Power Amplifier, 0.25 W
20 - 45 GHz

Features
- Wide Frequency Range: 20 - 45 GHz
- High Gain: 24.5 dB @ 39 GHz
- P1dB: 23.5 dBm @ 39 GHz
- Output IP3: 30 dBm
- Integrated Power Detector
- Bare Die
- RoHS* Compliant

Applications
- ISM/MM

Description
The MAAM-011277-DIE is a 4-stage, 0.25 W power amplifier 2.5 x 1.15 mm MMIC die. This power amplifier operates from 20 to 45 GHz and provides 22 dB of linear gain, 0.25 W at P1dB compression, and 17% efficiency (P3) while biased at 5 V.

This device can be used as a driver amplifier ideally suited for various operational band in between 20 GHz and 45 GHz.

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>MAAM-011277-DIE</td>
<td>Bare Die</td>
</tr>
</tbody>
</table>

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

Functional Schematic

Pin Configuration¹

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IN</td>
<td>RF Input</td>
</tr>
<tr>
<td>2, 8</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>3, 13</td>
<td>VG</td>
<td>Gate Voltage</td>
</tr>
<tr>
<td>4, 10, 12</td>
<td>N/C</td>
<td>Not Connected</td>
</tr>
<tr>
<td>5, 11</td>
<td>VD</td>
<td>Drain Voltage</td>
</tr>
<tr>
<td>6</td>
<td>VDET_O</td>
<td>Detector Voltage</td>
</tr>
<tr>
<td>7</td>
<td>OUT</td>
<td>RF Output</td>
</tr>
<tr>
<td>9</td>
<td>VDET_R</td>
<td>Detector Reference</td>
</tr>
</tbody>
</table>

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

For further information and support please visit:
https://www.macom.com/support
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20 - 45 GHz

Electrical Specifications: Freq. = 20 - 45 GHz, $T_A = +25^\circ C$, $V_D = 5\, \text{V}$, $I_{DSQ} = 0.3\, \text{A}$, $Z_0 = 50\, \Omega$

<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>$P_{IN} = -10, \text{dBm}$</td>
<td>dB</td>
<td>21.0</td>
<td>24.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>20 GHz</td>
<td></td>
<td>18.5</td>
<td>20.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>30 GHz</td>
<td></td>
<td>21.5</td>
<td>24.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>39 GHz</td>
<td></td>
<td>—</td>
<td>18.5</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>—</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>$P_{1dB}$</td>
<td>20 GHz</td>
<td>dBm</td>
<td>21.5</td>
<td>23.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>30 GHz</td>
<td></td>
<td>21.0</td>
<td>22.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>39 GHz</td>
<td></td>
<td>22.5</td>
<td>23.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>45 GHz</td>
<td></td>
<td>—</td>
<td>22.0</td>
<td>—</td>
</tr>
<tr>
<td>$P_{3dB}$</td>
<td>—</td>
<td>dBm</td>
<td>—</td>
<td>25</td>
<td>—</td>
</tr>
<tr>
<td>OIP3</td>
<td>$P_{OUT/Tone} = 18, \text{dBm}$</td>
<td>dBm</td>
<td>—</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>—</td>
<td>V</td>
<td>—</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td>Drain Current @ $P_{1dB}$</td>
<td>—</td>
<td>mA</td>
<td>—</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>$P_{3dB}$</td>
<td>%</td>
<td>—</td>
<td>17</td>
<td>—</td>
</tr>
</tbody>
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Maximum Operating Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>$P_{IN} \leq 3, \text{dB Compression}$</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>

2. Operating at nominal conditions with junction temperature $\leq +160^\circ C$ will ensure $MTTF > 1 \times 10^6$ hours.
3. Junction Temperature ($T_J$) = $T_C + \Theta_{JC} \times (V \times I) - (P_{OUT} - P_{IN})$.
   a) For $T_C = +25^\circ C$
      $T_J = 56.2^\circ C$ @ 5 V, 443 mA, $P_{OUT} = 25.4\, \text{dBm}$, $P_{IN} = 4\, \text{dBm}$
   b) For $T_C = +85^\circ C$
      $T_J = 117.1^\circ C$ @ 5 V, 434 mA, $P_{OUT} = 24.0\, \text{dBm}$, $P_{IN} = 8\, \text{dBm}$

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 250 V HBM Class 1A devices.
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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 - C3</td>
<td>1 µF</td>
<td>0402</td>
</tr>
</tbody>
</table>

Sample Board Thru Loss
Refer to the plot on page 9 for sample board thru 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
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 two 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, $I_{DB} = 300$ mA (controlled with $V_G$). The drain bias voltage range is 4 to 6 V, and the quiescent drain current biasing range is 250 to 350 mA.

$V_G$ pins 3 and 11 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 $V_{DN}$ and $V_{DS}$ (north and south). North $V_D$ supplies and south $V_D$ supplies are not connected internally.

Operating the MAAM-011277-DIE

**Turn-on**
1. Apply $V_G$ (-1.5 V).
2. Apply $V_D$ (5.0 V typical).
3. Set $I_{DB}$ by adjusting $V_G$ more positive (typically -0.9 to -1.0 V for $I_{DB} = 300$ 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.
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Typical Performance Curves: $V_D = 5\, \text{V}, I_{DSQ} = 300\, \text{mA}$

**Small Signal Gain vs. Frequency**

[Graph showing S21 vs. Frequency for different temperatures and supply voltages]

**Input Return Loss vs. Frequency**

[Graph showing S11 vs. Frequency for different temperatures and supply voltages]

**Output Return Loss vs. Frequency**

[Graph showing S22 vs. Frequency for different temperatures and supply voltages]
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Typical Performance Curves: $V_D = 5$ V

**Small Signal Gain vs. Frequency**

**Input Return Loss vs. Frequency**

**Output Return Loss vs. Frequency**
Power Amplifier, 0.25 W
20 - 45 GHz

Typical Performance Curves: $V_D = 5$ V, $I_{DSQ} = 300$ mA

**P3dB vs. Frequency**

- $P3dB$ (dBm) vs. Frequency (GHz)
  - $+25°C$: Solid green line
  - $-40°C$: Solid blue line
  - $+85°C$: Solid red line

**P1dB vs. Frequency**

- $P1dB$ (dBm) vs. Frequency (GHz)
  - $+25°C$: Solid green line
  - $-40°C$: Solid blue line
  - $+85°C$: Solid red line

**Ids vs. Frequency @ P3dB**

- $Ids$ (mA) vs. Frequency (GHz)
  - $+25°C$: Solid green line
  - $-40°C$: Solid blue line
  - $+85°C$: Solid red line

**Igs vs. Frequency @ P3dB**

- $Igs$ (mA) vs. Frequency (GHz)
  - $+25°C$: Solid green line
  - $-40°C$: Solid blue line
  - $+85°C$: Solid red line
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Typical Performance Curves: \( V_D = 5 \text{ V}, I_{DSQ} = 300 \text{ mA} \)

**Output Power vs. Input Power**

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

**Drain Current vs. Input Power**

**PAE vs. Input Power**

**Detector Voltage vs. Output Power**

**Detector Voltage vs. Output Power @ 30 GHz**
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Typical Performance Curves: \( V_D = 5 \text{ V}, \ I_{DSQ} = 300 \text{ mA} \)

Output IP3 vs. Frequency @ \( P_{out} = 18 \text{ dBm} / \text{Tone} \)

Output IP3 vs. Frequency @ \( P_{out} = 18 \text{ dBm} / \text{Tone} \)

Sample Board Thru Losses
Includes Two 2.4 mm Connectors

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Die Dimensions

Units are in micro meters with a tolerance of ±5 µm, except for die exterior dimensions which are street-center-to-street-center – nominal saw or laser kerf is ~25 µm each dimension. Pads and backside metal are 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, 7</td>
<td>68</td>
<td>228</td>
</tr>
<tr>
<td>2, 8</td>
<td>68</td>
<td>78</td>
</tr>
<tr>
<td>3, 10, 13</td>
<td>85</td>
<td>85</td>
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<tr>
<td>4, 5, 11, 12</td>
<td>75</td>
<td>85</td>
</tr>
<tr>
<td>6, 9</td>
<td>65</td>
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