MAAP-011233

Power Amplifier, 4 W
28.5 - 31 GHz

Features

- High Gain: 25 dB @ 30 GHz
- P1dB: 34.5 dBm
- P3dB: 36 dBm
- IM3 Level: -27 dBc @ POUT 29 dBm/tone
- Power Added Efficiency: 27.5 % at 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 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 Information

<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-TR0500</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 Configuration

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>RFIN</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>RFOUT</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>
<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>
</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.

Power Amplifier, 4 W  
28.5 - 31 GHz 

Electrical Specifications: Freq. = 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>$P_{IN} = 0 \text{ dBm}$</td>
<td>dB</td>
<td>22</td>
<td>25.0</td>
<td>—</td>
</tr>
<tr>
<td>$P_{OUT}$</td>
<td>$P_{IN} = +14 \text{ dBm}$</td>
<td>dBm</td>
<td>34.5</td>
<td>36.0</td>
<td>—</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>$P_{OUT} = 29 \text{ dBm} / \text{tone}$</td>
<td>dBC</td>
<td>—</td>
<td>-27.0</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{IN} = +14 \text{ dBm}$</td>
<td>%</td>
<td>—</td>
<td>27.5</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$P_{IN} = -20 \text{ dBm}$</td>
<td>dB</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>$P_{IN} = -20 \text{ dBm}$</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>$P_{IN} = +14 \text{ dBm}$</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</td>
<td>$+160^\circ C$</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>$-40^\circ C$ to $+85^\circ C$</td>
</tr>
</tbody>
</table>

Absolute Maximum Ratings

<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</td>
<td>$+175^\circ C$</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$-65^\circ C$ to $+125^\circ C$</td>
</tr>
</tbody>
</table>

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

Application Schematic

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>
<tr>
<td>L1 - L4</td>
<td>BLM18HE601SN1D</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

For further information and support please visit:
https://www.macom.com/support
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.

Biasing Conditions
Recommended biasing conditions are $V_D = 6\, \text{V}$, $I_DQ = 2\, \text{A}$ (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 $I_D$ by adjusting $V_G$ more positive (typically -0.9 to -1.0 V for $I_D = 2\, \text{A}$).
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.
Power Amplifier, 4 W
28.5 - 31 GHz

Typical Performance Curves

Small Signal Gain vs. Frequency over Temperature

![Small Signal Gain vs. Frequency over Temperature](image1)

Small Signal Gain vs. Frequency over Bias Voltage

![Small Signal Gain vs. Frequency over Bias Voltage](image2)

Input Return Loss vs. Frequency over Temperature

![Input Return Loss vs. Frequency over Temperature](image3)

Input Return Loss vs. Frequency over Bias Voltage

![Input Return Loss vs. Frequency over Bias Voltage](image4)

Output Return Loss vs. Frequency over Temperature

![Output Return Loss vs. Frequency over Temperature](image5)

Output Return Loss vs. Frequency over Bias Voltage

![Output Return Loss vs. Frequency over Bias Voltage](image6)
Typical Performance Curves

$P_{3dB}$ vs. Frequency over Temperature

$P_{3dB}$ vs. Frequency over Bias Voltage

$P_{1dB}$ vs. Frequency over Temperature

$P_{1dB}$ vs. Frequency over Bias Voltage
Typical Performance Curves: $P_{\text{out}} = 29 \text{ dBm} / \text{Tone}$

**Output IP3 vs. Frequency over Temperature**

- Frequency (GHz): 28.5 to 31.0
- Temperature: -25°C, 25°C, 40°C

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

- Frequency (GHz): 28.5 to 31.0
- Bias Voltage: 5.5 V, 6.0 V, 6.5 V

**IM3 vs. Frequency over Temperature**

- Frequency (GHz): 28.5 to 31.0
- Temperature: -25°C, 25°C, 40°C

**IM3 vs. Frequency over Bias Voltage**

- Frequency (GHz): 28.5 to 31.0
- Bias Voltage: 5.5 V, 6.0 V, 6.5 V
Power Amplifier, 4 W
28.5 - 31 GHz

Typical Performance Curves

**P1dB & P3dB vs. Frequency**

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

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

![Graph showing PAE and Gain 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**

![Graph showing output power vs. input power with curves for 28 GHz, 30 GHz, and 31 GHz.]

**PAE vs. Input Power**

![Graph showing power-added efficiency (PAE) vs. input power with curves for 28 GHz, 30 GHz, and 31 GHz.]

**Bias Current vs. Input Power**

![Graph showing bias current vs. input power with curves for 28 GHz, 30 GHz, and 31 GHz.]

**Quiescent Drain Current vs. Temperature**

![Graph showing quiescent drain current vs. temperature.]

MACOM Technology Solutions Inc. (MACOM) and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice.

Visit [www.macom.com](http://www.macom.com) for additional data sheets and product information.

For further information and support please visit: [https://www.macom.com/support](https://www.macom.com/support)
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.
MACOM Technology Solutions Inc. All rights reserved.

Information in this document is provided in connection with MACOM Technology Solutions Inc ("MACOM") products. These materials are provided by MACOM as a service to its customers and may be used for informational purposes only. Except as provided in MACOM's Terms and Conditions of Sale for such products or in any separate agreement related to this document, MACOM assumes no liability whatsoever. MACOM assumes no responsibility for errors or omissions in these materials. MACOM may make changes to specifications and product descriptions at any time, without notice. MACOM makes no commitment to update the information and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to its specifications and product descriptions. No license, express or implied, by estoppels or otherwise, to any intellectual property rights is granted by this document.

THESE MATERIALS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, CONSEQUENTIAL OR INCIDENTAL DAMAGES, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. MACOM FURTHER DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. MACOM SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS, WHICH MAY RESULT FROM THE USE OF THESE MATERIALS.

MACOM products are not intended for use in medical, lifesaving or life sustaining applications. MACOM customers using or selling MACOM products for use in such applications do so at their own risk and agree to fully indemnify MACOM for any damages resulting from such improper use or sale.