MAAP-011250

Power Amplifier, 4 W
27.5 - 30 GHz

Features

- High Gain: 24 dB
- P1dB: 34.8 dBm
- P3dB: 36 dBm
- IM3 Level: -23 dBc @ P_out = 30 dBm/tone
- Power Added Efficiency: 20% @ P3dB
- Temperature Compensated Output Power Detector
- Lead-Free 5 mm AQFN 32-lead Package
- RoHS* Compliant

Description

The MAAP-011250 is a balanced 4 W, 4-stage power amplifier assembled in a lead-free 5 mm 32-lead AQFN plastic package. This power amplifier operates from 27.5 to 30 GHz and provides 24 dB of linear gain, 4 W saturated output power and 20% efficiency while biased at 6 V.

The MAAP-011250 can be used as a power amplifier stage or as a driver stage in higher power applications. This device is ideally suited for VSAT and 28 GHz PTP applications.

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

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-011250-TR0500</td>
<td>500 Piece Reel</td>
</tr>
<tr>
<td>MAAP-011250-SMB</td>
<td>Sample Board</td>
</tr>
</tbody>
</table>

1. Reference Application Note M513 for reel size information.
2. All sample boards include 3 loose parts.

Functional Schematic

Pin Configuration

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 3, 8, 9, 16, 17, 20, 22, 24, 25, 32</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>2, 5, 6, 7, 13, 18, 23, 30</td>
<td>N/C</td>
<td>No Connection</td>
</tr>
<tr>
<td>4</td>
<td>RF_IN</td>
<td>RF Input</td>
</tr>
<tr>
<td>10, 11, 31</td>
<td>V_G</td>
<td>Gate Voltage</td>
</tr>
<tr>
<td>12, 29</td>
<td>V_D1</td>
<td>Drain Voltage 1</td>
</tr>
<tr>
<td>14, 27, 28</td>
<td>V_D2</td>
<td>Drain Voltage 2</td>
</tr>
<tr>
<td>15, 26</td>
<td>V_D3</td>
<td>Drain Voltage 3</td>
</tr>
<tr>
<td>19</td>
<td>DET</td>
<td>Detector</td>
</tr>
<tr>
<td>21</td>
<td>RF_OUT</td>
<td>RF Output</td>
</tr>
</tbody>
</table>

3. MACOM recommends connecting all No Connection (N/C) pins to ground.
4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
Power Amplifier, 4 W
27.5 - 30 GHz

Electrical Specifications: Freq. = 27.5 & 30 GHz, $T_A = +25^\circ C$, $V_D = 6$ 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>$P_{IN} = 0$ dBm, 27.5 GHz</td>
<td>dB</td>
<td>21.0</td>
<td>26.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>$P_{IN} = 0$ dBm, 30.0 GHz</td>
<td></td>
<td>21.0</td>
<td>24.5</td>
<td>—</td>
</tr>
<tr>
<td>$P_{OUT}^5$</td>
<td>$P_{IN} = 14.5$ dBm, 27.5 GHz</td>
<td>dBm</td>
<td>34.5</td>
<td>37.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>$P_{IN} = 15.0$ dBm, 30.0 GHz</td>
<td></td>
<td>34.5</td>
<td>36.0</td>
<td>—</td>
</tr>
<tr>
<td>IM3</td>
<td>$P_{OUT} = 30$ dBm / tone</td>
<td>dBc</td>
<td>—</td>
<td>-23</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Freq. = 27.5 - 30 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{IN} = 14.5$ dBm, Freq. = 27.5 - 30 GHz</td>
<td>%</td>
<td>—</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$P_{IN} = -20$ dBm, Freq. = 27.5 - 30 GHz</td>
<td>dB</td>
<td>—</td>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>$P_{IN} = -20$ dBm, Freq. = 27.5 - 30 GHz</td>
<td>dB</td>
<td>—</td>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>$I_{DSQ}$ (see bias conditions, page 4)</td>
<td>mA</td>
<td>—</td>
<td>2300</td>
<td>—</td>
</tr>
<tr>
<td>Drain Current (V_D1 + V_D2 + V_D3)</td>
<td>$P_{IN} = 14.5$ dBm</td>
<td>mA</td>
<td>—</td>
<td>3600</td>
<td>4300</td>
</tr>
</tbody>
</table>

5. MACOM does not recommend sustained operation at power levels above 3 dB gain compression.

Maximum Operating Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power$^5$</td>
<td>15 dBm</td>
</tr>
<tr>
<td>Junction Temperature$^6,7$</td>
<td>+160°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

6. Operating at nominal conditions with junction temperature ≤ +160°C will ensure MTTF > 1 x 10^8 hours.

7. Junction Temperature ($T_J$) = $T_C + \Theta_{JC} \times ((V \times I) - (P_{OUT} - P_{IN}))$ 
   Typical thermal resistance ($\Theta_{JC}$) = 4°C/W.
   a) For $T_C = +25°C$
      $T_J = +88^\circ C @ 6$ V, 3.3 A, $P_{OUT} = 36$ dBm, $P_{IN} = 14.5$ dBm
   b) For $T_C = +85°C$
      $T_J = +146^\circ C @ 6$ V, 3.0 A, $P_{OUT} = 34.5$ dBm, $P_{IN} = 14.5$ 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.
Sample Board Layout

Application Schematic

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 - C12</td>
<td>22 µF</td>
<td>0603</td>
</tr>
<tr>
<td>R1 - R8</td>
<td>10 Ω</td>
<td>0402</td>
</tr>
<tr>
<td>J1</td>
<td>jumper</td>
<td>0603</td>
</tr>
</tbody>
</table>

Sample Board Material Specifications

Top Layer: 1/2 oz Copper Cladding, 0.017 mm thickness  
Dielectric Layer: Rogers RO4003C 0.203 mm thickness  
Bottom Layer: 1/2 oz Copper Cladding, 0.017 mm thickness  
Finished overall thickness: 0.238 mm
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Recommended PCB Layout Detail:
RF input and output pre-matching circuit patterns are identical and are designed to compensate packaging effects. Transmission line dimensions apply to a PCB with 0.203 mm thick Rogers RO4003C laminate dielectric. Performance curves shown in this data sheet were measured with these circuit patterns.

Operating the MAAP-011250

Turn-on
1. Apply \( V_G \) (-1.5 V).
2. Apply \( V_D \) (6.0 V typical).
3. Set \( I_{DSQ} \) by adjusting \( V_G \) more positive (typically -0.9 to -1.0 V for \( I_{DSQ} = 2.3 \) 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.

Biasing Conditions
Recommended biasing conditions are \( V_D = 6 \) V, \( I_{DSQ} = 2.3 \) A (controlled with \( V_G \)). The drain bias voltage range is 3 to 6 V, and the quiescent drain current biasing range is 2 to 2.5 A.

\( V_G \) pins 10 and 11 are connected internally but are not connected to pin 31; \( V_G \) bias must be applied to pins 31 and 10 or 11. 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 all \( V_{DX} \) pins (\( V_{D1}, V_{D2}, \) and \( V_{D3} \)) on both sides of device as these pins are not internally connected.
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Typical Performance Curves: \( V_D = 6 \) V, \( I_{DSQ} = 2300 \) 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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Power Amplifier, 4 W
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Typical Performance Curves: $V_D = 6 \text{ V}$, $I_{DSQ} = 2300 \text{ mA}$

- **$P_{3dB}$ vs. Frequency over Temperature**
- **$P_{1dB}$ vs. Frequency over Temperature**
- **$P_{3dB}$ vs. Frequency over Bias Voltage**
- **$P_{1dB}$ vs. Frequency over Bias Voltage**
Power Amplifier, 4 W
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Typical Performance Curves: $V_D = 6\,\text{V}$, $I_{DSQ} = 2300\,\text{mA}$

**Output IP3 over Temperature ($P_{OUT} = 30\,\text{dBm} /\text{Tone}$)**

![Graph showing OIP3 over Frequency for different temperatures.]

**Output IP3 over Bias Voltage ($P_{OUT} = 30\,\text{dBm} /\text{Tone}$)**

![Graph showing OIP3 over Frequency for different bias voltages.]

**IM3 over Temperature ($P_{OUT} = 30\,\text{dBm} /\text{Tone}$)**

![Graph showing IM3 over Frequency for different temperatures.]

**IM3 over Bias Voltage ($P_{OUT} = 30\,\text{dBm} /\text{Tone}$)**

![Graph showing IM3 over Frequency for different bias voltages.]

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Typical Performance Curves: \( V_D = 6 \text{ V}, I_{DSQ} = 2300 \text{ mA} \)

\begin{align*}
\text{P1dB, P3dB vs. Frequency} & \quad \text{Gain and PAE @ P3dB vs. Frequency} \\
\text{IM3 vs. Output Power} & \quad \text{Output IP3 vs. Output Power}
\end{align*}
Power Amplifier, 4 W
27.5 - 30 GHz

Typical Performance Curves: $V_D = 6$ V, $I_{DSQ} = 2300$ mA

Output Power vs. Input Power

PAE vs. Input Power

Bias Current vs. Input Power

Quiescent Drain Current vs. Temperature

Detector Voltage vs. Output Power @ 29 GHz
Lead-Free 5 mm 32-Lead AQFN Package†

† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is NiPdAu.
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