continuous Power Dissipation (Pdiss), T_A = 85°C (Derate 22 mW/°C)</td>
<td>1.97 W</td>
</tr>
<tr>
<td>Thermal Resistance, Rth (Junction to Ground Paddle)</td>
<td>45.5°C/W</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>−40°C to +85°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>−65°C to +150°C</td>
</tr>
<tr>
<td>ESD Sensitivity, Human Body Model (HBM)</td>
<td>Class 0, passed 150 V</td>
</tr>
<tr>
<td>Maximum Peak Reflow Temperature</td>
<td>260°C</td>
</tr>
</tbody>
</table>

Stresses at or above those listed under 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 conditions for extended periods may affect product reliability.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.
## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

**Figure 2. Pin Configuration**

![HMC1131 Top View](image)

**NOTES**
1. NIC = NOT INTERNALLY CONNECTED.
2. THE EXPOSED PAD MUST BE CONNECTED TO RF/DC GROUND.

### Table 4. Pin Function Descriptions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 5 to 7, 9, 10, 12 to 14, 18, 19, 24</td>
<td>NIC</td>
<td>Not Internally Connected. However, all data was measured with these pins connected to RF/dc ground externally.</td>
</tr>
<tr>
<td>2, 4, 15, 17</td>
<td>GND</td>
<td>Ground. These pins must be connected to RF/dc ground.</td>
</tr>
<tr>
<td>3</td>
<td>RFIN</td>
<td>RF Input. This pin is ac-coupled and matched to 50 Ω.</td>
</tr>
<tr>
<td>8</td>
<td>( V_{GG1} )</td>
<td>Gate Bias Pin for the First and Second Stages. External bypass capacitors of 100 pF, 10 nF, and 4.7 μF are required for this pin.</td>
</tr>
<tr>
<td>11</td>
<td>( V_{GG2} )</td>
<td>Gate Bias Pin for the Third and Fourth Stages. External bypass capacitors of 100 pF, 10 nF, and 4.7 μF are required for this pin.</td>
</tr>
<tr>
<td>16</td>
<td>RFOUT</td>
<td>RF Output. This pin is ac-coupled and matched to 50 Ω.</td>
</tr>
<tr>
<td>20 to 23</td>
<td>( V_{DD4} ) to ( V_{DD1} )</td>
<td>Drain Bias Voltage Pins. External bypass capacitors of 100 pF, 10 nF, and 4.7 μF are required for these pins.</td>
</tr>
<tr>
<td></td>
<td>EPAD</td>
<td>Exposed Pad. The exposed pad must be connected to RF/dc ground.</td>
</tr>
</tbody>
</table>
INTERFACE SCHEMATICS

Figure 3. RFIN Interface Schematic

Figure 4. GND Interface Schematic

Figure 5. VGG1/VGG2 Interface Schematic

Figure 6. RFOUT Interface Schematic

Figure 7. VDD1 to VDD4 Interface Schematic
TYPICAL PERFORMANCE CHARACTERISTICS

Figure 8. Response (Broadband Gain and Return Loss) vs. Frequency

Figure 11. Gain vs. Frequency at Various Temperatures

Figure 9. Input Return Loss vs. Frequency at Various Temperatures

Figure 12. Output Return Loss vs. Frequency at Various Temperatures

Figure 10. P1dB vs. Frequency at Various Temperatures

Figure 13. P1dB vs. Frequency at Various Supply Voltages
Figure 14. $P_{\text{SAT}}$ vs. Frequency at Various Temperatures

Figure 15. $P_{\text{1dB}}$ vs. Frequency at Various Supply Currents

Figure 16. Output IP3 vs. Frequency at Various Temperatures, $P_{\text{OUT/Tone}} = 10$ dBm

Figure 17. $P_{\text{SAT}}$ vs. Frequency at Various Supply Voltages

Figure 18. $P_{\text{SAT}}$ vs. Frequency at Various Supply Currents

Figure 19. Output IP3 vs. Frequency at Various Supply Currents, $P_{\text{OUT/Tone}} = 10$ dBm
Figure 20. Output IP3 vs. Frequency for Various Supply Voltages, $P_{\text{OUT}}$/Tone = 10 dBm

Figure 21. Output Third-Order Intermodulation (IM3) vs. $P_{\text{OUT}}$/Tone at $V_{\text{DD}}$ = 5 V

Figure 22. Gain, P1dB, and PSAT vs. Supply Current ($I_{\text{DD}}$) at 30.5 GHz

Figure 23. Output Third-Order Intermodulation (IM3) vs. $P_{\text{OUT}}$/Tone at $V_{\text{DD}}$ = 4 V

Figure 24. Power Compression at 30.5 GHz (PAE is Power Added Efficiency)

Figure 25. Gain, P1dB, and PSAT vs. Supply Voltage ($V_{\text{DD}}$) at 30.5 GHz
Figure 26. Reverse Isolation vs. Frequency at Various Temperatures

Figure 27. Input IP3 vs. $I_{DD}$ over $P_{OUT}$/Tone at 30 GHz, $V_{DD} = 5\, V$, $I_{DD} = 225\, mA$, $I_{DD2}$ = Fixed, and $I_{DD1}$ Varies from 0 mA to 50 mA

Figure 28. Power Dissipation ($P_{DISS}$) at 85°C vs. Input Power for Various Frequencies

Figure 29. Output IP3 vs. $I_{DD}$ over $P_{OUT}$/Tone at 30 GHz, $V_{DD} = 5\, V$, $I_{DD} = 225\, mA$, $I_{DD2}$ = Fixed, and $I_{DD1}$ Varies from 0 mA to 50 mA

Figure 30. Gain vs. $I_{DD}$ over $P_{OUT}$/Tone = 14 dBm at 30 GHz, $V_{DD} = 5\, V$, $I_{DD} = 225\, mA$, $I_{DD2}$ = Fixed, and $I_{DD1}$ Varies from 0 mA to 50 mA
**APPLICATIONS INFORMATION**

The HMC1131 is a GaAs, pHEMT, MMIC, medium power amplifier consisting of four gain stages in series. V\_G\_1 is the gate bias pin for the first and second stages, while V\_G\_2 is the gate bias pin for the third and fourth stages. A simplified block diagram is shown in Figure 31.

All measurements for this device were taken using the evaluation printed circuit board (PCB) in its default configuration. Unless otherwise noted, the V\_G\_1, V\_G\_2, and V\_D\_1 to V\_D\_4 pins were tied together during measurement, respectively.

The following is the recommended bias sequence during power-up:

1. Connect to ground.
2. Set V\_G\_1 and V\_G\_2 to −2 V.
3. Set V\_D\_1 through V\_D\_4 to 5 V.
4. Increase V\_G\_1 and V\_G\_2 to achieve a quiescent IDD = 225 mA.
5. Apply the RF signal.

The following is the recommended bias sequence during power-down:

1. Turn the RF signal off.
2. Decrease V\_G\_1 and V\_G\_2 to −2 V to achieve a quiescent IDD = 0 mA (approximately).
3. Decrease V\_D\_1 through V\_D\_4 to 0 V.
4. Increase V\_G\_1 and V\_G\_2 to 0 V.

The V\_D\_X = 5 V and IDD = 225 mA bias conditions are the operating points recommended to optimize the overall performance. Unless otherwise noted, the data shown was taken using the recommended bias conditions. Operation of the HMC1131 at different bias conditions may result in performance that differs from that shown in Figure 27 and Figure 30. Biasing the HMC1131 for higher drain current typically results in higher P1dB, OIP3, and gain but at the expense of increased power consumption.

![Figure 31. Simplified Block Diagram](image-url)
EVALUATION PCB

Generate the evaluation PCB used in this application with proper RF circuit design techniques. Signal lines at the RF port must have 50 Ω impedance, and the package ground leads and exposed paddle must be connected directly to the ground plane similar to what is shown in Figure 32. Use a sufficient number of via holes to connect the top and bottom ground planes.

![Figure 32. 600-00145-00-1 Evaluation PCB](image)

**Bill of Materials**

Table 5. Evaluation Board (EV1HMC1131LC4) Bill of Materials

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Manufacturer¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1, J2</td>
<td>PCB mount, K connector</td>
<td></td>
</tr>
<tr>
<td>TP1 to TP7</td>
<td>DC pin</td>
<td></td>
</tr>
<tr>
<td>C1 to C6</td>
<td>100 pF capacitors, 0402 package</td>
<td></td>
</tr>
<tr>
<td>C8 to C13</td>
<td>10000 pF capacitors, 0402 package</td>
<td></td>
</tr>
<tr>
<td>C15 to C20</td>
<td>2.2 µF capacitors, 0402 package</td>
<td></td>
</tr>
<tr>
<td>U1</td>
<td>HMC1131LC4</td>
<td>Analog Devices, Inc.</td>
</tr>
<tr>
<td>PCB</td>
<td>600-00145-00-1 evaluation board, Rogers 4350 or Arlon 25FR circuit board material</td>
<td>600-00145-00-1, Analog Devices, Inc.</td>
</tr>
</tbody>
</table>

¹ Blank cells in the manufacturer column left blank intentionally for they are user selectable.
TYPICAL APPLICATION CIRCUIT

Figure 33. Typical Application Circuit
OUTLINE DIMENSIONS

Figure 34. 24-Terminal Ceramic Leadless Chip Carrier (LCC) (HE-24-1)
Dimensions shown in millimeters

ORDERING GUIDE

<table>
<thead>
<tr>
<th>Model</th>
<th>Temperature Range</th>
<th>MSL Rating</th>
<th>Lead Finish</th>
<th>Package Description</th>
<th>Package Option</th>
<th>Branding</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMC1131LC4</td>
<td>−40°C to +85°C</td>
<td>MSL3</td>
<td>Gold over Nickel</td>
<td>24-Terminal LCC</td>
<td>HE-24-1</td>
<td>H131</td>
</tr>
<tr>
<td>HMC1131LC4TR</td>
<td>−40°C to +85°C</td>
<td>MSL3</td>
<td>Gold over Nickel</td>
<td>24-Terminal LCC</td>
<td>HE-24-1</td>
<td>H131</td>
</tr>
<tr>
<td>EV1HMC1131LC4</td>
<td></td>
<td></td>
<td></td>
<td>Evaluation Board</td>
<td></td>
<td>XXXX</td>
</tr>
</tbody>
</table>

1 The HMC1131LC4 and the HMC1131LC4TR are RoHS Compliant.
2 See the Absolute Maximum Ratings section.
3 XXXX is the 4-digit lot number.