MAAP-011106

Power Amplifier, 71 - 86 GHz

Features
- 4 Stage Power Amplifier for E Band
- 20 dB Gain
- 15 dB input and output match
- 25 dBm saturated output power
- 30 dBm OIP3
- Variable gain with adjustable bias
- Integrated detector
- Bare die
- RoHS* compliant and 260°C reflow compatible
- HBM ESD rating of 100 V
- Size: 3780 x 2500 x 50 µm

Description
The MAAP-011106 is a bare die power amplifier that operates from 71 - 86 GHz. The amplifier provides 20 dB small signal gain. The input and output are matched to 50 Ω with bond wires to external board. It is designed for use as a power amplifier stage in transmit chains and is ideally suited for E band point to point radios.

Each device is 100% RF tested to ensure performance compliance. The part is fabricated using an efficient pHEMT process.

Chip Device Layout

Pad Configuration

<table>
<thead>
<tr>
<th>Pad No.</th>
<th>Function</th>
<th>Pad No.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VD1</td>
<td>9</td>
<td>VREF</td>
</tr>
<tr>
<td>2</td>
<td>VD2</td>
<td>10</td>
<td>GNDDET</td>
</tr>
<tr>
<td>3</td>
<td>VD3</td>
<td>11</td>
<td>VG4</td>
</tr>
<tr>
<td>4</td>
<td>VD4</td>
<td>12</td>
<td>VG3</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>13</td>
<td>VG2</td>
</tr>
<tr>
<td>6</td>
<td>RFOUT</td>
<td>14</td>
<td>VG1</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>15</td>
<td>GND</td>
</tr>
<tr>
<td>8</td>
<td>VDET</td>
<td>16</td>
<td>RFIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17</td>
<td>GND</td>
</tr>
</tbody>
</table>

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1. Quiescent DC Bias: $I_{D1} = 60$ mA, $I_{D2} = 120$ mA, $I_{D3} = 240$ mA, $I_{D4} = 300$ mA. Total DC power = 2.88 W
2. Minimum limits are the on-wafer minimum test limits

### Electrical Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>dB</td>
<td>18</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>dB</td>
<td>-</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>dB</td>
<td>-</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>$P_{1dB}$</td>
<td>dB</td>
<td>-</td>
<td>23</td>
<td>-</td>
</tr>
<tr>
<td>$P_{OUT}$ with $P_{IN}$ = 13 dBm</td>
<td>dBm</td>
<td>-</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>$P_{SAT}$ (P4dB)</td>
<td>dBm</td>
<td>24</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>OIP3 (worst tone) for Gain = 20 turned down to -5 dB</td>
<td>dBm</td>
<td>-</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>IIP3 (worst tone)</td>
<td>dBm</td>
<td>-</td>
<td>10</td>
<td>-</td>
</tr>
</tbody>
</table>

### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Voltage</td>
<td>+4.3 V</td>
</tr>
<tr>
<td>Drain Current</td>
<td>935 mA</td>
</tr>
<tr>
<td>Gate Bias Voltage $(V_{G1,2,3,4})$</td>
<td>$-1.5 &lt; V_{G} &lt; 0$ V</td>
</tr>
<tr>
<td>Input Power</td>
<td>+16 dBm</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-55°C to +150°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>+150°C</td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td>16.15°C/W</td>
</tr>
</tbody>
</table>

3. Exceeding any one or combination of these limits may cause permanent damage to this device.
4. MACOM does not recommend sustained operation near these survivability limits.
5. Operating at nominal conditions with $T_J \leq +150^\circ$C will ensure $MTTF > 1 \times 10^6$ hours.

### 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 static sensitive devices.
Typical Performance Curves

S-Parameters (Wideband)

P1dB and P4dB

S-Parameters

P_{OUT} @ P_{IN} = 13 \, \text{dBm}
Typical Performance Curves

**S-Parameters @ 80 GHz vs. Current**

**Detector Delta Voltage vs. Output Power**

**Worst Tone Output IP3**

**Lower and Upper Tone Gain, IIP3 and OIP3 vs. Current**

For further information and support please visit: https://www.macom.com/support
**Calibration Plane**

All data was measured on die with 200 µm pitch probes. The calibration plane is at the middle of the through, 178.5 µm from the middle of the RF pad.

![Calibration Plane Diagram]

**App Note [1] Biasing**

All gates should be pinched-off \(V_G < -1\) V before applying drain voltage \(V_D = 4\) V. Then the gate voltages can be increased until the desired quiescent drain current is reached in each stage. The recommended quiescent bias is \(V_D = 4\) V, \(I_{D1} = 60\) mA, \(I_{D2} = 120\) mA, \(I_{D3} = 240\) mA and \(I_{D4} = 300\) mA. The performance in this datasheet has been measured with fixed gate voltage and no drain current regulation under large signal operation. It is also possible to regulate the drain current dynamically, to limit the DC power dissipation under RF drive. To turn off the device, the turn on bias sequence should be followed in reverse.

**App Note [2] Bias Arrangement**

Each DC pin \((V_D1,2,3,4\) and \(V_G1,2,3,4)) needs to have bypass capacitance \((120\) pF and \(10\) nF) mounted as close to the MMIC as possible.

**App Note [3] Wire Bonding**

The loop height of the RF bonds should be minimized. Where the die is mounted above the PCB, it is recommended to use Reverse Ball-Stitch-on-Ball bonds (BSOB). If the die is mounted inside a cavity on the board, forward loop bonding may result in a lower loop height. V-shape RF bond with two wires (diameter = 25 µm) is recommended for optimum RF performance. RF bond wire length to be minimized to reduce the inductance effect. Simulations suggest no more than 300 µm. Substrate RF pad can be optimized to improve the microstrip to MMIC bond transition as shown in the example below.

![Wire Bonding Diagram]
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App Note [4] Detector biasing schematic -
As shown in the schematic below, the power
detector is biased by matched 120 kΩ resistors
to a +5 V supply. The difference voltage between
$V_{DET}$ and $V_{REF}$ pins can be obtained using the
op-amp differencing circuit shown below.

App Note [5] Common Gates and Drains -
When biasing the device with only a single gate
or drain source additional isolation is required
between each stage. On the gate side a 10 Ω
resistor should be placed in series and tied
together in a star to a common supply. The drain
side resistance should be reduced to less than
5 Ω to minimize any voltage drop across the
resistor. Suitable bias pass capacitance should
still be applied to each stage as per
App Note [2].

Layout Dimensions

Die Thickness: 50 µm
RF Pads = 60 x 120 µm²
DC Pads = 100 x 100 µm²
& 100 x 200 µm²