MAAP-011233

Power Amplifier, 4 W
28.5 - 31.0 GHz

Features
- High Gain: 25 dB @ 30 GHz
- P1dB: 34.5 dBm
- P3dB: 36.0 dBm
- IM3 Level: -27 dBc @ P_OUT 29 dBm/tone
- Power Added Efficiency: 27.5% @ P3dB
- Lead-Free 5 mm 32-lead AQFN Package
- RoHS* Compliant

Description
The MAAP-011233 is a 4-stage, 4 W power amplifier assembled in a lead-free 5 mm 32-lead AQFN plastic package. This power amplifier operates from 28.5 to 31.0 GHz and provides 26 dB of linear gain, 4 W saturated output power and 27.5% efficiency while biased at 6 V.

The MAAP-011233 can be used as a power amplifier ideally suited for VSAT communications.

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

Ordering Information¹,²

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-011233</td>
<td>Bulk</td>
</tr>
<tr>
<td>MAAP-011233-TRP0500</td>
<td>500 Piece Reel</td>
</tr>
<tr>
<td>MAAP-011233-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 Configuration³,⁴

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 3, 5, 8, 9, 16, 17, 20, 22, 24, 25, 32</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>2, 6, 7, 12, 13, 18, 19, 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</td>
<td>VG</td>
<td>Gate Voltage</td>
</tr>
<tr>
<td>14, 27, 28</td>
<td>VD3</td>
<td>Drain Voltage 3</td>
</tr>
<tr>
<td>15, 26</td>
<td>VD4</td>
<td>Drain Voltage 4</td>
</tr>
<tr>
<td>21</td>
<td>RF_OUT</td>
<td>RF Output</td>
</tr>
<tr>
<td>29</td>
<td>VD2</td>
<td>Drain Voltage 2</td>
</tr>
<tr>
<td>31</td>
<td>VD1</td>
<td>Drain Voltage 1</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.
Electrical Specifications:  Freq. = 30 GHz, $T_A = +25^\circ$C, $V_D = 6$ V, $Z_0 = 50$ Ω

<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</td>
<td>dB</td>
<td>22</td>
<td>25.0</td>
<td>—</td>
</tr>
<tr>
<td>$P_{OUT}$</td>
<td>$P_{IN} = +14$ dBm</td>
<td>dBm</td>
<td>34.5</td>
<td>36.0</td>
<td>—</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>$P_{OUT} = 29$ dBm/tone</td>
<td>dBC</td>
<td>—</td>
<td>-27.0</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{IN} = +14$ dBm</td>
<td>%</td>
<td>—</td>
<td>27.5</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$P_{IN} = -20$ dBm</td>
<td>dB</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>$P_{IN} = -20$ dBm</td>
<td>dB</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>$I_{DO}$ (see bias conditions, page 4)</td>
<td>mA</td>
<td>—</td>
<td>2000</td>
<td>—</td>
</tr>
<tr>
<td>Current</td>
<td>$P_{IN} = +14$ dBm</td>
<td>mA</td>
<td>—</td>
<td>2800</td>
<td>3600</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>14 dBm</td>
</tr>
<tr>
<td>Junction Temperature$^{5,6}$</td>
<td>$+160^\circ$C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

Absolute Maximum Ratings$^{7,8}$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>20 dBm</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>6.5 V</td>
</tr>
<tr>
<td>Gate Voltage</td>
<td>-3 to 0 V</td>
</tr>
<tr>
<td>Junction Temperature$^8$</td>
<td>$+175^\circ$C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +125°C</td>
</tr>
</tbody>
</table>

5. Operating at nominal conditions with junction temperature $< +160^\circ$C will ensure MTTF $> 1 \times 10^6$ hours.
6. Junction Temperature ($T_J = T_C + \Theta_{JC} \cdot (V* I) - (P_{OUT} - P_{IN})$). Typical thermal resistance ($\Theta_{JC}$) is 4.4 °C/W.
   a) For $T_C = +25^\circ$C, $T_J = +82^\circ$C @ 6 V, 2.8 A, $P_{OUT} = 36$ dBm, $P_{IN} = 14$ dBm
   b) For $T_C = +85^\circ$C, $T_J = +137^\circ$C @ 6 V, 2.5 A, $P_{OUT} = 35$ dBm, $P_{IN} = 14$ dBm

Handling Procedures
Please observe the following precautions to avoid damage:

Static Sensitivity
These electronics 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**

![Sample Board Layout Diagram]

**Application Schematic**

![Application Schematic Diagram]

**Parts List**

<table>
<thead>
<tr>
<th>Part</th>
<th>Value</th>
<th>Case Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - C7</td>
<td>0.01 µF</td>
<td>0402</td>
</tr>
<tr>
<td>C8 - C12</td>
<td>1 µF</td>
<td>0603</td>
</tr>
<tr>
<td>C13 - C16</td>
<td>10 µF</td>
<td>0805</td>
</tr>
<tr>
<td>R1 - R7</td>
<td>10 Ω</td>
<td>0402</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
**Sample Board Layout:**
RF input and output port pre-matching circuit patterns are designed to compensate for packaging effects. Input and output patterns are identical.

![Sample Board Layout Diagram]

**Biasing Conditions**
Recommended biasing conditions are \( V_D = 6 \text{ V} \), \( I_{DO} = 2 \text{ A} \) (controlled with \( V_G \)). The drain bias voltage range is 3 to 6 V, and the quiescent drain current biasing range is 1.5 to 2.5 A.

\( V_G \) pins 10 and 11 are connected internally; choose either pin for layout convenience. Muting can be accomplished by setting the \( V_G \) to the pinched off voltage (\( V_G = -2 \text{ V} \)).

\( V_D \) bias must be applied to \( V_D1 \), \( V_D2 \), \( V_D3 \), and \( V_D4 \) pins.

\( V_D3 \) pins 14 and either pin 27 or 28 are required for current symmetry. Pins 27 and 28 are connected internally; choose either pin for layout convenience.

Both \( V_D4 \) pins 15 and 26 are required for current symmetry.

**Operating the MAAP-011233**

**Turn-on**
1. Apply \( V_G \) (-1.5 V).
2. Apply \( V_{D1}, V_{D2}, V_{D3}, V_{D4} \) (6.0 V typical).
3. Set \( I_{DO} \) by adjusting \( V_G \) more positive (typically -0.9 to -1.0 V for \( I_{DO} = 2 \text{ A} \)).
4. Apply \( RF_{IN} \) signal.

**Turn-off**
1. Remove \( RF_{IN} \) signal.
2. Decrease \( V_G \) to -1.5 V.
3. Decrease \( V_{D1}, V_{D2}, V_{D3}, V_{D4} \) to 0 V.

**Application Information**
The MAAP-011233 is designed to be easy to use yet high performance. The ultra small size and simple bias allow easy placement on system board. RF input and output ports are DC de-coupled internally.
Typical Performance Curves

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

- **S21 (dB)**
  - Frequency (GHz)
  - Temperature: +25°C, -40°C, +85°C

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

- **S11 (dB)**
  - Frequency (GHz)
  - Temperature: +25°C, -40°C, +85°C

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

- **S22 (dB)**
  - Frequency (GHz)
  - Temperature: +25°C, -40°C, +85°C

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

- **S21 (dB)**
  - Frequency (GHz)
  - Bias Voltage: 5.5 V, 6.0 V, 6.5 V

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

- **S11 (dB)**
  - Frequency (GHz)
  - Bias Voltage: 5.5 V, 6.0 V, 6.5 V

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

- **S22 (dB)**
  - Frequency (GHz)
  - Bias Voltage: 5.5 V, 6.0 V, 6.5 V
Power Amplifier, 4 W
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Typical Performance Curves

**P3dB vs. Frequency over Temperature**

**P3dB vs. Frequency over Bias Voltage**

**P1dB vs. Frequency over Temperature**

**P1dB vs. Frequency over Bias Voltage**

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Typical Performance Curves: $P_{\text{OUT}} = 29 \text{ dBm} / \text{Tone}$

**Output IP3 vs. Frequency over Temperature**

**Output IP3 vs. Frequency over Bias Voltage**

**IM3 vs. Frequency over Temperature**

**IM3 vs. Frequency over Bias Voltage**
Power Amplifier, 4 W
28.5 - 31.0 GHz

Typical Performance Curves

**P1dB & P3dB vs. Frequency**

![Graph showing P1dB & P3dB vs. Frequency](image)

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

![Graph showing PAE & Gain @ P3dB vs. Frequency](image)

**IM3 vs. Output Power**

![Graph showing IM3 vs. Output Power](image)

**Output IP3 vs. Output Power**

![Graph showing Output IP3 vs. Output Power](image)
Typical Performance Curves

**Output Power vs. Input Power**

**PAE vs. Input Power**

**Bias Current vs. Input Power**

**Quiescent Drain Current vs. Temperature**
Lead-Free 5 mm 32-Lead AQFN Package†

All dimensions shown as inches [mm].

† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is NiPdAu.
Power Amplifier, 4 W
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