Power Amplifier, 1 W
20 - 55 GHz

Features

- High Gain: 22 dB
- P1dB: 29 dBm
- PSAT: 30 dBm
- Output IP3: 39 dBm
- Bias Voltage: VDD = 5 V
- Bias Current: IDSS = 1500 mA
- 50 Ω Matched Input / Output
- Temperature Compensated Output Power Detector
- Lead-Free 5 x 7 mm 12 lead SMT package
- RoHS* Compliant

Applications

- Test & Measurement
- 5G FR2, EW, ECM
- Radar

Description

The MAAP-011379 is a 1 W distributed power amplifier offered in die form. The power amplifier operates from 20 to 55 GHz and provides 22 dB of linear gain and 30 dBm saturated output power. The device is fully matched across the band and includes a temperature compensated output power detector.

The MAAP-011379 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, 5G FR2, EW, ECM, and radar applications.

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>MAAP-011379-TR0500</td>
<td>500 piece reel</td>
</tr>
<tr>
<td>MAAP-011379-SMB</td>
<td>Sample Board</td>
</tr>
</tbody>
</table>

3. Ground paddle must be connected to RF, DC and thermal ground.
4. It is recommended that these pins are grounded on the application PCB.

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**Power Amplifier, 1 W**
**20 - 55 GHz**

AC Electrical Specifications: \( T_A = +25^\circ C, V_D = 5 \, \text{V}, \, I_{DSQ} = 1500 \, \text{mA}, \, Z_0 = 50 \, \Omega \)

<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>Gain</td>
<td>( P_{IN} = -10 , \text{dBm} )</td>
<td>dB</td>
<td>16.5</td>
<td>19.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>20.0 GHz</td>
<td></td>
<td>19.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.0 GHz</td>
<td></td>
<td>22.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.0 GHz</td>
<td></td>
<td>21.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48.5 GHz</td>
<td></td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>55.0 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>20.0 GHz</td>
<td>dBm</td>
<td>24.5</td>
<td>28.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>30.0 GHz</td>
<td></td>
<td>29.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.0 GHz</td>
<td></td>
<td>28.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48.5 GHz</td>
<td></td>
<td>23.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>55.0 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( P_{SAT} )</td>
<td>20.0 GHz</td>
<td>dBm</td>
<td>30.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.0 GHz</td>
<td></td>
<td>30.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.0 GHz</td>
<td></td>
<td>30.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48.5 GHz</td>
<td></td>
<td>26.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>55.0 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OIP3</td>
<td>( P_{OUT/Tone} = 21 , \text{dBm}, , \Delta f = 2 , \text{MHz} )</td>
<td>dBm</td>
<td>—</td>
<td>38.5</td>
<td>—</td>
</tr>
<tr>
<td>Drain Current</td>
<td>( P_{SAT}, 40 , \text{GHz} )</td>
<td>mA</td>
<td>—</td>
<td>1950</td>
<td>—</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>( P_{SAT}, 40 , \text{GHz} )</td>
<td>%</td>
<td>—</td>
<td>9</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>16 , \text{dBm}</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>5.5 , \text{V}</td>
</tr>
<tr>
<td>Junction Temperature(^{5,6})</td>
<td>+160°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

5. Operating at nominal conditions with junction temperature \( \leq +160°C \) will ensure MTTF > 1 x 10\(^6\) hours.

6. Junction Temperature (\( T_J \)) = \( T_C + \Theta_{JC} * [V \cdot I] - (P_{OUT} - P_{IN}) \).

   Typical thermal resistance (\( \Theta_{JC} \)) = 5.6°C/W

   a) For \( T_C = +25°C \) at the backside of the die
      \( T_J = 74°C \) @ 5 \, \text{V}, 1.95 \, \text{A},
      \( P_{OUT} = 30 \, \text{dBm}, \, P_{IN} = 15 \, \text{dBm} \)

   b) For \( T_C = +85°C \) at the backside of the die
      \( T_J = 134°C \) @ 5 \, \text{V}, 1.9 \, \text{A},
      \( P_{OUT} = 29 \, \text{dBm}, \, P_{IN} = 15 \, \text{dBm} \)

**Absolute Maximum Ratings\(^7,8\)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>27 , \text{dBm}</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>6.5 , \text{V}</td>
</tr>
<tr>
<td>Gate Voltage</td>
<td>-3 , \text{to} , 0 , \text{V}</td>
</tr>
<tr>
<td>Junction Temperature(^6)</td>
<td>+175°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +125°C</td>
</tr>
</tbody>
</table>

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

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

9. Junction temperature directly effects device MTTF. Junction temperature should be kept as low as possible to maximize lifetime.
Pin Configuration and Functional Descriptions

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RF\textsubscript{IN}</td>
<td>RF Signal Input. This pin is matched to 50 $\Omega$ and is AC coupled.</td>
</tr>
<tr>
<td>2, 12</td>
<td>$V_{G1}, V_{G2}$</td>
<td>Power amplifier gate controls. Adjust from $-2$ V to 0 V to achieve the desired quiescent current. External bypass capacitors are required as described in the applications schematic. There is no internal connection between pin 2 &amp; 12 and so both need to be externally connected to the gate voltage.</td>
</tr>
<tr>
<td>3, 11</td>
<td>NC</td>
<td>These pins are not internally connected (i.e. open circuit). It is recommended that these are connected to ground on the application PCB.</td>
</tr>
<tr>
<td>4</td>
<td>$V_{D4}$</td>
<td>Drain bias 4 for the amplifier. External bypass capacitors are required as described in the applications schematic.</td>
</tr>
<tr>
<td>5</td>
<td>$V_{D5}$</td>
<td>Drain bias 5 for the amplifier. External bypass capacitors are required as described in the applications schematic.</td>
</tr>
<tr>
<td>6</td>
<td>$V_{DET}$</td>
<td>Power detector output voltage. There is an internal 5$\Omega$ resistor on this pin.</td>
</tr>
<tr>
<td>7</td>
<td>RF\textsubscript{OUT}</td>
<td>RF Signal Output. This pin is matched to 50 $\Omega$ and is AC coupled</td>
</tr>
<tr>
<td>8</td>
<td>$V_{D3}$</td>
<td>Drain bias 3 for the amplifier. External bypass capacitors are required as described in the applications schematic.</td>
</tr>
<tr>
<td>9</td>
<td>$V_{D2}$</td>
<td>Drain bias 2 for the amplifier. External bypass capacitors are required as described in the applications schematic.</td>
</tr>
<tr>
<td>10</td>
<td>$V_{D1}$</td>
<td>Drain bias 1 for the amplifier. External bypass capacitors are required as described in the applications schematic.</td>
</tr>
</tbody>
</table>
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Interface Schematics

Biasing Conditions
Recommended biasing conditions are $V_D = 5 \text{ V}$, $I_{DQ} = 1500 \text{ mA}$ (controlled with $V_G$). The drain bias voltage range is 4 to 5.5 V, and the quiescent drain current biasing range is 1300 to 1700 mA.

Operating the MAAP-011379

Turn-on
1. Apply $V_G$ (-2 V).
2. Apply $V_D$ (5 V typical).
3. Set $I_{DQ}$ by adjusting $V_G$ more positive (typically -0.45 V for $I_{DQ} = 1500 \text{ mA}$).
4. Apply RFIN signal.

Turn-off
1. Remove RFIN signal.
2. Decrease $V_G$ to -2 V.
3. Decrease $V_D$ to 0 V.

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 1A devices.
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Evaluation Board Layout

Parts List

<table>
<thead>
<tr>
<th>Part</th>
<th>Value</th>
<th>Case Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6, C10, C13, C17, C20</td>
<td>1 µF</td>
<td>603</td>
</tr>
<tr>
<td>C5, C7, C8, C14, C15, C16, C23, C24</td>
<td>0.1 µF</td>
<td>603</td>
</tr>
<tr>
<td>C1, C2, C3, C4, C11, C12, C19</td>
<td>100 pF</td>
<td>402</td>
</tr>
<tr>
<td>R1, R2, R3, R4, R6, R7, R8</td>
<td>10 Ω</td>
<td>402</td>
</tr>
<tr>
<td>L1, L2, L3, L5, L7</td>
<td>10 nH</td>
<td>603</td>
</tr>
<tr>
<td>C9, C18, C21, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C36, C37, C38, C39, C40, C41 R5, R9, R10, R11, R12, R13, R14 L4, L6, L8, L9, L10</td>
<td>DNI</td>
<td>DNI</td>
</tr>
</tbody>
</table>

DESIGN NOTES:
RO4003C, 8 MIL THICK, 1/2 COPPER, SOFT GOLD PLATING
RF TRACE: 14 MIL WIDTH AND 6.5 MIL SPACING
RF PROBE: 8 MIL TRACE WIDTH, 4.5 MIL SPACING
EDGE WRAP ON J3, J4, J5, J6.
Evaluation Board Notes

The 100 pF capacitors should be placed as close to the amplifier as practically possible. For the larger 0.1 µF capacitors proximity to the PA is less important. The circuit is not sensitive to the positioning of the 1.0 µF capacitors however these should be on the same PCB as the rest of the biasing components.

The capacitors on the detector output are optional: values will depend on the required response time of the detector output. There is an internal series 5 kΩ resistor on this pin.

To ensure proper grounding the number of ground vias under the device should be maximized (within practical limits imposed by the PCB vendor).

Due to the relatively high power dissipation of this high performance power amplifier, consideration needs to be given to the thermal design of the PCB. MACOM recommends the use of fully copper plated thermal vias beneath the amplifier.
Power Amplifier, 1 W
20 - 55 GHz

Typical Performance Curves: $V_D = 5$ V, $I_{DSQ} = 1500$ mA

Small Signal Gain vs. Frequency

Small Signal Gain vs. Frequency

Input Return Loss vs. Frequency

Input Return Loss vs. Frequency

Output Return Loss vs. Frequency

Output Return Loss vs. Frequency
Power Amplifier, 1 W
20 - 55 GHz

Typical Performance Curves: $V_D = 5$ V

**Small Signal Gain vs. Frequency**

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

**Eval Board Thru Losses**

![Graph of Eval Board Thru Losses](image)

**Input Return Loss vs. Frequency**

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

**Output Return Loss vs. Frequency**

![Graph of Output Return Loss vs. Frequency](image)
Power Amplifier, 1 W
20 - 55 GHz

Typical Performance Curves: $V_D = 5\, \text{V}, I_{\text{DSQ}} = 1500\, \text{mA}$

Psat vs. Frequency

P1dB vs. Frequency

Psat vs. Frequency

P1dB vs. Frequency

Psat vs. Frequency

P1dB vs. Frequency

Psat vs. Frequency

P1dB vs. Frequency

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Typical Performance Curves: $V_D = 5 \, V$, $I_{DSQ} = 1500 \, mA$

**Output Power vs. Input Power**

**PAE vs. Input Power**

**Drain Current vs. Input Power**

**Detector Voltage vs. Output Power**

**Gate Current vs. Input Power**

**Detector Voltage vs. Output Power and Temperature**
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DC-0031198
Power Amplifier, 1 W
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Lead-Free 5 mm x 7 mm 12-Lead SMT 10,11,12,13,14

10. All units in in (mm), unless otherwise noted, with a tolerance of .xxxx = ±.0005 in and .xxx = ±.005 in.
11. Lead finish: NiPdAu plating
12. Marking: line 2 part number; line 3 wafer lot number; line 4 c = country of origin, yyyww = date code, N = Nickel/Palladium/Gold plating
13. Reference Application Note S2083 for lead-free solder reflow recommendations.
14. Meets JEDEC moisture sensitivity level 3 requirements.
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