Power Amplifier, 1 W
0.001 - 22 GHz

Features
- Positive Gain Slope
- High Gain: 14 dB
- P1dB: 30 dBm
- P_{SAT}: 32 dBm
- Output IP3: 46.5 dBm
- Bias Voltage: V_{DD} = 10 V
- Bias Current: I_{DSQ} = 500 mA
- 50 Ω Matched Input / Output
- Temperature Compensated Output Power Detector
- 1500 x 2900 µm Die Size
- RoHS* Compliant

Applications
- Test & Measurement, EW, ECM, and Radar

Description
The MAAP-011327-DIE is a 1 W distributed power amplifier die. The power amplifier operates from 0.001 to 22 GHz and provides 14 dB of linear gain and 32 dBm of output power at saturation. The device is fully matched across the band and includes a temperature compensated output power detector.

The MAAP-011327-DIE can be used as a power amplifier stage or as a driver stage in higher power applications. This device is ideally suited for test and measurement, EW, ECM, and radar applications.

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 two 0.025 mm (1 mil) wire bonds of minimal length 0.31 mm (12 mils) on the RF_{IN} and RF_{OUT}/V_{DD} ports.

Functional Schematic

Pin Configuration

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 3, 6, 8, 9, 11</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>RF_{IN}</td>
<td>RF Input</td>
</tr>
<tr>
<td>4</td>
<td>VD_AUX</td>
<td>VD Auxiliary</td>
</tr>
<tr>
<td>5</td>
<td>DET</td>
<td>Power Detector</td>
</tr>
<tr>
<td>7</td>
<td>RF_{OUT}/V_{DD}</td>
<td>RF Output / Drain Voltage</td>
</tr>
<tr>
<td>10</td>
<td>VG_AUX</td>
<td>VG Auxiliary</td>
</tr>
<tr>
<td>12</td>
<td>V_{G1}</td>
<td>Gate Voltage</td>
</tr>
</tbody>
</table>

2. Backside of die on the die bottom must be connected to RF, DC and thermal ground.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-011327-DIE</td>
<td>Gel Pack¹</td>
</tr>
<tr>
<td>MAAP-011327-DIESMB</td>
<td>Sample Board</td>
</tr>
</tbody>
</table>

¹ Die quantity varies.

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

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DC-0023538
## Electrical Specifications: \( T_A = +25^\circ C, V_{DD} = 10 \, V, I_{DSQ} = 500 \, mA, Z_0 = 50 \, \Omega \)

<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><strong>Gain</strong></td>
<td>2 GHz, 10 GHz, 18 GHz, 22 GHz</td>
<td>dB</td>
<td>—</td>
<td>13.0</td>
<td>13.5</td>
</tr>
<tr>
<td><strong>PSAT</strong></td>
<td>( P_{IN} = +24 , dBm )</td>
<td>dBm</td>
<td>—</td>
<td>32.0</td>
<td>31.0</td>
</tr>
<tr>
<td><strong>P1dB</strong></td>
<td>2 GHz, 10 GHz, 18 GHz, 22 GHz</td>
<td>dBm</td>
<td>—</td>
<td>30.0</td>
<td>29.5</td>
</tr>
<tr>
<td><strong>OIP3</strong></td>
<td>( P_{OUT} = +18 , dBm/tone (10 , MHz , Tone , Spacing) )</td>
<td>dBm</td>
<td>—</td>
<td>46.5</td>
<td>42.0</td>
</tr>
<tr>
<td><strong>PAE</strong></td>
<td>( P_{IN} = +22 , dBm )</td>
<td>%</td>
<td>—</td>
<td>29.0</td>
<td>23.0</td>
</tr>
<tr>
<td><strong>Input Return Loss</strong></td>
<td>( P_{IN} = -20 , dBm )</td>
<td>dB</td>
<td>—</td>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td><strong>Output Return Loss</strong></td>
<td>( P_{IN} = -20 , dBm )</td>
<td>dB</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td><strong>I_{DD} (with RF drive)</strong></td>
<td>( P_{IN} = +23 , dBm )</td>
<td>mA</td>
<td>—</td>
<td>600</td>
<td>—</td>
</tr>
<tr>
<td><strong>I_{G1}</strong></td>
<td>( P_{IN} = +23 , dBm )</td>
<td>mA</td>
<td>—</td>
<td>-0.22</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>24 dBm</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>12 V</td>
</tr>
<tr>
<td>Junction Temperature(^3,4)</td>
<td>+150°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

3. Operating at nominal conditions with junction temperature \( \leq +150^\circ C \) will ensure MTTF \( \geq 1 \times 10^6 \) hours.

4. Junction Temperature \( (T_J) = T_{C} + \Theta_{JC} \times (V \times I) - (P_{OUT} - P_{IN}) \)

   Typical thermal resistance \( (\Theta_{JC}) = 12.2 \, ^\circ C/W. \)

   a) For \( T_{C} = +85^\circ C, T_J = +151^\circ C \) @ 10 V, 0.60 A, \( P_{OUT} = 29 \, dBm, P_{IN} = 24 \, dBm, 22 \, GHz \)

### Absolute Maximum Ratings\(^5,6\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>30 dBm</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>+13 V</td>
</tr>
<tr>
<td>Gate Voltage</td>
<td>-2 to 0 V</td>
</tr>
<tr>
<td>Junction Temperature(^7)</td>
<td>+175°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +125°C</td>
</tr>
</tbody>
</table>

5. Exceeding any one or combination of these limits may cause permanent damage to this device.

6. MACOM does not recommend sustained operation near these survivability limits.

7. Junction temperature directly effects device MTTF. Junction temperature should be kept as low as possible to maximize lifetime.
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Application Schematic

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 2 devices.

Airbridges
The top of the die has exposed airbridges which can be damaged if mishandled. Please take appropriate precautions when handling the die.

Bill of Materials

<table>
<thead>
<tr>
<th>Part</th>
<th>Value</th>
<th>Size</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - C3</td>
<td>1 µF</td>
<td>0402</td>
<td>bypass</td>
</tr>
</tbody>
</table>

8. C1 & C2 are required for operation below 1 GHz.
9. High power external bias tee was used for measurements.
10. External DC block was used on input.

Biasing Conditions
Recommended biasing conditions are \( V_{DD} = 10 \) V, \( I_{DSQ} = 500 \) mA (controlled with \( V_{G1} \)).

\( V_{DD} \) Bias must be applied through a resonant free high inductance on the RF output line.

Bypass capacitors C1 and C2 for the auxiliary pads are for low frequency operation extension (below 1 GHz).

Mounting and Bonding Information
The DIE should be directly attached to the RF/DC ground plane; either with solder (AuSn) or a thin application of conductive epoxy. Avoid overflows.

Any connecting microstrip (50 Ω Transmission Line) substrate should be brought as close as possible to the die in order to minimize bond wire inductance. A typical spacing between die and microstrip substrate should be kept between 75 - 125 µm for best RF behavior. All bonds should be kept as short as possible. Use minimum ultrasonic energy for reliable wire bonds.

Recommended PCB Information
RF input and output are 50 Ω transmission lines. Single layer 8 mil Rogers RO4008 with 1/2 oz. Cu. Use copper filled vias under die backside ground pad.

Grounding
It is recommended that the total ground (common mode) inductance not exceed 0.03 nH (30 pH). This is equivalent to placing at least four 8 mil (200 µm) diameter vias under the device, assuming an 8 mil (200 µm) thick RF layer to ground; however, for good thermals, it is recommended to use as many as physically possible.

Operating the MAAP-011327-DIE

Turn-on
1. Apply \( V_{G1} \) (-1.5 V).
2. Increase \( V_{DD} \) to 10 V.
3. Set \( I_{DSQ} \) by adjusting \( V_{G1} \) more positive (typically −0.8 V for \( I_{DSQ} = 500 \) mA).
4. Apply RF\(_{IN}\) signal.

Turn-off
1. Remove RF\(_{IN}\) signal.
2. Decrease \( V_{G1} \) to -1.5 V.
3. Decrease \( V_{DD} \) to 0 V.
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PCB Layout

Co-Planar transmission line: Width = 340 µm, Gap = 130 µm
Copper filled vias: 300 µm diameter, 5 x 5 array under die

Die Bonding Close Up
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Typical Performance Curves $V_{DD} = 10$ V, $I_{DSQ} = 500$ mA, $V_{G1} = -0.8$ V typical

**S Parameters**

- $S_{21}$, $S_{11}$, $S_{22}$ (dB)

**Gain**

- $S_{21}$ (dB)

**Input Return Loss**

- $S_{11}$ (dB)

**Output Return Loss**

- $S_{22}$ (dB)

**Isolation**

- $S_{12}$ (dB)

**Gain over Voltage**

- Gain (dB)
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Typical Performance Curves $V_{DD} = 10$ V, $I_{DSQ} = 500$ mA, $V_{G1} = -0.8$ V typical

**$P_{1dB}$ over Temperature**

**$P_{SAT}$ over Temperature**

**$P_{1dB}$ over Voltage**

**$P_{SAT}$ over Voltage**

**$P_{1dB}$ over Current**

**$P_{SAT}$ over Current**
Power Amplifier, 1 W  
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Typical Performance Curves $V_{DD} = 10$ V, $I_{DSQ} = 500$ mA, $V_{G1} = -0.8$ V typical

Output IP3 vs. Frequency over Temperature  
@Po=18dBm/tone

Output IP3 vs. Frequency over Drain Current  
@Po=18dBm/tone

Output IP2 vs. Frequency  
@Po=18dBm/tone

2nd Harmonic level vs. Frequency over Output Power

Noise Figure vs. Frequency
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Typical Performance Curves $V_{DD} = 10$ V, $I_{DSQ} = 500$ mA, $V_{G1} = -0.8$ V typical

Power Compression @ 2 GHz

Power Compression @ 12 GHz

Power Compression @ 22 GHz

Detector Voltage vs. Power

Current
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Die Dimensions^{11,12,13}

11. 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.
12. Bondpad and backside metal is gold.
13. Die thickness is 100 ± 10 µm.

Bond Pad Dimensions (µm)

<table>
<thead>
<tr>
<th>Pad</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,3,8</td>
<td>77</td>
<td>87</td>
</tr>
<tr>
<td>2,7</td>
<td>77</td>
<td>137</td>
</tr>
<tr>
<td>4,5,6,9,10,11,12</td>
<td>89</td>
<td>89</td>
</tr>
</tbody>
</table>
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