MAAP-011140-DIE

Power Amplifier, 6 W
27.5 - 30.0 GHz

Rev. V3

Features
- High Gain: 24 dB
- P1dB: 37.5 dBm
- PSAT: 38.5 dBm
- IM3 Level: -24 dBc @ POUT = 33 dBm/tone
- Power Added Efficiency: 23% @ PSAT
- Return Loss: 12 dB
- Bare Die Dimensions: 3.6 x 3.8 x 0.05 mm
- RoHS* Compliant

Description
The MAAP-011140-DIE is a 4-stage, 6 W power amplifier in bare die form. This power amplifier operates from 27.5 to 30.0 GHz and provides 24 dB of linear gain, 6 W saturated output power, and 23% efficiency while biased at 6 V.

The MAAP-011140-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.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-011140-DIE</td>
<td>Die in Gel Pack</td>
</tr>
</tbody>
</table>

1. Die quantity varies

Functional Diagram

Pin Configuration

<table>
<thead>
<tr>
<th>Pad</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RFIN</td>
<td>RF Input</td>
</tr>
<tr>
<td>2, 4, 7, 9, 11,</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>13, 15, 16, 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>VD1</td>
<td>Drain Voltage Stage 1</td>
</tr>
<tr>
<td>5</td>
<td>VD2</td>
<td>Drain Voltage Stage 2</td>
</tr>
<tr>
<td>6, 14</td>
<td>VD3</td>
<td>Drain Voltage Stage 3</td>
</tr>
<tr>
<td>8, 12</td>
<td>VD4</td>
<td>Drain Voltage Stage 4</td>
</tr>
<tr>
<td>10</td>
<td>RFOUT</td>
<td>RF Output</td>
</tr>
<tr>
<td>17</td>
<td>VG</td>
<td>Gate Voltage</td>
</tr>
</tbody>
</table>

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

Power Amplifier, 6 W
27.5 - 30.0 GHz

Electrical Specifications: 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>36.0</td>
<td>37.5</td>
<td>—</td>
</tr>
<tr>
<td>IM3 Level</td>
<td>$P_{OUT} = 33$ dBm / tone</td>
<td>dBC</td>
<td>—</td>
<td>-24</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{SAT}(P_{IN} = 17$ dBm)</td>
<td>%</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$P_{IN} = -20$ dBm</td>
<td>dB</td>
<td>—</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>$P_{IN} = -20$ dBm</td>
<td>dB</td>
<td>—</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>$I_{DQ}$ (see bias conditions, page 5)</td>
<td>mA</td>
<td>—</td>
<td>3000</td>
<td>—</td>
</tr>
<tr>
<td>Current</td>
<td>$P_{SAT}(P_{IN} = 17$ dBm)</td>
<td>mA</td>
<td>—</td>
<td>5250</td>
<td>—</td>
</tr>
</tbody>
</table>

3. Specifications apply to MMIC die with two RF input and two RF output bond wires, and tested with 50 Ω GSG probes. Further performance tuning to optimize the RF input and RF output impedance matching is shown on Recommended Bonding Diagram and PCB Layout Detail (pg. 4). Typical performance curves are achieved by using the recommended bonding diagram and PCB layout detail.

Maximum Operating Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>+19 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 $T_C \leq +160^\circ C$ will ensure MTTF > $1 \times 10^6$ hours.

5. Junction Temperature ($T_J$) = $T_C + \Theta_{JC} \ast (V \ast I) - (P_{OUT} - P_{IN})$
Typical thermal resistance ($\Theta_{JC}$) = 3.4°C/W.

a) For $T_C = +25^\circ C$,
   $T_J = 108^\circ C$ @ 6 V, 5.25 A, $P_{OUT} = 38.5$, $P_{IN} = 17$ dBm
b) For $T_C = +80^\circ C$,
   $T_J = 159^\circ C$ @ 6 V, 4.96 A, $P_{OUT} = 38.1$, $P_{IN} = 17$ 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>+24 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>(Chip Ferrite Bead) BLM18HE601SN1D</td>
<td>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

M/A-COM Technology Solutions Inc. (MACOM) and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice. Visit www.macom.com for additional data sheets and product information.

For further information and support please visit: https://www.macom.com/support
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.

Input Match

Output Match
Application Information
The MAAP-011140 is designed to be easy to use yet high performance. The ultra small size and simple bias allows easy placement on system board. RF input and output ports are DC de-coupled internally.

Biasing conditions
Recommended biasing conditions are $V_D = 6$ V, $I_{DQ} = 3000$ mA (controlled with $V_G$). The drain bias voltage range, $V_D$, is 3 to 6.5 V, and the quiescent drain current biasing range, $I_{DQ}$, is 2000 to 4000 mA.

$V_G$ bias must be applied to $V_D1$, $V_D2$, $V_D3$, and $V_D4$ pads.

Both $V_D3$ pads (6 and 14) are required for current symmetry.

Both $V_D4$ pads (8 and 12), are required for current symmetry.

A single DC voltage ($V_G$) will bias all amplifier stages. Muting can be accomplished by setting the $V_G$ to the pinched off voltage ($V_G = -2$ V).

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.

Operating the MAAP-011140-DIE

Turn-on
1. Apply $V_G$ (-1.5 V).
2. Apply $V_D$ (6.0 V typical).
3. Set $I_{DQ}$ by adjusting $V_G$ more positive (typically $V_G ~ -0.9$ V for $I_{DQ} = 3000$ 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.

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 devices.
Typical Performance Curves

Small Signal Gain vs. Frequency over Temperature

S21 (dB) vs. Frequency (GHz) over temperatures of +25°C, -40°C, and +85°C, and bias voltages of 5.5 V, 6.0 V, and 6.5 V.

Input Return Loss vs. Frequency over Temperature

S11 (dB) vs. Frequency (GHz) over temperatures of +25°C, -40°C, and +85°C.

Output Return Loss vs. Frequency over Temperature

S22 (dB) vs. Frequency (GHz) over temperatures of +25°C, -40°C, and +85°C.

Visit www.macom.com for additional data sheets and product information.

For further information and support please visit:
https://www.macom.com/support
Typical Performance Curves

$P_{SAT}$ vs. Frequency over Temperature

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

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

$P_{1dB}$ vs. Frequency over Bias Voltage

M/A-COM Technology Solutions Inc. (MACOM) and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice.

Visit www.macom.com for additional data sheets and product information.
Power Amplifier, 6 W
27.5 - 30.0 GHz

Typical Performance Curves

**Output IP3 vs. Frequency over Temperature**

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

**IM3 vs. Frequency over Temperature**
*(P_{OUT} = +33 dBm/Tone)*

**IM3 vs. Frequency over Bias Voltage**
*(P_{OUT} = +33 dBm/Tone)*
Power Amplifier, 6 W
27.5 - 30.0 GHz

Typical Performance Curves

$P_{1dB}, P_{SAT}$ vs. Frequency

PAE, Gain vs. Frequency

IM3 vs. Output Power per Tone

Output IP3 vs. Output Power per Tone
Typical Performance Curves

Output Power vs. Input Power

PAE vs. Input Power

Drain Current vs. Input Power

Quiescent Drain Current over Temperature

9. Typical performance curves are achieved by using the recommended bonding diagram and PCB layout detail.
Power Amplifier, 6 W
27.5 - 30.0 GHz

MMIC Die Outline

<table>
<thead>
<tr>
<th>Pad</th>
<th>Size (x)</th>
<th>Size (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, C</td>
<td>88</td>
<td>88</td>
</tr>
<tr>
<td>D, M</td>
<td>169</td>
<td>88</td>
</tr>
<tr>
<td>E, L, O</td>
<td>161</td>
<td>88</td>
</tr>
<tr>
<td>F</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>G, K</td>
<td>249</td>
<td>88</td>
</tr>
<tr>
<td>H, J, Q, S</td>
<td>89</td>
<td>99</td>
</tr>
<tr>
<td>I, R</td>
<td>89</td>
<td>159</td>
</tr>
<tr>
<td>N, P</td>
<td>158</td>
<td>88</td>
</tr>
</tbody>
</table>

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

Information in this document is provided in connection with MACOM Technology Solutions Inc ("MACOM") products. These materials are provided by MACOM as a service to its customers and may be used for informational purposes only. Except as provided in MACOM's Terms and Conditions of Sale for such products or in any separate agreement related to this document, MACOM assumes no liability whatsoever. MACOM assumes no responsibility for errors or omissions in these materials. MACOM may make changes to specifications and product descriptions at any time, without notice. MACOM makes no commitment to update the information and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to its specifications and product descriptions. No license, express or implied, by estoppeps or otherwise, to any intellectual property rights is granted by this document.

THESE MATERIALS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, CONSEQUENTIAL OR INCIDENTAL DAMAGES, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. MACOM FURTHER DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. MACOM SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS, WHICH MAY RESULT FROM THE USE OF THESE MATERIALS.

MACOM products are not intended for use in medical, lifesaving or life sustaining applications. MACOM customers using or selling MACOM products for use in such applications do so at their own risk and agree to fully indemnify MACOM for any damages resulting from such improper use or sale.

For further information and support please visit: https://www.macom.com/support