Power Amplifier, 4 W
13.5 - 15.0 GHz

MAAP-011313
Rev. V1

Features
- High Gain: 36 dB
- P1dB: 34.5 dBm
- P3dB: 36.0 dBm
- IM3 Level: -28 dBc @ Pout = 28 dBm/tone
- Power Added Efficiency: 28% @ P3dB
- Temperature Compensated Output Power Detector
- Lead-Free 5 mm AQFN 32-lead Package
- RoHS* Compliant

Applications
- VSAT

Description
The MAAP-011313 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 13.5 to 15 GHz and provides 35 dB of linear gain, 4 W saturated output power and 28% efficiency while biased at 6 V.

The MAAP-011313 can be used as a power amplifier stage or as a driver stage in higher power applications. This device is ideally suited for linear Ku-band 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-011313</td>
<td>bulk part</td>
</tr>
<tr>
<td>MAAP-011313-TR0500</td>
<td>500 part reel</td>
</tr>
<tr>
<td>MAAP-011313-001SMB</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.

Functional Schematic

Pin Configuration

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 3, 8, 9, 16, 17, 22, 24, 25, 32</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>2, 5, 6, 7, 13, 19, 20, 23</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, 31</td>
<td>VG</td>
<td>Gate Voltage</td>
</tr>
<tr>
<td>12</td>
<td>VD2S</td>
<td>Drain 2 South Voltage</td>
</tr>
<tr>
<td>14</td>
<td>VD3S</td>
<td>Drain 3 South Voltage</td>
</tr>
<tr>
<td>15</td>
<td>VD4S</td>
<td>Drain 4 South Voltage</td>
</tr>
<tr>
<td>18</td>
<td>DET</td>
<td>Power Detector</td>
</tr>
<tr>
<td>21</td>
<td>RFOUT</td>
<td>RF Output</td>
</tr>
<tr>
<td>26</td>
<td>VD4N</td>
<td>Drain 4 North Voltage</td>
</tr>
<tr>
<td>27, 28</td>
<td>VD3N</td>
<td>Drain 3 North Voltage</td>
</tr>
<tr>
<td>29</td>
<td>VD2N</td>
<td>Drain 2 North Voltage</td>
</tr>
<tr>
<td>30</td>
<td>VD1</td>
<td>Drain 1 Voltage</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.
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Rev. V1

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

<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>13.5 GHz 15 GHz</td>
<td>dB</td>
<td>34</td>
<td>36</td>
<td>—</td>
</tr>
<tr>
<td>Gain Flatness</td>
<td>within 14 - 14.5 GHz band any 20 MHz channel</td>
<td>dB</td>
<td>—</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td>Output Power</td>
<td>P1dB</td>
<td>dBm</td>
<td>—</td>
<td>34.5</td>
<td>—</td>
</tr>
<tr>
<td>Output Power (@ ( P_{IN} = 3 \text{ dBm} ))</td>
<td>P3dB, 13.5 GHz</td>
<td>dBm</td>
<td>34.5</td>
<td>36</td>
<td>—</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>( P_{OUT} = 28 \text{ dBm/tone, } \Delta F = 10 \text{ MHz} )</td>
<td>dBc</td>
<td>—</td>
<td>-28</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>P3dB</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>15</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>---</td>
<td>dB</td>
<td>—</td>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>( I_{DSQ} ) (see bias conditions, page 4 )</td>
<td>mA</td>
<td>—</td>
<td>1600</td>
<td>—</td>
</tr>
<tr>
<td>Drain Current (( V_{D1} + V_{D2} + V_{D3} + V_{D4} ))</td>
<td>P3dB</td>
<td>mA</td>
<td>—</td>
<td>3000</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(^5,6)</td>
<td>+160°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

- Operating at nominal conditions with junction temperature \( +160°C \) will ensure MTTF > \( 1 \times 10^6 \text{ hours} \).
- Junction Temperature \( (T_J) = T_C + \Theta_{JC} \times (V - I) \times (P_{OUT} - P_{IN}) = 85 + 4.56 \times (6 \times 2.82 - (5 - 0.004)) = 139.4^\circ\text{C} \)
- Typical thermal resistance \( (\Theta_{JC}) = 4.56^\circ\text{C/W} \).

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, 4 W
13.5 - 15.0 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 - C9</td>
<td>0.01 µF</td>
<td>0402</td>
</tr>
<tr>
<td>C10 - C14</td>
<td>22 µF</td>
<td>0603</td>
</tr>
<tr>
<td>R1 - R9</td>
<td>10 Ω</td>
<td>0402</td>
</tr>
<tr>
<td>L1 - L5</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
13.5 - 15.0 GHz

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, $I_{DSQ} = 1.6$ A (controlled with $V_G$). The drain bias voltage range is 4 to 6 V and the quiescent drain current biasing range is 1.5 to 2.2 A.

$V_G$ pins 10 and 11 are connected internally and only one pin is required for biasing. Pin 31 is not connected internally; an external connection to pin 10 or 11 is required. 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 all VDX pins ($V_{D1}$, $V_{D2}$, $V_{D3}$ and $V_{D4}$) on both sides of the device as these pins are not internally connected.

Operating the MAAP-011313

**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 $I_{DSQ} = 1.6$ A).
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, 4 W
13.5 - 15.0 GHz

Typical Performance Curves: \( V_D = 6 \text{ V}, \, I_{DSQ} = 1600 \text{ mA} \)

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

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

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

![Small Signal 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)

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

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

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

![Output Return Loss vs. Frequency over Bias Voltage](image)
Power Amplifier, 4 W
13.5 - 15.0 GHz

Typical Performance Curves: \( V_D = 6 \text{ V}, I_{DSQ} = 1600 \text{ mA} \)

**P3dB vs. Frequency over Temperature**

**P3dB vs. Frequency over Bias Voltage**

**P1dB vs. Frequency over Temperature**

**P1dB vs. Frequency over Bias Voltage**
Power Amplifier, 4 W
13.5 - 15.0 GHz

Typical Performance Curves: \( V_D = 6 \text{ V}, I_{DSQ} = 1600 \text{ mA} \)

**IM3 vs. Output Power (13.75 GHz)**

**IM3 vs. Output Power @ 25°C**

**IM3 vs. Output Power (14.5 GHz)**

**IM3 vs. Frequency @ Output Power = 28 dBm/tone**

**IM3 vs. Output Power (15 GHz)**

**Output IP3 vs. Output Power**
Power Amplifier, 4 W
13.5 - 15.0 GHz

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

**IM3 vs. Output Power by Drain Current @ 13.75 GHz**

**IM3 vs. Output Power by Drain Current @ 14.5 GHz**

**IM3 vs. Output Power by Drain Current @ 15 GHz**

**IM3 vs. Frequency by Drain Current @ Output Power = 28 dBm/tone**

**Output IP3 vs. Output Power @ 14.5 GHz**

**Sample Board Thru Loss**

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Typical Performance Curves: $V_D = 6 \, \text{V}, \, I_{DSQ} = 1600 \, \text{mA}, \, 25^\circ \text{C}$

**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 @ 14 GHz**
Power Amplifier, 4 W
13.5 - 15.0 GHz

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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