MAAP-011139-DIE

Power Amplifier, 4 W
28.5 - 31.0 GHz

Features
- High Gain: 24 dB @ 30 GHz
- P1dB: 34.5 dBm
- $P_{\text{SAT}}$: 36.5 dBm
- IM3 Level: $-27 \text{ dBc} @ P_{\text{OUT}} = 29 \text{ dBm/tone}$
- Power Added Efficiency: 23% @ $P_{\text{SAT}}$
- Return Loss: 10 dB
- Bare Die Dimensions: 3.1 x 2.8 x 0.05 mm
- RoHS* Compliant

Description
The MAAP-011139-DIE is a 4-stage, 4 W power amplifier in bare die form. This power amplifier operates from 28.5 to 31.0 GHz and provides 24 dB of linear gain, 4 W saturated output power, and 23% efficiency while biased at 6 V.

The MAAP-011139-DIE is a power amplifier ideally suited for VSAT communications.

This product is fabricated using a GaAs pHEMT device process which features full passivation for enhanced reliability.

Functional Diagram

Pin Configuration

<table>
<thead>
<tr>
<th>Pad</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RF$_{\text{IN}}$</td>
<td>RF Input</td>
</tr>
<tr>
<td>2, 16</td>
<td>$V_G$</td>
<td>Gate Voltage</td>
</tr>
<tr>
<td>3, 7, 11, 15 &amp; backside</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>4, 14</td>
<td>$V_D1$</td>
<td>Drain Voltage 1</td>
</tr>
<tr>
<td>5, 13</td>
<td>$V_D2$</td>
<td>Drain Voltage 2</td>
</tr>
<tr>
<td>6, 12</td>
<td>$V_D3$</td>
<td>Drain Voltage 3</td>
</tr>
<tr>
<td>8, 10</td>
<td>$V_D4$</td>
<td>Drain Voltage 4</td>
</tr>
<tr>
<td>9</td>
<td>RF$_{\text{OUT}}$</td>
<td>RF Output</td>
</tr>
</tbody>
</table>

1. Die quantity varies

2. Backside metal is RF, DC and thermal ground.

Electrical Specifications\(^3\): Freq. = 30 GHz, \(T_C = +25^\circ\)C, \(V_D = +6\) V, \(Z_0 = 50\) Ω

<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>22</td>
<td>24</td>
<td>—</td>
</tr>
<tr>
<td>(P_{OUT})</td>
<td>(P_{IN} = 17) dBm</td>
<td>dBm</td>
<td>35.0</td>
<td>36.5</td>
<td>—</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>(P_{OUT} = 29) dBm / tone</td>
<td>dBc</td>
<td>—</td>
<td>-27</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>(P_{SAT} (P_{IN} = 17) dBm)</td>
<td>%</td>
<td>—</td>
<td>23</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>(P_{IN} = -20) dBm</td>
<td>dB</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>(P_{IN} = -20) dBm</td>
<td>dB</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>(I_{DQ}) (see bias conditions, page 5 )</td>
<td>mA</td>
<td>—</td>
<td>2000</td>
<td>—</td>
</tr>
<tr>
<td>Current</td>
<td>(P_{SAT} (P_{IN} = +17) dBm)</td>
<td>mA</td>
<td>—</td>
<td>3200</td>
<td>—</td>
</tr>
</tbody>
</table>

3. Specifications apply to MMIC die with two RF input and two RF output bond wires.

Maximum Operating Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>+17 dBm</td>
</tr>
<tr>
<td>Junction Temperature(^4,5)</td>
<td>+160°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

4. Operating at nominal conditions with junction temperature \(\leq +160^\circ\)C will ensure MTTF > \(1 \times 10^8\) hours.
5. Junction Temperature \((T_J) = T_C + \Theta_{JC} \times (V \times I) - (P_{OUT} - P_{IN})\)
   Typical thermal resistance \((\Theta_{JC}) = 3.4^\circ\)C/W.
   a) For \(T_C = +25^\circ\)C,
      \(T_J = +75^\circ\)C @ 6 V, 3.2 A, \(P_{OUT} = 36.5\) dBm, \(P_{IN} = 17\) dBm
   b) For \(T_C = +85^\circ\)C,
      \(T_J = +133^\circ\)C @ 6 V, 3.0 A, \(P_{OUT} = 36.0\) dBm, \(P_{IN} = 17\) dBm

Absolute Maximum Ratings\(^6,7\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>+23 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(^6)</td>
<td>+175°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +150°C</td>
</tr>
</tbody>
</table>

6. Exceeding any one or combination of these limits may cause permanent damage to this device.
7. MACOM does not recommend sustained operation near these survivability limits.
8. Junction temperature directly effects device MTTF. Junction temperature should be kept as low as possible to maximize lifetime.
Application PCB Layout

Application Diagram

Application 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 - C16</td>
<td>10 µF</td>
<td>0805</td>
</tr>
<tr>
<td>R1 - R7</td>
<td>10 Ω</td>
<td>0402</td>
</tr>
<tr>
<td>L1 - L4</td>
<td></td>
<td>BLM18HE601SN1D 0603</td>
</tr>
</tbody>
</table>

PCB Material Specifications

Top Layer: 1/2 oz Copper Cladding, 0.017 mm thickness
Dielectric Layer: Rogers RO4350B, 0.101 mm thickness
Bottom Layer: 1/2 oz Copper Cladding, 0.017 mm thickness
Finished overall thickness: 0.135 mm

Visit www.macom.com for additional data sheets and product information.
Recommended Bonding Diagram and PCB Layout Detail:

For optimum power match, RF input and output microstrip lines require open stubs on the application board for bonding wire inductance compensation. Optimum bonding wire inductance for the RF I/O connection is 0.2 nH, and physical length for the gold bond wire (.001” dia.) is approximately 350 µm each for the two wire connection.

All units are in microns.
Application Information
The MAAP-011139 is designed to be easy to use yet high performance. The ultra small size and simple bias allow easy placement on system board. RF input and output ports are DC de-coupled internally.

Biasing conditions
Recommended biasing conditions are $V_D = 6\, \text{V}$, $I_{\text{DQ}} = 2000\, \text{mA}$ (controlled with $V_G$). The drain bias voltage range is 3 to 6 V, and the quiescent drain current biasing range is 1500 to 2500 mA.

$V_G$ pads 2 and 16 are connected internally; choose either pad 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 $V_D4$ pads.

$V_D1$ pads 4 and 14 are connected internally, and only one pad is required for biasing. Choose either pad for layout convenience.

$V_D2$ pads 5 and 13 are connected internally, and only one pad is required for biasing. Choose either pad for layout convenience.

Both $V_D3$ pads (6 and 12) are required for current symmetry.

Both $V_D4$ pads (8 and 10) are required for current symmetry.

Operating the MAAP-011139-DIE

**Turn-on**
1. Apply $V_G$ (-1.5 V).
2. Apply $V_D$ (6.0 V typical).
3. Set $I_{\text{DQ}}$ by adjusting $V_G$ more positive (typically $V_G = -0.9\, \text{V}$ for $I_{\text{DQ}} = 2000\, \text{mA}$).
4. Apply RF$_{\text{IN}}$ signal.

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

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.

Die Attachment
This product is manufactured from 0.050 mm (0.002”) thick GaAs substrate and has vias through to the backside to enable grounding to the circuit.

Recommended conductive epoxy is Namics Unimec XH9890-6. Epoxy should be applied and cured in accordance with the manufacturer’s specifications and should avoid contact with the top of the die.
Typical Performance Curves

Small Signal Gain vs. Frequency over Temperature

![Graph of S21 (dB) vs. Frequency (GHz) for different temperatures (25°C, 40°C, 85°C).]

Small Signal Gain vs. Frequency over Bias Voltage

![Graph of S21 (dB) vs. Frequency (GHz) for different bias voltages (5.5 V, 6.0 V, 6.5 V).]

Input Return Loss vs. Frequency over Temperature

![Graph of S11 (dB) vs. Frequency (GHz) for different temperatures (25°C, 40°C, 85°C).]

Input Return Loss vs. Frequency over Bias Voltage

![Graph of S11 (dB) vs. Frequency (GHz) for different bias voltages (5.5 V, 6.0 V, 6.5 V).]

Output Return Loss vs. Frequency over Temperature

![Graph of S22 (dB) vs. Frequency (GHz) for different temperatures (25°C, 40°C, 85°C).]

Output Return Loss vs. Frequency over Bias Voltage

![Graph of S22 (dB) vs. Frequency (GHz) for different bias voltages (5.5 V, 6.0 V, 6.5 V).]
Typical Performance Curves

$P_{\text{SAT}}$ vs. Frequency over Temperature

$P_{\text{SAT}}$ vs. Frequency over Bias Voltage

$P_{1\text{dB}}$ vs. Frequency over Temperature

$P_{1\text{dB}}$ vs. Frequency over Bias Voltage
Typical Performance Curves

**Output IP3 vs. Frequency over Temperature**

![Graph showing Output IP3 vs. Frequency over Temperature](image)

**Output IP3 vs. Frequency over Bias Voltage**

![Graph showing Output IP3 vs. Frequency over Bias Voltage](image)

**IM3 vs. Frequency over Temperature**

**IM3 Level (dBc)**

![Graph showing IM3 vs. Frequency over Temperature](image)

**IM3 vs. Frequency over Bias Voltage**

**IM3 Level (dBc)**

![Graph showing IM3 vs. Frequency over Bias Voltage](image)
**Typical Performance Curves**

**P1dB, $P_{SAT}$ vs. Frequency**

- Graph showing $P1dB$ and $P_{SAT}$ vs. Frequency from 28.5 GHz to 31.0 GHz.

**PAE vs. Frequency**

- Graph showing PAE vs. Frequency from 28.5 GHz to 31.0 GHz.

**IM3 vs. Output Power per Tone**

- Graph showing IM3 vs. Output Power per Tone from 5 dBm to 35 dBm for 29 GHz, 30 GHz, and 31 GHz.

**Output IP3 vs. Output Power per Tone**

- Graph showing Output IP3 vs. Output Power per Tone from 20 dBm to 50 dBm for 29 GHz, 30 GHz, and 31 GHz.
9. Typical performance curves are achieved by using the recommended bonding diagram and PCB layout detail.
Power Amplifier, 4 W
28.5 - 31.0 GHz

MMIC Die Outline

Notes:
1. All units are in µm, unless otherwise noted, with a tolerance of ±5 µm.
2. Die thickness is 50 ±10 µm.

<table>
<thead>
<tr>
<th>Pad</th>
<th>Size (x)</th>
<th>Size (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, Q</td>
<td>88</td>
<td>112</td>
</tr>
<tr>
<td>B, P</td>
<td>105</td>
<td>96</td>
</tr>
<tr>
<td>C, D, O, N</td>
<td>108</td>
<td>83</td>
</tr>
<tr>
<td>E, M</td>
<td>163</td>
<td>83</td>
</tr>
<tr>
<td>F, L</td>
<td>169</td>
<td>88</td>
</tr>
<tr>
<td>G, K</td>
<td>248</td>
<td>88</td>
</tr>
<tr>
<td>H, J, R, T</td>
<td>89</td>
<td>99</td>
</tr>
<tr>
<td>I, S</td>
<td>89</td>
<td>159</td>
</tr>
</tbody>
</table>

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