MAAP-011298

Power Amplifier, 2.3 W
27 - 31.5 GHz

Rev. V1

Features
- High Gain: 24.5 dB
- P1dB: 32.5 dBm
- P3dB: 33.5 dBm
- IM3 Level: -17.5 dBc @ POUT = 30 dBm/tone
- Power Added Efficiency: 26% @ P3dB
- Temperature Compensated Output Power Detector
- Lead-Free 5 mm AQFN 32-lead Package
- RoHS* Compliant

Description
The MAAP-011298 is a 2.3 Watt, 4-stage power amplifier assembled in a lead-free 5 mm 32-lead AQFN plastic package. This power amplifier operates from 27 to 31.5 GHz and provides 24.5 dB of linear gain, 2.3 W saturated output power and 26% efficiency while biased at 6 V.

The MAAP-011298 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.

Functional Schematic

Pin Configuration

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<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>19</td>
<td>DET</td>
<td>Power Detector</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>
<tr>
<td>1, 3, 8, 9, 16, 20, 22, 24, 25, 32</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>2, 5 - 7, 12, 13, 18, 23, 30</td>
<td>N/C</td>
<td>No Connection</td>
</tr>
</tbody>
</table>

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

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

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DC-0015566
Power Amplifier, 2.3 W
27 - 31.5 GHz

Electrical Specifications: \( T_A = +25^\circ C, V_D = 6 \, V, Z_0 = 50 \, \Omega \)

<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}, 27 , \text{GHz} ) ( P_{IN} = -5 , \text{dBm}, 29 , \text{GHz} ) ( P_{IN} = -5 , \text{dBm}, 31 , \text{GHz} )</td>
<td>dB</td>
<td>21.0</td>
<td>26.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>24.0</td>
<td>27.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Output Power</td>
<td>( P_{IN} = 9.0 , \text{dBm}, 27 , \text{GHz} ) ( P_{IN} = 10.5 , \text{dBm}, 29 , \text{GHz} ) ( P_{IN} = 12.5 , \text{dBm}, 31 , \text{GHz} )</td>
<td>dBm</td>
<td>31.0</td>
<td>33.0</td>
<td>34.5</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>( P_{OUT} = 30 , \text{dBm / tone} )</td>
<td>dBc</td>
<td>—</td>
<td>-17.5</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>( P_{IN} = 12 , \text{dBm} )</td>
<td>%</td>
<td>—</td>
<td>26</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_{DSQ} ) (see bias conditions, page 4 )</td>
<td>mA</td>
<td>—</td>
<td>1000</td>
<td>—</td>
</tr>
<tr>
<td>Drain Current (( V_{D1} + V_{D2} + V_{D3} + V_{D4} ))</td>
<td>( P_{IN} = 12 , \text{dBm} )</td>
<td>mA</td>
<td>—</td>
<td>1700</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>( P_{IN} \leq 3 , \text{dB Compression} )</td>
</tr>
<tr>
<td>Junction Temperature(^{5,6} )</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\(^{7,8} \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>15 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(^9 )</td>
<td>(+175^\circ C )</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>(-65^\circ C ) to (+125^\circ 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 (\( T_J \) = \( T_C \) + \( \Theta_{JC} \) \* \((V \times I) - (P_{OUT} - P_{IN})\) , Typical thermal resistance (\( \Theta_{JC} \)) = 7.4 °C/W.
   a) For \( T_C = +25^\circ C \), \( P_{OUT} = 10.5 \, \text{dBm} \)
      \( T_J = +80^\circ C \) @ 6 \, \text{V}, 1.7 \, \text{A}, \( P_{OUT} = 34.5 \, \text{dBm} \)
   b) For \( T_C = +85^\circ C \), \( P_{IN} = 10.5 \, \text{dBm} \)
      \( T_J = +140^\circ C \) @ 6 \, \text{V}, 1.6 \, \text{A}, \( P_{OUT} = 33.3 \, \text{dBm} \)

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.

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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 - C14</td>
<td>10 µF</td>
<td>0805</td>
</tr>
<tr>
<td>R1 - R7</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
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.

Biasing Conditions
Recommended biasing conditions are $V_D = 6\, \text{V}$, $I_{DSQ} = 1000\, \text{mA}$ (controlled with $V_G$). The drain bias voltage range is 5.5 to 6.5 V.

$V_G$ 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 pin 14, 27 or 28 for layout convenience. Two $V_D4$ pins 15 and 26 (not connected internally) are required for current symmetry.

Operating the MAAP-011298

**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 $I_{DSQ} = 1000\, \text{mA}$).
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.
Typical Performance Curves: \( V_D = 6 \, \text{V}, \, I_{DSQ} = 1000 \, \text{mA}, \, V_G = -0.9 \, \text{V} \) typical

**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**
Power Amplifier, 2.3 W
27 - 31.5 GHz

Typical Performance Curves: \( V_D = 6 \text{ V}, I_{DSQ} = 1000 \text{ mA}, V_G = -0.9 \text{ V typical} \)

\[ \text{P3dB vs. Frequency over Temperature} \]

\[ \text{P1dB vs. Frequency over Temperature} \]

\[ \text{P3dB vs. Frequency over Bias Voltage} \]

\[ \text{P1dB vs. Frequency over Bias Voltage} \]
Typical Performance Curves: $V_D = 6\, \text{V}$, $I_{DSQ} = 1000\, \text{mA}$, $V_G = -0.9\, \text{V}$ typical

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

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

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

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

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27 - 31.5 GHz

Typical Performance Curves: \( V_D = 6 \text{ V}, I_{DSQ} = 1000 \text{ mA}, V_G = -0.9 \text{ V typical} \)

**P1dB, P3dB vs. Frequency**

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

**IM3 vs. Output Power**

**Output IP3 vs. Output Power**

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Typical Performance Curves: \( V_D = 6 \text{ V}, I_{DSQ} = 1000 \text{ mA}, V_G = -0.9 \text{ V typical} \)

### Output Power vs. Input Power

- 27 GHz
- 29 GHz
- 31 GHz

### PAE vs. Input Power

- 27 GHz
- 29 GHz
- 31 GHz

### Bias Current vs. Input Power

- 27 GHz
- 29 GHz
- 31 GHz

### Quiescent Drain Current vs. Temperature

- +25°C
- -40°C
- +85°C

### Detector Voltage vs. Output Power @ 30 GHz

- +25°C
- -40°C
- +85°C
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.