Power Amplifier, 1 W
20 - 45 GHz

Features
- Wide Frequency Range: 20 - 45 GHz
- High Gain: 19 dB
- P1dB: 28.5 dBm
- P3dB: 30 dBm
- Bare Die
- RoHS* Compliant

Applications
- ISM/MM

Description
The MAAM-011291-DIE is a 4-stage, 1 W power amplifier MMIC die. This power amplifier operates from 20 to 45 GHz and provides 19 dB of linear gain, 1 W at P3dB compression, and 15% efficiency at P3dB while biased at 5 V.

This device can be used as a power amplifier ideally suited for 5G systems and test and measurement applications in the 20 to 45 GHz range.

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

All data is taken with the chip connected via three 1 mil diameter gold bond wires that are each approximately 350 µm long.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAM-011291-DIE</td>
<td>Bare Die</td>
</tr>
</tbody>
</table>

Functional Schematic

Bond Pad Configuration

<table>
<thead>
<tr>
<th>Pad #</th>
<th>Pad Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RF IN</td>
<td>RF Input</td>
</tr>
<tr>
<td>2, 14</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>3, 4</td>
<td>VG</td>
<td>Gate Voltage</td>
</tr>
<tr>
<td>5, 9</td>
<td>VD1</td>
<td>Drain Voltage 1</td>
</tr>
<tr>
<td>6, 10</td>
<td>VD2</td>
<td>Drain Voltage 2</td>
</tr>
<tr>
<td>7, 11</td>
<td>VD3</td>
<td>Drain Voltage 3</td>
</tr>
<tr>
<td>8, 12</td>
<td>VD4</td>
<td>Drain Voltage 4</td>
</tr>
<tr>
<td>13</td>
<td>RF OUT</td>
<td>RF Output</td>
</tr>
</tbody>
</table>

1. Backside of die must be connected to RF, DC and thermal ground.

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

MACOM 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, 1 W
20 - 45 GHz

MACOM 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

MACOM 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.

DC-0020461

Electrical Specifications: Freq. = 20 - 45 GHz, $T_A = +25^\circ C$, $V_D = 5 V$, $I_{DSQ} = 1 A$, $Z_0 = 50 \Omega$

<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>$P_{IN} = -10$ dBm</td>
<td>dB</td>
<td>18.0</td>
<td>19.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 GHz</td>
<td></td>
<td>15.5</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 GHz</td>
<td></td>
<td>19.0</td>
<td>21.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>39 GHz</td>
<td></td>
<td></td>
<td>17.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Return loss</td>
<td></td>
<td>dB</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Return Loss</td>
<td></td>
<td>dB</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1dB</td>
<td>20 GHz</td>
<td>dBm</td>
<td>27</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 GHz</td>
<td></td>
<td>29</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>39 GHz</td>
<td></td>
<td>28</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3dB</td>
<td>20 GHz</td>
<td>dBm</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>45 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OIP3</td>
<td>$P_{OUT}/$Tone = 14$ dBm, $\Delta f = 2$ MHz</td>
<td>dBm</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain Current</td>
<td>P3dB, 39 GHz</td>
<td>mA</td>
<td>1450</td>
<td>1800</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>$P_{IN} \leq 3$ dBm Compression</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>4 to 6 V</td>
</tr>
<tr>
<td>Junction Temperature$^{2,3}$</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$^{4,5}$

<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$^\circ C$</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65$^\circ C$ to +125$^\circ C$</td>
</tr>
</tbody>
</table>

2. Operating at nominal conditions with junction temperature $\leq +160^\circ C$ will ensure MTTF $> 1 \times 10^6$ hours.
3. Junction Temperature ($T_J$) = $T_C + \Theta_{JC} \times [|V| + I] - (P_{OUT} - P_{IN})$.
   Typical thermal resistance ($\Theta_{JC}$) = 5.1$^\circ C$/W
   a) For $T_C = +25^\circ C$
      $T_J = 60.1^\circ C$ @ 5 V, 1604 mA,
      $P_{OUT} = 30.8$ dBm, $P_{IN} = 18$ dBm
   b) For $T_C = +85^\circ C$
      $T_J = 115.1^\circ C$ @ 5 V, 1341 mA,
      $P_{OUT} = 29.3$ dBm, $P_{IN} = 17.6$ dBm

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

Handling Procedures
Please observe the following precautions to avoid damage:

Static Sensitivity
These electronics devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these 300 V HBM Class 1A devices.
Power Amplifier, 1 W
20 - 45 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 - C6</td>
<td>1 μF</td>
<td>0402</td>
</tr>
</tbody>
</table>

Sample Board Loss

Refer to the plot on page 9 for sample board loss.

Sample Board Material Specifications

Top Layer: 1/2 oz Copper Cladding, 0.0175 mm thickness
Dielectric Layer: Rogers RO4003C 0.203 mm thickness
Bottom Layer: 1/2 oz Copper Cladding, 0.0175 mm thickness
Finished overall thickness: 0.238 mm
Power Amplifier, 1 W
20 - 45 GHz

Recommended Bonding Diagram and PCB Details:
For optimum performance, RF input and output transmission lines require open stubs on the application board for bonding wire inductance compensation. The physical length for the 1 mil diameter gold wire is approximately 350 µm each for the three wire connection.

Use copper filled and plated over vias for the thermal, DC and RF ground vias.

Biasing Conditions
Recommended biasing conditions are $V_D = 5$ V, $I_{DQ} = 1000$ mA (controlled with $V_G$). The drain bias voltage range is 4 to 6 V, and the quiescent drain current biasing range is 800 to 1200 mA.

$V_G$ pads 3 and 4 are internally connected; therefore, interconnection is not 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 $V_{D1}$ through $V_{D4}$. $V_{D1}$ through $V_{D4}$ supplies are not connected internally.

Operating the MAAM-011291-DIE

Turn-on
1. Apply $V_G (-2$ V).
2. Apply $V_D (5.0$ V typical).
3. Set $I_{DQ}$ by adjusting $V_G$ more positive (typically -0.9 to -1.0 V for $I_{DQ} = 1$ A).
4. Apply $RF_{IN}$ signal.

Turn-off
1. Remove $RF_{IN}$ signal.
2. Decrease $V_G$ to -2 V.
3. Decrease $V_D$ to 0 V.
Power Amplifier, 1 W
20 - 45 GHz

Typical Performance Curves: \(V_D = 5\) V, \(I_{DSQ} = 1000\) mA

**Small Signal Gain vs. Frequency**

**Input Return Loss vs. Frequency**

**Output Return Loss vs. Frequency**

**Small Signal Gain vs. Frequency**

**Input Return Loss vs. Frequency**

**Output Return Loss vs. Frequency**
Power Amplifier, 1 W
20 - 45 GHz

Typical Performance Curves: $V_D = 5$ V

Small Signal Gain vs. Frequency

Input Return Loss vs. Frequency

Output Return Loss vs. Frequency
Power Amplifier, 1 W
20 - 45 GHz

Typical Performance Curves: $V_D = 5\ V$, $I_{DSQ} = 1000\ mA$

**$P_{3dB}$ vs. Frequency**

![Graph of $P_{3dB}$ vs. Frequency]

**$P_{1dB}$ vs. Frequency**

![Graph of $P_{1dB}$ vs. Frequency]

**$I_{ds}$ vs. Frequency @ $P_{3dB}$**

![Graph of $I_{ds}$ vs. Frequency @ $P_{3dB}$]

**$I_{gs}$ vs. Frequency @ $P_{3dB}$**

![Graph of $I_{gs}$ vs. Frequency @ $P_{3dB}$]
Power Amplifier, 1 W
20 - 45 GHz

Typical Performance Curves: $V_D = 5$ V, $I_{DSQ} = 1000$ mA

**Output Power vs. Input Power**

![Output Power vs. Input Power graph]

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

![Gain and PAE @ P3dB vs. Frequency graph]

**Drain Current vs. Input Power**

![Drain Current vs. Input Power graph]

**PAE vs. Input Power**

![PAE vs. Input Power graph]
Power Amplifier, 1 W
20 - 45 GHz

Typical Performance Curves: \( V_D = 5 \text{ V}, \ I_{DSQ} = 1000 \text{ mA} \)

**Output IP3 vs. Frequency @ \( P_{out} = 14 \text{ dBm} / \text{Tone} \)**

![Graph showing Output IP3 vs. Frequency at different temperatures (40°C, 25°C, 85°C) and voltages (4 V, 5 V, 6 V).]

**Output IP3 vs. Frequency @ \( P_{out} = 14 \text{ dBm} / \text{Tone} \)**

![Graph showing Output IP3 vs. Frequency at different currents (800 mA, 1000 mA, 1200 mA).]

**Sample Board Loss**
Includes Two 2.4 mm Connectors

![Graph showing Sample Board Loss (S21 dB) vs. Frequency.]
Power Amplifier, 1 W
20 - 45 GHz

Die Dimensions

Units are in microns with a tolerance of ±5 µm, except for die exterior dimensions which are street-center-to-street-center – nominal saw or laser kerf ~ 25 µm tolerance each dimension. Pad and backside metal is gold.

Die thickness is 100 ± 10 µm.

Pad Dimensions (µm)

<table>
<thead>
<tr>
<th>Pad #</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 13</td>
<td>76</td>
<td>186</td>
</tr>
<tr>
<td>2, 14</td>
<td>76</td>
<td>86</td>
</tr>
<tr>
<td>3–12</td>
<td>93</td>
<td>93</td>
</tr>
</tbody>
</table>
MACOM Technology Solutions Inc. (“MACOM”). All rights reserved. These materials are provided in connection with MACOM’s products as a service to its customers and may be used for informational purposes only. Except as provided in its Terms and Conditions of Sale or any separate agreement, MACOM assumes no liability or responsibility whatsoever, including for (i) errors or omissions in these materials; (ii) failure to update these materials; or (iii) conflicts or incompatibilities arising from future changes to specifications and product descriptions, which MACOM may make at any time, without notice. These materials grant no license, express or implied, to any intellectual property rights.

THESE MATERIALS ARE PROVIDED "AS IS" WITH NO WARRANTY OR LIABILITY, EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHT, ACCURACY OR COMPLETENESS, OR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES WHICH MAY RESULT FROM 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

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