MAAP-011289

Power Amplifier, 3 W
28 - 30 GHz

Features
- High Gain: 24 dB
- P1dB: 34 dBm
- P3dB: 35 dBm
- IM3 Level: -18 dBc @ P_{OUT} 30 dBm/tone
- Power Added Efficiency: 23% @ P3dB
- Lead-Free 5 mm AQFN 32-lead Package
- RoHS* Compliant

Description
The MAAP-011289 is a 3 Watt, 4-stage power amplifier assembled in a lead-free 5 mm 32-lead AQFN plastic package. This power amplifier operates from 28 to 30 GHz and provides 24 dB of linear gain, 3 W saturated output power and 23% efficiency while biased at 6 V.

The MAAP-011289 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 Information1,2

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-011289-TR0500</td>
<td>500 piece reel</td>
</tr>
<tr>
<td>MAAP-011289-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

<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, 3</td>
<td>No Connection</td>
<td>21</td>
<td>RF Output</td>
</tr>
<tr>
<td>4</td>
<td>RF Input</td>
<td>22</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>Ground</td>
<td>23</td>
<td>No Connection</td>
</tr>
<tr>
<td>6, 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, 11</td>
<td>Gate Voltage</td>
<td>27, 28</td>
<td>Drain Voltage 3</td>
</tr>
<tr>
<td>12, 13</td>
<td>No Connection</td>
<td>29</td>
<td>Drain Voltage 2</td>
</tr>
<tr>
<td>14</td>
<td>Drain Voltage 3</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*</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.

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1* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
### Electrical Specifications: Freq. = 28 & 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>$P_{IN} = -5 , \text{dBm}, 28 , \text{GHz}$ \n$P_{IN} = -5 , \text{dBm}, 30 , \text{GHz}$</td>
<td>dB</td>
<td>22</td>
<td>26</td>
<td>—</td>
</tr>
<tr>
<td>$P_{OUT}$</td>
<td>$P_{IN} = 11 , \text{dBm}, 28 , \text{GHz}$ \n$P_{IN} = 13 , \text{dBm}, 30 , \text{GHz}$</td>
<td>dBm</td>
<td>33</td>
<td>34.0</td>
<td>34.5</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>$P_{OUT} = 30 , \text{dBm} / \text{tone}$</td>
<td>dBc</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{IN} = 11 , \text{dBm}$</td>
<td>%</td>
<td>—</td>
<td>23</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$P_{IN} = -20 , \text{dBm}$</td>
<td>dB</td>
<td>—</td>
<td>14</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>$I_{DD}$ (see bias conditions, page 4 )</td>
<td>mA</td>
<td>—</td>
<td>1500</td>
<td>—</td>
</tr>
<tr>
<td>Current</td>
<td>$P_{IN} = 11 , \text{dBm}$</td>
<td>mA</td>
<td>—</td>
<td>2300</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, Pulsed</td>
<td>16 dBm</td>
</tr>
<tr>
<td>Junction Temperature$^{5,6}$</td>
<td>+160°C</td>
</tr>
<tr>
<td>Operating Temperature</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 ($T_J$) = $T_C + \Theta_{JC} * (V * I) - (P_{OUT} - P_{IN})$
Typical CW thermal resistance ($\Theta_{JC}$) = 4.8 °C/W.
   a) For $T_C = +25^\circ C$
      $T_J = +75^\circ C$ @ 6 V, 2.3 A, $P_{OUT} = 35.2 \, \text{dBm}$, $P_{IN} = 13 \, \text{dBm}$
   b) For $T_C = +85^\circ C$
      $T_J = +132^\circ C$ @ 6 V, 2 A, $P_{OUT} = 33.6 \, \text{dBm}$, $P_{IN} = 13 \, \text{dBm}$

### 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.
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 - C4</td>
<td>0.01 µF</td>
<td>0402</td>
</tr>
<tr>
<td>C5 - C8</td>
<td>1 µF</td>
<td>0603</td>
</tr>
<tr>
<td>R1 - R4</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
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.

Input Tuning:

Output Tuning:

Biasing Conditions
Recommended biasing conditions are \( V_D = 6 \text{ V} \), \( I_{DQ} = 1500 \text{ mA} \) (controlled with \( V_G \)). The drain bias voltage range is 3 to 6 \text{ V}, and the quiescent drain current biasing range is 1300 to 1700 \text{ 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 (\( V_G = -2 \text{ V} \)).

\( V_D \) 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-011289

**Turn-on**
1. Apply \( V_G \) (-1.5 \text{ V}).
2. Apply \( V_D \) (6.0 \text{ V} typical).
3. Set \( I_{DQ} \) by adjusting \( V_G \) more positive (typically -0.9 to -1.0 \text{ V} for \( I_{DQ} = 1500 \text{ mA} \)).
4. Apply RF\(_{IN}\) signal.

**Turn-off**
1. Remove RF\(_{IN}\) signal.
2. Decrease \( V_G \) to -1.5 \text{ V}.
3. Decrease \( V_D \) to 0 \text{ V}.
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28 - 30 GHz

Typical Performance Curves

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

![Small Signal Gain vs. Frequency over Temperature graph]

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

![Small Signal Gain vs. Frequency over Bias Voltage graph]

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

![Input Return Loss vs. Frequency over Temperature graph]

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

![Input Return Loss vs. Frequency over Bias Voltage graph]

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

![Output Return Loss vs. Frequency over Temperature graph]

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

![Output Return Loss vs. Frequency over Bias Voltage graph]
Typical Performance Curves

**P3dB vs. Frequency over Temperature**

- 28.0 to 30.0 GHz
- +25°C, -40°C, +85°C
- Power Amplifier, 3 W

**P3dB vs. Frequency over Bias Voltage**

- 5.5 V, 6.0 V, 6.5 V

**P1dB vs. Frequency over Temperature**

- 28.0 to 30.0 GHz
- +25°C, -40°C, +85°C

**P1dB vs. Frequency over Bias Voltage**

- 5.5 V, 6.0 V, 6.5 V
Power Amplifier, 3 W
28 - 30 GHz

Typical Performance Curves

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

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

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

**IM3 over Bias Voltage** ($P_{\text{OUT}} = 30 \text{ dBm} / \text{Tone}$)
Power Amplifier, 3 W
28 - 30 GHz

Typical Performance Curves

**P1dB, P3dB vs. Frequency**

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

**IM3 vs. Output Power**

**Output IP3 vs. Output Power**

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Power Amplifier, 3 W
28 - 30 GHz

Typical Performance Curves

Output Power vs. Input Power

PAE vs. Input Power

Bias Current vs. Input Power

Quiescent Drain Current vs. Temperature

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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.