Balanced Power Amplifier, 4 W
13.5 - 15.0 GHz

Features
- High Gain: 26 dB
- P1dB: 37 dBm at 14 GHz
- P3dB: 37.8 dBm at 14 GHz
- IM3 Level: -28 dBc @ P_OUT 28 dBm/tone
- Power Added Efficiency: 27% at P3dB
- Die Size: 2.5 x 3.0 x 0.1 mm
- Integrated Temperature Compensated Power Detector
- Scratch Protection Die Coating
- RoHS* Compliant

Applications
- VSAT

Description
The MAAP-011333-DIE is a balanced 4 Watts power amplifier offered as a bare die part. This power amplifier operates from 13.5 to 15 GHz and provides 26 dB of linear gain and 4 W saturated output power with 27% efficiency while biased at 6 V.

The MAAP-011333-DIE can be used as a power amplifier stage or as a driver stage in higher power applications. This device is ideally suited for linear Ku-band VSAT communications.

This product is fabricated using a GaAs pHEMT process which features full passivation and scratch protection for enhanced reliability.

Functional Schematic

Pin Configuration

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RF_IN</td>
<td>RF Input</td>
</tr>
<tr>
<td>2, 7, 9, 15, 16</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>3, 14</td>
<td>V_G</td>
<td>Gate Voltage</td>
</tr>
<tr>
<td>4, 13</td>
<td>V_D1</td>
<td>Drain Voltage 1</td>
</tr>
<tr>
<td>5, 12</td>
<td>V_D2</td>
<td>Drain Voltage 2</td>
</tr>
<tr>
<td>6, 11</td>
<td>V_D3</td>
<td>Drain Voltage 3</td>
</tr>
<tr>
<td>8</td>
<td>RF_OUT</td>
<td>RF output</td>
</tr>
<tr>
<td>10</td>
<td>DET_O</td>
<td>Detector Output</td>
</tr>
</tbody>
</table>

1. Backside of die must be connected to RF, DC and thermal ground.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-011333-DIE</td>
<td>Gel Pack</td>
</tr>
<tr>
<td>MAAP-011333-DIESMB</td>
<td>Sample Board</td>
</tr>
</tbody>
</table>

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
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Electrical Specifications: Freq. = 14 GHz, \( T_A = +25^\circ\text{C}, V_D = +6 \text{ V}, Z_0 = 50 \Omega \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Units</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>( P_{IN} = 0 \text{ dBm} )</td>
<td>dB</td>
<td>24</td>
<td>26</td>
<td>—</td>
</tr>
<tr>
<td>( P_{OUT} )</td>
<td>( P_{IN} = +14 \text{ dBm} )</td>
<td>dBm</td>
<td>36</td>
<td>37.8</td>
<td>—</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>( P_{OUT} = 28 \text{ dBm} / \text{tone} )</td>
<td>dBc</td>
<td>—</td>
<td>28</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>( P_{SAT} (P_{IN} = +14 \text{ dBm}) )</td>
<td>%</td>
<td>—</td>
<td>27</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>( P_{IN} = -20 \text{ dBm} )</td>
<td>dB</td>
<td>—</td>
<td>17</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>( P_{IN} = -20 \text{ dBm} )</td>
<td>dB</td>
<td>—</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>( I_{DDQ} ) (see bias conditions, page 4)</td>
<td>mA</td>
<td>1700</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Current</td>
<td>( P_{SAT} (P_{IN} = +14 \text{ dBm}) )</td>
<td>mA</td>
<td>—</td>
<td>3600</td>
<td>—</td>
</tr>
</tbody>
</table>

Maximum Operating Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>( P_{IN} \leq 3 \text{ dB Compression} )</td>
</tr>
<tr>
<td>Junction Temperature(^{2,3})</td>
<td>+160°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

2. Operating at nominal conditions with junction temperature \( \leq +160^\circ\text{C} \) will ensure MTTF > \( 1 \times 10^6 \) hours.

3. Junction Temperature \( (T_J) = T_C + \Theta_{JC} \times (V \times I - (P_{OUT} - P_{IN})) \)
   Typical thermal resistance \( (\Theta_{JC}) = 3.63 \, ^\circ\text{C/W} \).
   a) For \( T_C = +25^\circ\text{C} \)
      \( T_J = +86.3^\circ\text{C} @ 6 \text{ V}, 3.84 \text{ A}, P_{OUT} = 37.9 \text{ dBm}, P_{IN} = 15 \text{ dBm} \)
   b) For \( T_C = +85^\circ\text{C} \)
      \( T_J = 142.3^\circ\text{C} @ 6 \text{ V}, 3.42 \text{ A}, P_{OUT} = 36.8 \text{ dBm}, P_{IN} = 15 \text{ dBm} \)

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.

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DC-0022341
Sample Board Layout

Sample Board Thru Loss
Refer to the plot on page 6 for sample board thru losses.

Sample Board Material Specifications
- Top Layer: 1/2 oz Copper Cladding, 0.0175 mm thickness
- Dielectric Layer: Rogers RO4350B 0.101 mm thickness
- Bottom Layer: 1/2 oz Copper Cladding, 0.0175 mm thickness
- Finished overall thickness: 0.136 mm

Parts List

<table>
<thead>
<tr>
<th>Part</th>
<th>Value</th>
<th>Case Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - C8</td>
<td>0.01 µF</td>
<td>0402</td>
</tr>
<tr>
<td>C9 - C13</td>
<td>22 µF</td>
<td>0603</td>
</tr>
<tr>
<td>R1 - R8</td>
<td>10 Ω</td>
<td>0402</td>
</tr>
<tr>
<td>L1 - L4</td>
<td>Ferrite Bead MURATA BLM18HE601SN1D</td>
<td>0603</td>
</tr>
</tbody>
</table>

Application Schematic

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Recommended Bonding Diagram and PCB Details:
For optimum performance, RF input and output microstrip lines require open stubs on the application board for bonding wire inductance compensation. Optimum bonding wire inductance for the RF I/O connection is 0.2 nH and physical length for the 1 mil diameter gold wire is approximately 350 µm each for the two wire connection.

Biasing conditions
Recommended biasing conditions are $V_D = 6$ V, $I_{DQ} = 1.7$ A (controlled with $V_G$). The drain bias voltage range is 4 to 6 V, and the quiescent drain current biasing range is 1.5 to 2.5 A.

$V_G$ pins 2 and 13 are internally connected; therefore, interconnection is not required. Muting can be accomplished by setting the $V_G$ to the pinched off voltage ($V_G = -2$ V).

$V_D$ Bias must be applied to $V_D1$, $V_D2$ and $V_D3$ pins from north and south sides. North $V_D$ supplies and south $V_D$ supplies are not connected internally.

Operating the MAAP-011333-DIE

Turn-on
1. Apply $V_G$ (-1.5 V).
2. Apply $V_D$ (6.0 V typical).
3. Set $I_{DQ}$ by adjusting $V_G$ more positive (typically -0.9 to -1.0 V for $I_{DQ} = 1.7$ A).
4. Apply RF$_{IN}$ signal.

Turn-off
1. Remove RF$_{IN}$ signal.
2. Decrease $V_G$ to -1.5 V.
3. Decrease $V_D$ to 0 V.
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Typical Performance Curves: \( V_D = 6 \text{ V}, \ I_{DSQ} = 1700 \text{ mA} \)

**Small Signal Gain vs. Frequency over Temperature**

**Small Signal Gain vs. Frequency over Bias Voltage**

**Input Return Loss vs. Frequency over Temperature**

**Input Return Loss vs. Frequency over Bias Voltage**

**Output Return Loss vs. Frequency over Temperature**

**Output Return Loss vs. Frequency over Bias Voltage**
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Typical Performance Curves: $V_D = 6$ V, $I_{DSQ} = 1700$ mA

**P3dB vs. Frequency over Temperature**

![P3dB vs. Frequency over Temperature graph]

**P3dB vs. Frequency over Bias Voltage**

![P3dB vs. Frequency over Bias Voltage graph]

**P1dB vs. Frequency over Temperature**

![P1dB vs. Frequency over Temperature graph]

**P1dB vs. Frequency over Bias Voltage**

![P1dB vs. Frequency over Bias Voltage graph]

**Sample Board Thru Loss**

*Includes Two 2.4mm Connectors*

![Sample Board Thru Loss graph]
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Typical Performance Curves: \( V_D = 6 \text{ V}, \; I_{DSQ} = 1700 \text{ mA} \)

**IM3 vs. Output Power by Temperature @ 13.75 GHz**

**IM3 vs. Output Power by Frequency**

**IM3 vs. Output Power by Temperature @ 14.5 GHz**

**IM3 Frequency @ Output Power = 28 dBm/tone**

**IM3 vs. Output Power by Temperature @ 15 GHz**

**Output IP3 vs. Output Power by Frequency**

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Typical Performance Curves: $V_D = 6$ V

IM3 vs. Output Power by Drain Current @ 13.75 GHz

IM3 vs. Frequency by Drain Current @ Pout = 28 dBm/tone

IM3 vs. Output Power by Drain Current @ 14.5 GHz

Output IP3 vs. Output Power by Drain Current @ 14.5 GHz

IM3 vs. Output Power by Drain Current @ 15 GHz

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Typical Performance Curves: \( V_D = 6 \text{ V} \), \( I_{DSQ} = 1700 \text{ mA} \)

**Output Power vs. Input Power**

**Gain and PAE @ P3dB vs. Frequency**

**Drain Current vs. Input Power**

**PAE vs. Input Power**

**Gate Current vs. Frequency @ \( P_{SAT} \)**

**Detector Voltage vs. Output Power @ 14 GHz**
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MMIC Die Outline\textsuperscript{7,8}

7. All units are in µm, unless otherwise noted, with a tolerance of ±5 µm.
8. Die thickness is 100 ±10 µm.

Bond Pad Detail\textsuperscript{9}

<table>
<thead>
<tr>
<th>Pad</th>
<th>Size (x)</th>
<th>Size (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 8</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>3, 14</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>4, 13</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>5, 12</td>
<td>160</td>
<td>100</td>
</tr>
<tr>
<td>6, 11</td>
<td>240</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

9. Pin 2, 7, 9, 15, and 16 are not in use.
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