Power Amplifier, 4 W
27.5 - 31.0 GHz

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MACOM-011317
Rev. V1

Features
- High Gain: 27.5 dB
- P1dB: 35.5 dBm
- P3dB: 36.0 dBm
- IM3 Level: -35 dBc @ POUT = +23 dBm/tone
- Power Added Efficiency: 28% @ P3dB
- Temperature Compensated Output Power Detector
- Lead-Free 5 mm AQFN 32-lead Package
- RoHS* Compliant

Applications
- Point-to-Point
- VSAT

Description
The MAAP-011317 is a 4 W, 4-stage power amplifier assembled in a lead-free 5 mm 32-lead air cavity QFN plastic package. This power amplifier operates from 27.5 to 31.0 GHz and provides 27.5 dB of linear gain, 4 W saturated output power and 28% efficiency while biased at 6 V.

The MAAP-011317 can be used as a power amplifier stage or as a driver stage in higher power 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-011317</td>
<td>Bulk part</td>
</tr>
<tr>
<td>MAAP-011317-TR0500</td>
<td>500 part reel</td>
</tr>
<tr>
<td>MAAP-011317-001SMB</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.

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

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, 23, 30</td>
<td>N/C</td>
<td>No Connection</td>
</tr>
<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>19</td>
<td>DET</td>
<td>Power Detector</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>
</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  
27.5 - 31.0 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>27.5 GHz</td>
<td>dB</td>
<td>24</td>
<td>27.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>31.0 GHz</td>
<td></td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Power (@ Pin = +12dBm)</td>
<td>27.5 GHz</td>
<td>dBm</td>
<td>34.5</td>
<td>36.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>31.0 GHz</td>
<td></td>
<td>34.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IM3 Level</td>
<td>(P_{OUT} = 23 , \text{dBm} / \text{tone})</td>
<td>dBc</td>
<td>—</td>
<td>-35</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>(P_{IN} = 15 , \text{dBm})</td>
<td>%</td>
<td>—</td>
<td>28</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>—</td>
<td>dB</td>
<td>—</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>—</td>
<td>dB</td>
<td>—</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>(I_{DSQ}) (see bias conditions, page 4)</td>
<td>mA</td>
<td>—</td>
<td>1700</td>
<td>—</td>
</tr>
<tr>
<td>Drain Current ((V_{D1} + V_{D2} + V_{D3} + V_{D4}))</td>
<td>(P_{IN} = 15 , \text{dBm})</td>
<td>mA</td>
<td>—</td>
<td>2700</td>
<td>—</td>
</tr>
</tbody>
</table>

**Maximum Operating Conditions**

<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*6</td>
<td>( +160^\circ C)</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>(-40^\circ C \text{ to } +85^\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 \((T_J) = T_C + \Theta_{JC} \times ((V_D + I) \times (P_{OUT} - P_{IN}))\)  
   Typical thermal resistance \((\Theta_{JC}) = 3.8 \, \text{°C/W}\).
   a) For \(T_C = +25^\circ C\)  
      \(T_J = +70^\circ C \text{ @ 6 V, 2.8 A, } P_{OUT} = 37 \, \text{dBm, } P_{IN} = 15 \, \text{dBm}\)
   b) For \(T_C = +85^\circ C\)  
      \(T_J = +132^\circ C \text{ @ 6 V, 2.8 A, } P_{OUT} = 36.5 \, \text{dBm, } P_{IN} = 15 \, \text{dBm}\)

**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.

**Absolute Maximum Ratings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>18 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°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +125°C</td>
</tr>
</tbody>
</table>

7. Exceeding any one or combination of these limits may cause permanent damage to this device.
8. MACOM does not recommend sustained operation near these survivability limits.
9. Junction temperature directly affects device MTTF. Junction temperature should be kept as low as possible to maximize lifetime.
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>22 µF</td>
<td>0603</td>
</tr>
<tr>
<td>R1 - R7</td>
<td>10 Ω</td>
<td>0402</td>
</tr>
<tr>
<td>L1 - L4</td>
<td>Ferrite bead Murata 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
Power Amplifier, 4 W
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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 $V_D = 6\, V$, $I_{DSQ} = 1700\, mA$ (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 ($V_G = -2\, V$).

$V_D$ 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-011317

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 $I_{DSQ} = 1700\, mA$).
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 $V$. 
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Typical Performance Curves: \( V_D = 6 \, \text{V}, \, I_{DSQ} = 1700 \, \text{mA}, \, V_G = -0.9 \, \text{V} \) 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, 4 W
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Typical Performance Curves: \( V_D = 6 \) V, \( I_{DSQ} = 1700 \) mA, \( V_G = -0.9 \) V typical

**P3dB vs. Frequency over Temperature**

```
+25°C
-40°C
+85°C
```

**P3dB vs. Frequency over Bias Voltage**

```
+25°C
-40°C
+85°C
```

**P1dB vs. Frequency over Temperature**

```
+25°C
-40°C
+85°C
```

**P1dB vs. Frequency over Bias Voltage**

```
+25°C
-40°C
+85°C
```
Power Amplifier, 4 W
27.5 - 31.0 GHz

Typical Performance Curves: \( V_D = 6 \text{ V}, I_{DSQ} = 1700 \text{ mA}, V_G = -0.9 \text{ V} \) typical

**IM3 vs. Output Power (27.5 GHz)**

**IM3 vs. Output Power @ 25°C**

**IM3 vs. Output Power (29 GHz)**

**IM3 vs. Frequency @ Output Power = 27 dBm/tone**

**IM3 vs. Output Power (31 GHz)**

**Output IP3 vs. Output Power**

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Power Amplifier, 4 W
27.5 - 31.0 GHz

Typical Performance Curves: \( V_D = 6 \text{ V}, 25^\circ \text{C} \)

**IM3 vs. Output Power by Drain Current @ 27.5 GHz**

![Graph showing IM3 vs. Output Power by Drain Current at 27.5 GHz]

**IM3 vs. Frequency by Drain Current @ Output Power = 27 dBm/tone**

![Graph showing IM3 vs. Frequency by Drain Current]

**IM3 vs. Output Power by Drain Current @ 29 GHz**

![Graph showing IM3 vs. Output Power by Drain Current at 29 GHz]

**Output IP3 vs. Output Power @ 29 GHz**

![Graph showing Output IP3 vs. Output Power]

**IM3 vs. Output Power by Drain Current @ 31 GHz**

![Graph showing IM3 vs. Output Power by Drain Current at 31 GHz]

**Sample Board Thru Loss**

![Graph showing Sample Board Thru Loss]

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Power Amplifier, 4 W  
27.5 - 31.0 GHz

Typical Performance Curves: $V_D = 6\, \text{V}, I_{\text{DSQ}} = 1700\, \text{mA}, V_G = -0.9\, \text{V}$ typical, 25°C

Output Power vs. Input Power

Gain and PAE @ P3dB vs. Frequency

Bias Current vs. Input Power

PAE vs. Input Power

Gate Current @ P3dB

Detector Voltage vs. Output Power @ 30 GHz
Power Amplifier, 4 W
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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.
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