NPA1008

GaN Wideband Power Amplifier, 28 V, 5 W
20 - 2700 MHz

Features
- GaN on Si HEMT D-Mode Integrated Amplifier
- Suitable for Linear and Saturated Applications
- Wideband tuned from 20 - 2700 MHz
- 50 Ω Input Matched
- 28 V Operation
- 45% Drain Efficiency
- 100% RF Tested
- Lead-Free 4 mm 24-lead PQFN Package
- Halogen-Free “Green” Mold Compound
- RoHS* Compliant

Description
The NPA1008 is a wideband integrated GaN power amplifier optimized for 20 - 2700 MHz operation. This amplifier has been designed for saturated and linear operation with output levels to 5 W (37 dBm) assembled in a lead-free 4 x 4 mm 24-lead QFN plastic package.

The NPA1008 is ideally suited for general purpose narrowband to broadband applications in test and measurement, defense communications, land mobile radio and wireless infrastructure.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPA1008</td>
<td>Bulk Quantity</td>
</tr>
<tr>
<td>NPA1008-SMB</td>
<td>Sample Board</td>
</tr>
</tbody>
</table>

Functional Schematic

Pin Designations

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V_G</td>
<td>Gate - DC Bias</td>
</tr>
<tr>
<td>2</td>
<td>N/C²</td>
<td>No Connection</td>
</tr>
<tr>
<td>3,4</td>
<td>RF_IN</td>
<td>RF Input</td>
</tr>
<tr>
<td>5-14</td>
<td>N/C²</td>
<td>No Connection</td>
</tr>
<tr>
<td>15,16</td>
<td>RF_OUT / V_D</td>
<td>RF Output / Drain</td>
</tr>
<tr>
<td>17-24</td>
<td>N/C²</td>
<td>No Connection</td>
</tr>
<tr>
<td>25</td>
<td>Paddle²</td>
<td>Ground / Source</td>
</tr>
</tbody>
</table>

1. All no connection pins may be left floating or grounded.
2. The exposed pad centered on the package bottom must be connected to RF and DC ground. This path must also provide a low thermal resistance heat path.
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**RF Electrical Specifications:** \( T_C = 25 \, ^\circ C \), \( V_{DS} = 28 \, V \), \( I_{DQ} = 88 \, mA \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Signal Gain</td>
<td>CW, 1900 MHz</td>
<td>( G_{SS} )</td>
<td>-</td>
<td>15.6</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Gain</td>
<td>CW, ( P_{OUT} = 37 ) , dBm, 1900 MHz</td>
<td>( G_P )</td>
<td>10.5</td>
<td>12.0</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Saturated Output Power</td>
<td>CW, 1900 MHz</td>
<td>( P_{SAT} )</td>
<td>-</td>
<td>38.9</td>
<td>-</td>
<td>dBm</td>
</tr>
<tr>
<td>Drain Efficiency</td>
<td>CW, 1900 MHz</td>
<td>( \eta_{SAT} )</td>
<td>44</td>
<td>47.0</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Power Added Efficiency</td>
<td>CW, ( P_{OUT} = 37 ) , dBm, 1900 MHz</td>
<td>PAE</td>
<td>-</td>
<td>44.7</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Ruggedness</td>
<td>All phase angles</td>
<td>( \Psi )</td>
<td>VSWR = 15:1, No Device Damage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DC Electrical Specifications:** \( T_C = 25^\circ C \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-Source Leakage Current</td>
<td>( V_{GS} = -8 , V ), ( V_{DS} = 100 , V )</td>
<td>( I_{DLK} )</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>Gate-Source Leakage Current</td>
<td>( V_{GS} = -8 , V ), ( V_{DS} = 0 , V )</td>
<td>( I_{GLK} )</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>Gate Threshold Voltage</td>
<td>( V_{DS} = 28 , V ), ( I_{D} = 4 , mA )</td>
<td>( V_T )</td>
<td>-2.5</td>
<td>-1.5</td>
<td>-0.5</td>
<td>V</td>
</tr>
<tr>
<td>Gate Quiescent Voltage</td>
<td>( V_{DS} = 28 , V ), ( I_{D} = 88 , mA )</td>
<td>( V_{GSQ} )</td>
<td>-2.1</td>
<td>-1.2</td>
<td>-0.3</td>
<td>V</td>
</tr>
<tr>
<td>On Resistance</td>
<td>( V_{DS} = 2 , V ), ( I_{D} = 45 , mA )</td>
<td>( R_{ON} )</td>
<td>-</td>
<td>1.2</td>
<td>-</td>
<td>Ω</td>
</tr>
<tr>
<td>Saturated Drain Current</td>
<td>( V_{DS} = 7 , V ) pulsed, pulse width 300 µs</td>
<td>( I_{D(SAT)} )</td>
<td>-</td>
<td>2.3</td>
<td>-</td>
<td>A</td>
</tr>
</tbody>
</table>
**Absolute Maximum Ratings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Source Voltage, $V_{DS}$</td>
<td>100 V</td>
</tr>
<tr>
<td>Gate Source Voltage, $V_{GS}$</td>
<td>-10 to 3 V</td>
</tr>
<tr>
<td>Gate Current, $I_G$</td>
<td>12 mA</td>
</tr>
<tr>
<td>Junction Temperature, $T_J$</td>
<td>+200°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +150°C</td>
</tr>
<tr>
<td>ESD Min. - Human Body Model (HBM)</td>
<td>+350 V</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 $T_J \leq 200°C$ will ensure $MTTF > 1 \times 10^6$ hours.

**Thermal Characteristics**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Typical</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Resistance</td>
<td>$V_{DS} = 28$ V, $T_J = 200°C$</td>
<td>$\Theta_{JC}$</td>
<td>12.1</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

7. The thermal resistance of the mounting configuration must be added to the device $\Theta_{JC}$, for proper $T_J$ calculation during operation. The recommended via pattern, shown on page 4, on a 20 mil thick, 1 oz plated copper, PCB adds an additional 4 °C/W to the typical value.

**Handling Procedures**

Please observe the following precautions to avoid damage:

**Static Sensitivity**

Gallium Nitride Circuits 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 1B devices.
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20 - 2700 MHz

Evaluation Board and Recommended Tuning Solution
20 - 2700 MHz Broadband Circuit

Description
Parts measured on evaluation board (20-mil thick RO4350). The PCB’s electrical and thermal ground is provided using a standard-plated densely packed via hole array (see recommended via pattern).

Matching is provided using a combination of lumped elements and transmission lines as shown in the simplified schematic above. Recommended tuning solution component placement, transmission lines, and details are shown on the next page.

Bias Sequencing

Turning the device ON
1. Set $V_{GS}$ to the pinch-off ($V_P$), typically -5 V.
2. Turn on $V_{DS}$ to nominal voltage (28 V).
3. Increase $V_{GS}$ until the $I_{DS}$ current is reached.
4. Apply RF power to desired level.

Turning the device OFF
1. Turn the RF power off.
2. Decrease $V_{GS}$ down to $V_P$.
3. Decrease $V_{DS}$ down to 0 V.
4. Turn off $V_{GS}$.

Recommended Via Pattern (All dimensions shown as inches)
Evaluation Board and Recommended Tuning Solution
20 - 2700 MHz Broadband Circuit

Parts list

<table>
<thead>
<tr>
<th>Reference</th>
<th>Value</th>
<th>Tolerance</th>
<th>Manufacturer</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C2</td>
<td>2400 pF</td>
<td>-</td>
<td>Dielectric Labs, Inc.</td>
<td>C08BL242X-5UN-X0</td>
</tr>
<tr>
<td>C3</td>
<td>10 µF</td>
<td>10%</td>
<td>TDK</td>
<td>C2012XR1C106M085AC</td>
</tr>
<tr>
<td>C4</td>
<td>4.7 µF</td>
<td>10%</td>
<td>TDK</td>
<td>C5750X7R2A475K230KA</td>
</tr>
<tr>
<td>C5, C8</td>
<td>0.6 pF</td>
<td>0.1 pF</td>
<td>ATC</td>
<td>800A0R6BT250X</td>
</tr>
<tr>
<td>C6</td>
<td>0.8 pF</td>
<td>0.1 pF</td>
<td>ATC</td>
<td>800A0R8BT250X</td>
</tr>
<tr>
<td>C7</td>
<td>0.5 pF</td>
<td>0.1 pF</td>
<td>ATC</td>
<td>800A0R5BT250X</td>
</tr>
<tr>
<td>C9</td>
<td>1000 pF</td>
<td>10%</td>
<td>Kemet</td>
<td>C0805C102K1RACTU</td>
</tr>
<tr>
<td>R1</td>
<td>470 Ω</td>
<td>10%</td>
<td>Panasonic</td>
<td>ERJ-P03F4700V</td>
</tr>
<tr>
<td>L1, L2</td>
<td>0.9 µH</td>
<td>10%</td>
<td>Coilcraft</td>
<td>1008AF-901XJLC</td>
</tr>
<tr>
<td>L3</td>
<td>2.2 nH</td>
<td>±0.2 nH</td>
<td>AVX</td>
<td>L08052R2CEW</td>
</tr>
<tr>
<td>L4</td>
<td>1.5 nH</td>
<td>±0.2 nH</td>
<td>AVX</td>
<td>L06031R5CGS</td>
</tr>
<tr>
<td>PCB</td>
<td></td>
<td></td>
<td>Rogers RO4350, εᵣ=3.5, 0.020&quot;</td>
<td></td>
</tr>
</tbody>
</table>
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Rev. V3

Typical Performance as measured in the Broadband Evaluation Board:
CW, \( V_{DS} = 28 \) V, \( I_{DQ} = 88 \) mA, \( T_C = 25^\circ \)C (unless noted)

**Device s-parameters (Deembedded)**

**Performance vs. Frequency at \( P_{OUT} = 37 \) dBm**

**Broadband Circuit s-Parameters**

**Performance vs. Input Return Loss at \( P_{OUT} = 37 \) dBm**
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Typical Performance as measured in the Broadband Evaluation Board:
CW, $V_{DS} = 28$ V, $I_{DQ} = 88$ mA, $T_C = 25^\circ$C (unless noted)

**Gain vs. Frequency**

- $P_{OUT} = 24$ dBm
- $P_{OUT} = 36$ dBm
- $P_{OUT} = 37$ dBm

- Frequency (GHz)
- Gain (dB)

**Input Return Loss vs. Frequency**

- $P_{OUT} = 24$ dBm
- $P_{OUT} = 36$ dBm
- $P_{OUT} = 37$ dBm

- Frequency (GHz)
- Input Return Loss (dB)

**Power Added Efficiency vs. Frequency**

- $P_{OUT} = 24$ dBm
- $P_{OUT} = 36$ dBm
- $P_{OUT} = 37$ dBm

- Frequency (GHz)
- Power Added Efficiency (%)

**Gain vs. Frequency at $P_{OUT} = 37$ dBm**

- $-40^\circ$C
- $+25^\circ$C
- $+85^\circ$C

- Frequency (GHz)
- Gain (dB)

**Input Return Loss at $P_{OUT} = 37$ dBm vs. Frequency**

- $-40^\circ$C
- $+25^\circ$C
- $+85^\circ$C

- Frequency (GHz)
- Input Return Loss (dB)

**Power Added Efficiency at $P_{OUT} = 37$ dBm vs. Frequency**

- $-40^\circ$C
- $+25^\circ$C
- $+85^\circ$C

- Frequency (GHz)
- Power Added Efficiency (%)
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Typical Performance as measured in the Broadband Evaluation Board:
CW, $V_{DS} = 28$ V, $I_{DQ} = 88$ mA, $T_C = 25^\circ$C (unless noted)

**Gain vs. $P_{OUT}$**

![Graph of Gain vs. $P_{OUT}$](image)

**Input Return Loss vs. $P_{OUT}$**

![Graph of Input Return Loss vs. $P_{OUT}$](image)

**Power Added Efficiency vs. $P_{OUT}$**

![Graph of Power Added Efficiency vs. $P_{OUT}$](image)
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Typical 2-Tone Performance as measured in the Broadband Evaluation Board
1 MHz Tone Spacing, Freq = 1900 MHz, V_DS = 28 V, I_DQ = 88 mA, T_C = 25°C (unless noted)

2-Tone IMD vs. Output Power vs. I_DQ

2-Tone Gain vs. Output Power vs. I_DQ

2-Tone IMD vs. Output Power

2-Tone IMD vs. Tone Spacing (P_OUT = 37 dBm-PEP)

Quiescent V_GS vs. Temperature

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Lead-Free 4 mm 24-Lead QFN Plastic Package†

All dimensions shown as inches [millimeters]

† Meets JEDEC moisture sensitivity level 3 requirements.
Plating is Matte Tin
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20 - 2700 MHz

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