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>
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</thead>
<tbody>
<tr>
<td>MAAM-011291-DIE</td>
<td>Bare Die</td>
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</table>

Functional Schematic

Bond Pad Configuration¹

<table>
<thead>
<tr>
<th>Pad #</th>
<th>Pad Name</th>
<th>Description</th>
</tr>
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<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.
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Electrical Specifications: Freq. = 20 - 45 GHz, $T_A = +25^\circ C$, $V_D = 5$ V, $I_{DSQ} = 1$ A, $Z_0 = 50$ Ω

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Units</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
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<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>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>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>28</td>
<td>29</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>39 GHz</td>
<td></td>
<td>28</td>
<td>29</td>
<td>—</td>
</tr>
<tr>
<td>P3dB</td>
<td>20 GHz</td>
<td>dBm</td>
<td>—</td>
<td>30</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>—</td>
<td>35</td>
<td>—</td>
</tr>
<tr>
<td>Drain Current</td>
<td>P3dB, 39 GHz</td>
<td>mA</td>
<td>—</td>
<td>1450</td>
<td>1800</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>P3dB, 39 GHz</td>
<td>%</td>
<td>—</td>
<td>15</td>
<td>—</td>
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Maximum Operating Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
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<tbody>
<tr>
<td>Input Power</td>
<td>$P_{IN} \leq$ 3dB Compression</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>4 to 6 V</td>
</tr>
<tr>
<td>Junction Temperature$^2$</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°C to +125°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°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
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MAAM-011291-DIE
Rev. V1

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 \( V_D = 5 \text{ V} \), \( I_{DO} = 1000 \text{ mA} \) (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 (\( V_G = -2 \text{ V} \)).

\( V_D \) 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 \( I_{DO} \) by adjusting \( V_G \) more positive (typically -0.9 to -1.0 V for \( I_{DO} = 1 \text{ A} \)).
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
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Typical Performance Curves: $V_D = 5\, \text{V}$, $I_{DSQ} = 1000\, \text{mA}$

**Small Signal Gain vs. Frequency**

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

**Input Return Loss vs. Frequency**

![Input Return Loss vs. Frequency](image)

**Output Return Loss vs. Frequency**

![Output Return Loss vs. Frequency](image)
Power Amplifier, 1 W
20 - 45 GHz

Typical Performance Curves: \(V_D = 5\) V

**Small Signal Gain vs. Frequency**

![Small Signal Gain vs. Frequency Graph]

**Input Return Loss vs. Frequency**

![Input Return Loss vs. Frequency Graph]

**Output Return Loss vs. Frequency**

![Output Return Loss vs. Frequency Graph]
Power Amplifier, 1 W
20 - 45 GHz

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

**P3dB vs. Frequency**

- Frequency (GHz)
- P3dB (dBm)
- +25°C
- -40°C
- +85°C

**P1dB vs. Frequency**

- Frequency (GHz)
- P1dB (dBm)
- +25°C
- -40°C
- +85°C

**Ids vs. Frequency @ P3dB**

- Frequency (GHz)
- Ids (mA)
- +25°C
- -40°C
- +85°C

**Igs vs. Frequency @ P3dB**

- Frequency (GHz)
- Igs (mA)
- +25°C
- -40°C
- +85°C
Power Amplifier, 1 W
20 - 45 GHz

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

**Output Power vs. Input Power**

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

**Drain Current vs. Input Power**

**PAE vs. Input Power**

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DC-0020461
Power Amplifier, 1 W
20 - 45 GHz

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

**Output IP3 vs. Frequency @ Pout = 14 dBm / Tone**

![Graph 1](image1)

**Output IP3 vs. Frequency @ Pout = 14 dBm / Tone**

![Graph 2](image2)

**Output IP3 vs. Frequency @ Pout = 14 dBm / Tone**

![Graph 3](image3)

Sample Board Loss
Includes Two 2.4 mm Connectors

![Graph 4](image4)
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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>
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