FEATURES
32 dBm typical saturated output power (P_{SAT}) at 18% power added efficiency (PAE) at 39 GHz
P1dB compression output power: 31.5 dBm typical
High output third-order intercept (IP3): 40 dBm typical
High gain: 24 dB typical
50 Ω matched input/output
Ceramic, 6 mm × 6 mm, high frequency, air cavity package

APPLICATIONS
Point to point radios
Point to multipoint radios
Very small aperture terminal (VSAT) and satellite communications (SATCOM)

GENERAL DESCRIPTION
The HMC7229LS6 is a four stage, gallium arsenide (GaAs), pseudomorphic high electron mobility transfer (pHEMT), monolithic microwave integrated circuit (MMIC), 1 W power amplifier, with an integrated temperature compensated on-chip power detector that operates between 37 GHz to 40 GHz. The HMC7229LS6 provides 24 dB of gain and 32 dBm of saturated output power at 18% PAE at 39 GHz from a 6 V supply. With an excellent IP3 of 40 dBm, the HMC7229LS6 is ideal for linear applications such as high capacity, point to point or multipoint radios or VSAT/SATCOM applications demanding 32 dBm of efficient saturated output power. The radio frequency (RF) input/outputs are internally matched and dc blocked for ease of integration into higher level assemblies. The HMC7229LS6 is housed in a ceramic, 6 mm × 6 mm, high frequency, air cavity package that exhibits low thermal resistance and is compatible with surface-mount manufacturing techniques.

FUNCTIONAL BLOCK DIAGRAM

Figure 1.
TABLE OF CONTENTS
Features ........................................................................................................... 1
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REVISION HISTORY
12/2017—Rev. C to Rev. D
Changes to Figure 33 ................................................................................ 11

9/2017—Rev. B to Rev. C
Changes to Theory of Operation Section and Figure 33 .................... 11
Changes to Ordering Guide ....................................................................... 15

6/2016—Rev. v01.0514 to Rev. B
This Hittite Microwave Products data sheet has been reformatted
to meet the styles and standards of Analog Devices, Inc.
Updated Format ......................................................................................... Universal
Changes to General Description Section .................................................. 1
Changes to Table 1 ..................................................................................... 3
Added Theory of Operation Section ......................................................... 11
Added Applications Information Section and Recommended Bias Sequence Section ......................................................... 12
Updated Outline Dimensions .................................................................. 15
Changes to Ordering Guide ....................................................................... 15
**SPECIFICATIONS**

**ELECTRICAL SPECIFICATIONS**

$T_A = 25^\circ\text{C}, V_{D01} \text{ to } V_{D04} (V_{DXX}) = 6 \text{ V}, I_{DD} = 1200 \text{ mA (adjust } V_{GG1}/V_{GG2}, V_{GGX}, \text{ between } -2 \text{ V to } 0 \text{ V to achieve an } I_{DD} = 1200 \text{ mA typical}),$ unless otherwise stated.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions/Comments</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY RANGE</td>
<td></td>
<td>37</td>
<td>40</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>GAIN</td>
<td>Gain Variation over Temperature</td>
<td>21</td>
<td>24</td>
<td>0.058</td>
<td>dB/°C</td>
</tr>
<tr>
<td>RETURN LOSS</td>
<td>Input</td>
<td>16</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Output</td>
<td>14</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>OUTPUT POWER</td>
<td>For P1dB Compression</td>
<td>28.5</td>
<td>31.5</td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td></td>
<td>Saturated ($P_{SAT}$)</td>
<td>With 18% PAE at 39 GHz</td>
<td>32</td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>OUTPUT THIRD-ORDER INTERCEPT (IP3)</td>
<td>Measurement taken at $P_{OUT}/\text{tone} = 20 \text{ dBm}$</td>
<td>40</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>TOTAL SUPPLY CURRENT ($I_{DD}$)</td>
<td>$V_{DD} = 5 \text{ V}, V_{DD} = 5.5 \text{ V, and } V_{DD} = 6 \text{ V}$</td>
<td>1200</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>

1 Adjust $V_{GGX}$ to achieve $I_{DD} = 1200 \text{ mA}$. 
### ABSOLUTE MAXIMUM RATINGS

Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Bias Voltage (V_{DDx})</td>
<td>7 V</td>
</tr>
<tr>
<td>RF Input Power (RFIN)</td>
<td>21 dBm</td>
</tr>
<tr>
<td>Channel Temperature</td>
<td>175°C</td>
</tr>
<tr>
<td>Continuous Power Dissipation, P_{Diss} (T = 85°C, Derates 95 mW/°C Above 85°C)</td>
<td>9.0 W</td>
</tr>
<tr>
<td>Thermal Resistance (Channel to Ground Paddle)</td>
<td>10°C/W</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>−65°C to +150°C</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>−40°C to +85°C</td>
</tr>
<tr>
<td>ESD Sensitivity (Human Body Model)</td>
<td>Class 0, passed 150 V</td>
</tr>
</tbody>
</table>

ESD Sensitivity (Human Body Model) Class 0, passed 150 V

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

Table 3. Pin Function Descriptions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 10, 11</td>
<td>VDD1 to VDD4</td>
<td>Drain Bias Voltages. External bypass capacitors of 100 pF, 10 nF, and 4.7 μF are required for each of these pins. See Figure 3.</td>
</tr>
<tr>
<td>3, 9</td>
<td>VGG1, VGG2</td>
<td>Gate Controls for the Power Amplifier. Adjust VGGx to achieve the recommended bias current. External bypass capacitors of 100 pF, 10 nF, and 4.7 μF are required for each of these pins. Apply VGGx bias to either Pin 3 or Pin 9. See Figure 4.</td>
</tr>
<tr>
<td>4, 8</td>
<td>NIC</td>
<td>No Internal Connection. Note that data shown herein was measured with these pins externally connected to RF/dc ground.</td>
</tr>
<tr>
<td>5, 7, 13, 15</td>
<td>GND</td>
<td>Ground Pins. Connect these pins and the exposed ground pad to RF/dc ground. See Figure 5.</td>
</tr>
<tr>
<td>6</td>
<td>RFIN</td>
<td>RF Input. This pin is ac-coupled and matched to 50 Ω. See Figure 6.</td>
</tr>
<tr>
<td>12</td>
<td>VDET</td>
<td>Detector Voltage. This pin is the dc voltage that represents the RF output power rectified by the diode that is biased through an external resistor. See Figure 8.</td>
</tr>
<tr>
<td>14</td>
<td>RFOUT</td>
<td>RF Output. This pin is ac-coupled and matched to 50 Ω. See Figure 9.</td>
</tr>
<tr>
<td>16</td>
<td>VREF</td>
<td>Detector Reference Voltage. This pin is the dc voltage of the diode biased through an external resistor used for the temperature compensation of VDET. See Figure 7.</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. VDD1, VDD2, VDD3, and VDD4 Interface Schematic

Figure 4. VGG1 and VGG2 Interface Schematic

Figure 5. GND Interface Schematic

Figure 6. RFIN Interface Schematic

Figure 7. VREF Interface Schematic

Figure 8. VDET Interface Schematic

Figure 9. RFOUT Interface Schematic
TYPICAL PERFORMANCE CHARACTERISTICS

Figure 10. Gain and Return Loss (S11, S21, and S22) vs. Frequency

Figure 11. Input Return Loss vs. Frequency for Various Temperatures

Figure 12. P1dB vs. Frequency for Various Temperatures

Figure 13. Gain vs. Frequency for Various Temperatures

Figure 14. Output Return Loss vs. Frequency for Various Temperatures

Figure 15. P1dB vs. Frequency for Various Supply Voltages
Figure 22. Output IP3 vs. Frequency for Various Supply Voltages
\[ P_{\text{out/Tone}} = 20 \text{ dBm} \]

Figure 23. Output IM3 at \( V_{\text{DD}} = 5.5 \text{ V} \) vs. \( P_{\text{out/Tone}} \)

Figure 24. Power Compression (\( P_{\text{out}}, \text{Gain}, \text{PAE}, \) and \( I_{\text{DD}} \)) at 38 GHz vs. Input Power

Figure 25. Output IM3 at \( V_{\text{DD}} = 5 \text{ V} \) vs. \( P_{\text{out/Tone}} \)

Figure 26. Output IM3 at \( V_{\text{DD}} = 6 \text{ V} \) vs. \( P_{\text{out/Tone}} \)

Figure 27. Power Compression (\( P_{\text{out}}, \text{Gain}, \text{PAE}, \) and \( I_{\text{DD}} \)) at 39 GHz vs. Input Power
Figure 28. Reverse Isolation vs. Frequency for Various Temperatures

Figure 29. Gain, P1dB, and PSAT vs. Supply Voltage (VDD) at 38.5 GHz

Figure 30. Gain, P1dB, and PSAT vs. Supply Current (IDD) at 38.5 GHz

Figure 31. Power Dissipation vs. Input Power

Figure 32. Detector Voltage (VREF − VDET) vs. Output Power for Various Temperatures at 38.5 GHz
THEORY OF OPERATION

The HMC7229LS6 is gallium arsenide (GaAs), pseudomorphic high electron mobility transfer (pHEMT), monolithic microwave integrated circuit (MMIC), 1 W power amplifier consisting of four gain stages that are in series. Figure 33 shows the simplified block diagram.

The input signal is divided evenly into two, each of these paths are amplified through four independent gain stages, and the amplified signals are then combined at the output. A portion of the RF output signal is directionally coupled to a diode for detection of the RF output power. When the diode is dc biased, it rectifies the RF power and makes it available for measurement as a dc voltage at VDET. To allow for temperature compensation of VDET, a identical and symmetrically located circuit, minus the coupled RF power, is available via VREF. Taking the difference of VREF – VDET provides a temperature compensated signal that is proportional to the RF output. (See Figure 32.)

The HMC7229LS6 has single-ended input and output ports whose impedances are nominally matched to 50 Ω internally over the 37 GHz to 40 GHz frequency range. Consequently, the HMC7229LS6 can directly insert into a 50 Ω system with no impedance matching circuitry required. In addition, multiple HMC7229LS6 devices can be cascaded back to back without requiring external matching circuitry. Similarly, multiple HMC7229LS6 devices can be used with power dividers at the input and power combiners at the output to obtain higher output power levels.

Because the input and output impedances are sufficiently stable vs. the variations in temperature and supply voltage, no impedance matching compensation is required.

To achieve the best performance and not damage the HMC7229LS6, do not exceed the absolute maximum ratings.
APPLICATIONS INFORMATION

Figure 35 shows the basic connections for operating the HMC7229LS6 and see the Theory of Operation section for additional details. The RF input and RF output are ac-coupled by the internal dc block capacitors. To avoid damaging the HMC7229LS6, follow the recommended bias sequencing during power-up and power-down.

The gate bias of the HMC7229LS6 is supplied by using either the VGG1 pin or the VGG2 pin. While applying drain bias to the HMC7229LS6, all of the VDD1, VDD2, VDD3, and VDD4 pins must be used.

RECOMMENDED BIAS SEQUENCE

During Power-Up

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

1. Connect the GND pin to ground.
2. Set VGGX to −2 V.
3. Set VDDX to 6 V.
4. Increase VGGX to achieve a typical IDD = 1200 mA.
5. Apply the RF signal.

During Power-Down

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

1. Turn the RF signal off.
2. Decrease VGGX to −2 V to achieve a typical IDD = 0 mA.
3. Decrease VDDX to 0 V.
4. Increase VGGX to 0 V.

The bias conditions previously listed (VDDX = 6 V, IDD = 1200 mA), are the recommended operating point to get optimum performance. The data used in this data sheet was taken with the recommended bias condition. When using the HMC7229LS6 with different bias conditions, different performance may result than what is shown in the Typical Performance Characteristics section.

The VDET and VREF pins are the output pins for the internal power detector. The VDET pin is the dc voltage output pin that represents the RF output power rectified by the internal diode, which is biased through an external resistor.

The VREF pin is the dc voltage output pin that represents the reference diode voltage, which is biased through an external resistor. This voltage then compensates for the temperature variation effects on both diodes. A typical circuit is shown in the Typical Application Circuit section that reads out the output voltage and represents the RF output power shown in Figure 35.
EVALUATION PRINTED CIRCUIT BOARD (PCB)

Use RF circuit design techniques to create the circuit board for this application. Ensure that signal lines have 50 Ω impedance, and connect the package ground leads and exposed paddle directly to the ground plane similar to that shown in Figure 35.

Use a sufficient number of via holes to connect the top and bottom ground planes. The evaluation circuit board shown in Figure 34 is available from Analog Devices, Inc., upon request.

Table 4. List of Materials for Evaluation PCB

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1, J2</td>
<td>K connector, SRI</td>
</tr>
<tr>
<td>J5, J6</td>
<td>DC pin</td>
</tr>
<tr>
<td>C1 to C6</td>
<td>100 pF capacitors, 0402 package</td>
</tr>
<tr>
<td>C7 to C12</td>
<td>10 nF capacitors, 0603 package</td>
</tr>
<tr>
<td>C13 to C18</td>
<td>4.7 µF capacitors, Case A package</td>
</tr>
<tr>
<td>R1, R2</td>
<td>40.2 kΩ resistors, 0402 package</td>
</tr>
<tr>
<td>U1</td>
<td>HMC7229LS6 amplifier</td>
</tr>
<tr>
<td>PCB</td>
<td>600-00812-00-1 evaluation board PCB, circuit board material is Rogers 4350 or Arlon 25FR</td>
</tr>
</tbody>
</table>
TYPICAL APPLICATION CIRCUIT

Figure 35. Typical Application Circuit
OUTLINE DIMENSIONS

Figure 36. 16-Terminal Ceramic Leadless Chip with Heat Sink [LCC_HS] (EP-16-2)
Dimensions shown in millimeters

ORDERING GUIDE

<table>
<thead>
<tr>
<th>Model</th>
<th>Package Body Material</th>
<th>Lead Finish</th>
<th>Temperature Range</th>
<th>Package Description</th>
<th>Package Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMC7229LS6</td>
<td>Alumina White</td>
<td>Gold over Nickel</td>
<td>−40°C to +85°C</td>
<td>16-Terminal LCC_HS</td>
<td>EP-16-2</td>
</tr>
<tr>
<td>HMC7229LS6TR</td>
<td>Alumina White</td>
<td>Gold over Nickel</td>
<td>−40°C to +85°C</td>
<td>16-Terminal LCC_HS</td>
<td>EP-16-2</td>
</tr>
<tr>
<td>EVAL01-HMC7229LS6</td>
<td>Alumina White</td>
<td>Gold over Nickel</td>
<td>−40°C to +85°C</td>
<td>Evaluation Board</td>
<td>EP-16-2</td>
</tr>
</tbody>
</table>

1 All Models are RoHS-Compliant.