NPA1008

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

Features
- GaN on Si HEMT D-Mode Integrated Amplifier
- Suitable for Linear & Saturated Applications
- Broadband Operation 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 an integrated GaN on silicon 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>

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
**GaN on Silicon Power Amplifier**

**20 - 2700 MHz, 28 V, 5 W**

**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>( \Omega )</td>
</tr>
<tr>
<td>Saturated Drain Current</td>
<td>( V_{DS} = 7 ) V pulsed, pulse width 300 ( \mu )s</td>
<td>( I_{(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.
**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)**
NPA1008

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

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-X00</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>

MACOM Technology Solutions Inc. (MACOM) and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice. Visit [www.macom.com](http://www.macom.com) for additional data sheets and product information.

For further information and support please visit: [https://www.macom.com/support](https://www.macom.com/support)
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)**

**Broadband Circuit s-Parameters**

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

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

- **Input Return Loss vs. Frequency**
  - $P_{OUT} = 24$ dBm
  - $P_{OUT} = 36$ dBm
  - $P_{OUT} = 37$ dBm

- **Power Added Efficiency vs. Frequency**
  - $P_{OUT} = 24$ dBm
  - $P_{OUT} = 36$ dBm
  - $P_{OUT} = 37$ dBm

- **Gain vs. Frequency at $P_{OUT} = 37$ dBm**
  - $-40^\circ$C
  - $+25^\circ$C
  - $+85^\circ$C

- **Input Return Loss at $P_{OUT} = 37$ dBm vs. Frequency**
  - $-40^\circ$C
  - $+25^\circ$C
  - $+85^\circ$C

- **Power Added Efficiency at $P_{OUT} = 37$ dBm vs. Frequency**
  - $-40^\circ$C
  - $+25^\circ$C
  - $+85^\circ$C
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. $P_{OUT}$**

![Gain vs. $P_{OUT}$ graph]

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

![Input Return Loss vs. $P_{OUT}$ graph]

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

![Power Added Efficiency vs. $P_{OUT}$ graph]
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)
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.
GaN on Silicon Power Amplifier
20 - 2700 MHz, 28 V, 5 W

MACOM Technology Solutions Inc. All rights reserved.

Information in this document is provided in connection with MACOM Technology Solutions Inc ("MACOM") products. These materials are provided by MACOM as a service to its customers and may be used for informational purposes only. Except as provided in MACOM’s Terms and Conditions of Sale for such products or in any separate agreement related to this document, MACOM assumes no liability whatsoever. MACOM assumes no responsibility for errors or omissions in these materials. MACOM may make changes to specifications and product descriptions at any time, without notice. MACOM makes no commitment to update the information and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to its specifications and product descriptions. No license, express or implied, by estoppels or otherwise, to any intellectual property rights is granted by this document.

THESE MATERIALS ARE PROVIDED “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, CONSEQUENTIAL OR INCIDENTAL DAMAGES, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. MACOM FURTHER DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. MACOM SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS, WHICH MAY RESULT FROM THE USE OF THESE MATERIALS.

MACOM products are not intended for use in medical, lifesaving or life sustaining applications. MACOM customers using or selling MACOM products for use in such applications do so at their own risk and agree to fully indemnify MACOM for any damages resulting from such improper use or sale.