MAAP-011246

Power Amplifier, 2 W
27.5 - 31.5 GHz

Features
- High Gain: 23 dB
- P1dB: 30 dBm
- P\(_{\text{SAT}}\): 33 dBm
- IM3 Level: -22 dBc @ P\(_{\text{OUT}}\) 27 dBm/tone
- Power Added Efficiency: 24\% at P\(_{\text{SAT}}\)
- Lead-Free 5 mm AQFN 32-lead Package
- RoHS\(^*\) Compliant

Description
The MAAP-011246 is a 2 Watt, 4-stage power amplifier assembled in a lead-free 5 mm 32-lead A QFN plastic package. This power amplifier operates from 27.5 to 31.5 GHz and provides 23 dB of linear gain, 2 W saturated output power and 24\% efficiency while biased at 6 V.

The MAAP-011246 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\(^{1,2}\)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-011246-TR0500</td>
<td>500 Piece Reel</td>
</tr>
<tr>
<td>MAAP-011246-1SMB</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\(^3\)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Function</th>
<th>Pin #</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground</td>
<td>20</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>No Connection</td>
<td>21</td>
<td>RF Output</td>
</tr>
<tr>
<td>3</td>
<td>Ground</td>
<td>22</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>RF Input</td>
<td>23</td>
<td>No Connection</td>
</tr>
<tr>
<td>5 - 7</td>
<td>No Connection</td>
<td>24, 25</td>
<td>Ground</td>
</tr>
<tr>
<td>8, 9</td>
<td>Ground</td>
<td>26</td>
<td>Drain Voltage 4</td>
</tr>
<tr>
<td>10</td>
<td>Gate Voltage</td>
<td>27, 28</td>
<td>Drain Voltage 3</td>
</tr>
<tr>
<td>11</td>
<td>Gate Voltage</td>
<td>29</td>
<td>Drain Voltage 2</td>
</tr>
<tr>
<td>12 - 14</td>
<td>No Connection</td>
<td>30</td>
<td>No Connection</td>
</tr>
<tr>
<td>15</td>
<td>Drain Voltage 4</td>
<td>31</td>
<td>Drain Voltage 1</td>
</tr>
<tr>
<td>16, 17</td>
<td>Ground</td>
<td>32</td>
<td>Ground</td>
</tr>
<tr>
<td>18, 19</td>
<td>No Connection</td>
<td>Paddle(^4)</td>
<td>Ground</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, 2 W
27.5 - 31.5 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>19</td>
<td>22</td>
<td>—</td>
</tr>
<tr>
<td>$P_{OUT}$</td>
<td>$P_{IN} = 15 , \text{dBm}$</td>
<td>dBm</td>
<td>31.5</td>
<td>33</td>
<td>—</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>$P_{OUT} = 27 , \text{dBm} / \text{tone}$</td>
<td>dBc</td>
<td>—</td>
<td>-22</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{SAT} (P_{IN} = 15 , \text{dBm})$</td>
<td>%</td>
<td>—</td>
<td>24</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>14</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>$I_{DQ}$ (see bias conditions, page 4 )</td>
<td>mA</td>
<td>—</td>
<td>900</td>
<td>—</td>
</tr>
<tr>
<td>Current</td>
<td>$P_{SAT} (P_{IN} = 15 , \text{dBm})$</td>
<td>mA</td>
<td>—</td>
<td>1450</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>15 dBm</td>
</tr>
<tr>
<td>Junction Temperature&lt;sup&gt;5,6&lt;/sup&gt;</td>
<td>+160°C</td>
</tr>
<tr>
<td>Operating Temperature&lt;sup&gt;5&lt;/sup&gt;</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

5. Operating at nominal conditions with junction temperature $\leq +160 ^\circ C$ will ensure MTTF $> 1 \times 10^6$ hours.

6. Junction Temperature ($T_J = T_C + \Theta_{JC} \times ((V \times I) - (P_{OUT} - P_{IN}))$)
   Typical thermal resistance ($\Theta_{JC}$) = 8°C/W.
   a) For $T_C = +25 ^\circ C$,
      $T_J = +79 ^\circ C @ 6 \, V$, 1.45 A, $P_{OUT} = 33.0 \, \text{dBm}$, $P_{IN} = 15 \, \text{dBm}$
   b) For $T_C = +85 ^\circ C$,
      $T_J = +136 ^\circ C @ 6 \, V$, 1.34 A, $P_{OUT} = 32.4 \, \text{dBm}$, $P_{IN} = 15 \, \text{dBm}$

### 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.
Power Amplifier, 2 W
27.5 - 31.5 GHz

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 - C6</td>
<td>0.01 μF</td>
<td>0402</td>
</tr>
<tr>
<td>C7 - C10</td>
<td>1 μF</td>
<td>0402</td>
</tr>
<tr>
<td>C11 - C13</td>
<td>10 μF</td>
<td>0603</td>
</tr>
<tr>
<td>R1 - R6</td>
<td>10 Ω</td>
<td>0402</td>
</tr>
<tr>
<td>L1 - L3</td>
<td>600 Ω @ 100 MHz</td>
<td>0603</td>
</tr>
</tbody>
</table>

10. L1 - L3 (chip ferrite bead) supplied from Murata, part number BLM18HE601SN1D.

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
Recommended PCB Layout Detail:
RF input and output pre-matching circuit patterns 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.

Biasing Conditions
Recommended biasing conditions are $V_D = 6$ V, $I_{DQ} = 900$ mA (controlled with $V_G$). The drain bias voltage range is 3 to 6 V, and the quiescent drain current biasing range is 600 to 1200 mA.

$V_G$ 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 ($V_G = -2$ V).

$V_D$ bias must be applied to $V_D1$, $V_D2$, $V_D3$, and $V_D4$ pins. $V_D3$ pins 27 and 28 are connected internally: choose either pin for layout convenience. Two $V_D4$ pins 15 and 26 (not connected internally) are required for current symmetry.

Operating the MAAP-011246

**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 $I_{DQ} = 900$ mA).
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.
Power Amplifier, 2 W
27.5 - 31.5 GHz

Electrical Specifications with the Recommended PCB Layout and bias conditions:
Freq. = 27.5 - 29.5 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</td>
<td>dB</td>
<td>19</td>
<td>27</td>
<td>30.5</td>
</tr>
<tr>
<td>$P_{SAT}$</td>
<td>dBm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IM3 Level</td>
<td>$P_{OUT} = 27$ dBm / tone</td>
<td>dBc</td>
<td></td>
<td>-20</td>
<td></td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{SAT}$</td>
<td>%</td>
<td></td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$P_{IN} = -20$ dBm</td>
<td>dB</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>$P_{IN} = -20$ dBm</td>
<td>dB</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>$I_{DQ}$ (see bias conditions, page 4)</td>
<td>mA</td>
<td></td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>$P_{SAT}$</td>
<td>mA</td>
<td></td>
<td>1600</td>
<td></td>
</tr>
</tbody>
</table>

Typical Performance Curves

**Gain vs. Frequency over Temperature**

![Gain vs. Frequency over Temperature](image)

**Gain vs. Frequency over Bias Voltage**

![Gain vs. Frequency over Bias Voltage](image)

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

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

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

![Input Return Loss vs. Frequency over Bias Voltage](image)
Typical Performance Curves over Temperature

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

- **S22 (dB)** vs. **Frequency (GHz)** for temperatures of +25°C, -40°C, and +85°C.

**P1dB Output Power vs. Frequency**

- **P1dB (dBm)** vs. **Frequency (GHz)** for temperatures of +25°C, -40°C, and +85°C.

**OIP3 vs. Frequency (P_{OUT} = 27 dBm/tone)**

- **OIP3 (dBm)** vs. **Frequency (GHz)** for temperatures of +25°C, -40°C, and +85°C.

**IM3 vs. Frequency (P_{OUT} = 27 dBm/tone)**

- **IM3 (dBc)** vs. **Frequency (GHz)** for temperatures of +25°C, -40°C, and +85°C.

For further information and support please visit: [https://www.macom.com/support](https://www.macom.com/support)
Typical Performance Curves over Bias Voltage

**P1dB Output Power vs. Frequency**

- **Frequency (GHz):** 27, 28, 29, 30, 31, 32
- **P1dB (dBm):** 26, 28, 30, 32, 34, 36
- **Bias Voltage:** 5.5 V, 6.0 V

**PSAT Output Power vs. Frequency**

- **Frequency (GHz):** 27, 28, 29, 30, 31, 32
- **PSAT (dBm):** 15, 20, 25, 30, 35, 40, 45
- **Bias Voltage:** 5.5 V, 6.0 V

**OIP3 vs. Frequency (P_{OUT} = 27 dBm/tone)**

- **Frequency (GHz):** 27, 28, 29, 30, 31, 32
- **OIP3 (dBm):** 15, 20, 25, 30, 35, 40
- **Bias Voltage:** 5.5 V, 6.0 V

**IM3 vs. Frequency (P_{OUT} = 27 dBm/tone)**

- **Frequency (GHz):** 27, 28, 29, 30, 31, 32
- **IM3 (dBc):** -15, -20, -25, -30, -35, -40, -45
- **Bias Voltage:** 5.5 V, 6.0 V
Power Amplifier, 2 W
27.5 - 31.5 GHz

Typical Performance Curves over Frequency

**\( P_{\text{OUT}} \) vs. \( P_{\text{IN}} \)**

\[
\begin{align*}
\text{\( P_{\text{OUT}} \) vs. \( P_{\text{IN}} \)} & \quad \text{Output Power (dBm)} \\
\text{\( P_{\text{OUT}} \) (dBm)} & \quad \text{Input Power (dBm)}
\end{align*}
\]

**\( \text{PAE vs. } P_{\text{IN}} \)**

\[
\begin{align*}
\text{\( \text{PAE} \) vs. \( P_{\text{IN}} \)} & \quad \text{Power Added Efficiency (%)} \\
\text{\( \text{PAE} \) (%)} & \quad \text{Input Power (dBm)}
\end{align*}
\]

**\( \text{IM3 Level vs. } P_{\text{OUT}} \)**

\[
\begin{align*}
\text{\( \text{IM3 Level} \) vs. \( P_{\text{OUT}} \)} & \quad \text{Output Power / Tone (dBm)} \\
\text{\( \text{IM3 Level} \) (dBm)} & \quad \text{Output Power / Tone (dBm)}
\end{align*}
\]

For further information and support please visit: [www.macom.com/support](https://www.macom.com/support)
**Lead-Free 5 mm AQFN 32-Lead**

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.