MAAP-015030-DIE

Power Amplifier, 13 W
8.5 - 11.75 GHz

Features
- 12 W X-Band Power Amplifier
- 21 dB Large Signal Gain
- 41 dBm Saturated Pulsed Output Power
- 40% Power Added Efficiency
- On Chip Gate Bias Circuit
- 100% On-wafer DC & RF Power Tested
- 100% Visual Inspection to MIL-STD-833
- Bare Die

Description
The MAAP-015030-DIE two stage 8.5 - 11.75 GHz GaAs MMIC power amplifier has a saturated pulsed output power of 41 dBm and a large signal gain of 21 dB. The power amplifier can be biased using a direct gate voltage or using an on chip gate bias circuit.

This device is well suited for communication and radar applications.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAP-015030-DIE</td>
<td>Die in Vacuum release gel pack</td>
</tr>
<tr>
<td>MAAP-015030-DIEEV1</td>
<td>Direct gate bias sample board</td>
</tr>
<tr>
<td>MAAP-015030-DIEEV2</td>
<td>On chip gate bias sample board</td>
</tr>
</tbody>
</table>

Functional Schematic

Pad Configuration

<table>
<thead>
<tr>
<th>Pad #</th>
<th>Function</th>
<th>Pad #</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vg1</td>
<td>12</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>Bias Circuit GND</td>
<td>13</td>
<td>Vg2</td>
</tr>
<tr>
<td>3</td>
<td>No Connection</td>
<td>14</td>
<td>Vg1</td>
</tr>
<tr>
<td>4</td>
<td>Vg1</td>
<td>15</td>
<td>Vg2</td>
</tr>
<tr>
<td>5</td>
<td>Vg2</td>
<td>16</td>
<td>Bias Circuit GND</td>
</tr>
<tr>
<td>6</td>
<td>Bias Circuit GND</td>
<td>17</td>
<td>Vb2</td>
</tr>
<tr>
<td>7</td>
<td>Vg2</td>
<td>18</td>
<td>Vb1</td>
</tr>
<tr>
<td>8</td>
<td>Vg1</td>
<td>19</td>
<td>GND</td>
</tr>
<tr>
<td>9</td>
<td>Vg2</td>
<td>20</td>
<td>Bias Circuit GND</td>
</tr>
<tr>
<td>10</td>
<td>GND</td>
<td>21</td>
<td>Vg1</td>
</tr>
<tr>
<td>11</td>
<td>RFOUT</td>
<td>22</td>
<td>RFIN</td>
</tr>
</tbody>
</table>

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
Electrical Specifications:
Freq. = 8.5 - 11.5 GHz, \( T_A = +25^\circ \text{C} \), Duty Cycle = 5%, \( P_{IN} = 20 \text{ dBm} \), \( V_G = -0.9 \text{ V} \)

<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 (Large Signal)</td>
<td>8.5 - 11.5 GHz</td>
<td>dB</td>
<td>20</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>11.5 - 11.75 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain</td>
<td></td>
<td>dB</td>
<td>25</td>
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<td>Gain Flatness</td>
<td></td>
<td>dB</td>
<td>1</td>
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<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>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated Output Power</td>
<td>8.5 - 11.5 GHz</td>
<td>dBm</td>
<td>40</td>
<td>39</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>11.5 - 11.75 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Power Added Efficiency</td>
<td>8.5 - 9.0 GHz</td>
<td>%</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.0 - 10.0 GHz</td>
<td></td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.0 - 11.75 GHz</td>
<td></td>
<td>40</td>
<td></td>
<td></td>
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<tr>
<td>Drain Bias Voltage</td>
<td></td>
<td>V</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain Current</td>
<td></td>
<td>A</td>
<td>5</td>
<td>5.5</td>
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</table>

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
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<tbody>
<tr>
<td>Input Power</td>
<td>23 dBm</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>8.5 V</td>
</tr>
<tr>
<td>Gate Voltage</td>
<td>(-2.0 \text{ V} &lt; V_G &lt; -0.7 \text{ V})</td>
</tr>
<tr>
<td>Bias Voltage</td>
<td>(-6.5 \text{ V} &lt; V_B &lt; -4.5 \text{ V})</td>
</tr>
<tr>
<td>Drain Current</td>
<td>(&lt; 6.0 \text{ A})</td>
</tr>
<tr>
<td>Gate Current</td>
<td>(&lt; 30 \text{ mA})</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>(-40^\circ \text{C to } +85^\circ \text{C})</td>
</tr>
<tr>
<td>Junction Temperature (\Omega_{jc})</td>
<td>(+175^\circ \text{C})</td>
</tr>
</tbody>
</table>

Handling Procedures
Please observe the following precautions to avoid damage:

Static Sensitivity
Gallium Arsenide Integrated Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

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Bonding Diagram - On Chip Bias

Bonding Diagram - Direct Gate Bias

5. Components C1 - C8 are all 100 pF chips.

MMIC Bare Die
Power Amplifier, 13 W
8.5 - 11.75 GHz

Typical Performance Curves over Voltage

**Gain vs. Frequency**

![Gain vs. Frequency Graph](image)

**Reverse Isolation vs. Frequency**

![Reverse Isolation vs. Frequency Graph](image)

**Input Return Loss vs. Frequency**

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

**Output Return Loss vs. Frequency**

![Output Return Loss vs. Frequency Graph](image)
Power Amplifier, 13 W
8.5 - 11.75 GHz

Typical Performance Curves over Voltage

Gain vs. Frequency

Output Power vs. Frequency

Drain Current vs. Frequency

PAE vs. Frequency
Typical Performance Curves over Frequency

**Gain vs. Input Power**

Input Power (dBm)

**Output Power vs. Input Power**

Input Power (dBm)

**Drain Current vs. Input Power**

Input Power (dBm)

**Gate Current vs. Input Power**

Input Power (dBm)

**PAE vs. Input Power**

Input Power (dBm)
Power Amplifier, 13 W
8.5 - 11.75 GHz

Typical Performance Curves over Temperature: $P_{\text{IN}} = 19.5$ dBm

- **Gain vs. Frequency**
- **Output Power vs. Frequency**
- **Drain Current vs. Frequency**
- **PAE vs. Frequency**
Typical Performance Curves over Temperature

Gain vs. Input Power

Output Power vs. Input Power

Drain Current vs. Input Power

PAE vs. Input Power

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Applications Section

Application Notes

Note 1 - Biasing
The gate biasing is applied in one of the following:
1. Direct Gate Bias: $V_{G1}$ & $V_{G2}$ provide the direct
gate bias input to the 2 MMIC stages. This
method of biasing allows the user to control the
total drain current without the scaling factor
provided by the bias circuit. It is recommended
that the gate voltage is supplied by both sides of
the Die. Optimum performance can be achieved
with a -0.9 V operation.
2. Bias Circuit Biasing: Applying -5 V to $V_{B1}$ & $V_{B2}$
will typically draw 2A with no further adjustment
necessary. Wafer lot variation may result in
some devices experiencing higher or lower drain
currents than the typical 2 A. It is necessary to
connect the Bias Circuit Ground (Pad 2,6,16,20)
to ground in order for this bias circuit to function
correctly. It is recommended that the bias
circuits on both sides of the PA are used.

Note 2 - Bias Sequence
When switching on the PA, in each case, the gate
bias must be applied before the drain voltage is
applied. Both the $V_{D1}$ and $V_{D2}$ should be biased
from the top and bottom sides of the die.

Note 3 - Decoupling Circuits
Each bias pad, $V_G$ or $V_B$ and the $V_{D1}$, $V_{D2}$ must have
a decoupling capacitor of 100 pF as close to the
device as possible, as is shown in the bonding
diagrams. In the case where the bias circuit is used
the additional bond wire to ground must be made as
short as possible.

Note 4 - Pulse Operation
The performance of the MAAP-015030-BD is
characterized under pulsed conditions with a duty
cycle of 5% consisting of a pulse width of 5 µs
applied to the drain. Under pulsed conditions the
gate is constantly biased using either the on chip
bias circuit or using a gate voltage directly applied to
the PA. It is recommended that the die is mounted
with an adequate thermal solution.

Note 5 - CW Operation
The PA is only recommended for CW operation at
reduced drain voltages.
Applications Section

Handling and Assembly

Die Attachment
This product is 0.100 mm (0.004") thick and has vias through to the backside to enable grounding to the circuit. Microstrip substrates should be brought as close to the die as possible. The mounting surface should be clean and flat. If using conductive epoxy, recommended epoxies are Tanaka TS3332LD, Die Mat DM6030HK or DM6030HK-Pt cured in a nitrogen atmosphere per manufacturer's cure schedule. Apply epoxy sparingly to avoid getting any on to the top surface of the die. An epoxy fillet should be visible around the total die periphery. For additional information please see the MACOM "Epoxy Specifications for Bare Die" application note. If eutectic mounting is preferred, then a flux-less gold-tin (AuSn) preform, approximately 0.0012 thick, placed between the die and the attachment surface should be used. A die bonder that utilizes a heated collet and provides scrubbing action to ensure total wetting to prevent void formation in a nitrogen atmosphere is recommended. The gold-tin eutectic (80% Au 20% Sn) has a melting point of approximately 280ºC (Note: Gold Germanium should be avoided). The work station temperature should be 310ºC +/- 10ºC. Exposure to these extreme temperatures should be kept to minimum. The collet should be heated, and the die pre-heated to avoid excessive thermal shock. Avoidance of air bridges and force impact are critical during placement.

Wire Bonding
Windows in the surface passivation above the bond pads are provided to allow wire bonding to the die's gold bond pads. The recommended wire bonding procedure uses 0.076 mm x 0.013 mm (0.003" x 0.0005") 99.99% pure gold ribbon with 0.5 - 2% elongation to minimize RF port bond inductance. Gold 0.025 mm (0.001") diameter wedge or ball bonds are acceptable for DC Bias connections. Aluminium wire should be avoided. Thermo-compression bonding is recommended though thermo-sonic bonding may be used providing the ultrasonic content of the bond is minimized. Bond force, time and ultrasonic's are all critical parameters. Bonds should be made from the bond pads on the die to the package or substrate. All bonds should be as short as possible.
Application Circuit

50Ω TX Line

2.2μF 1nF 120pF

2.2μF 1nF 120pF

MAAP-015030-DIE

VG1/ VG2/ VD1 VD2
VB1 VB2

VB1/ VB2/
VG1 VG2/
VD1 VD2

VB1 VB2
VG1 VG2
VD1 VD2

120pF 1nF 2.2μF

120pF 1nF 2.2μF

120pF

120pF

10Ω 47nF

10Ω 47nF

50Ω TX Line
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