GaN Power Amplifier, 28 V, 125 W
2.1 - 2.7 GHz

Features
• GaN on Si HEMT D-Mode Power Amplifier
• Suitable for Linear & Saturated Applications
• Broadband Operation from 2.1 - 2.7 GHz
• 125 W P3dB Peak Envelope Power
• 90 W P3dB CW Power
• 10 W Linear Power @ 2% EVM for Single Carrier OFDM, 10.3 dB peak/avg., 10 MHz channel bandwidth
• 16.5 dB Gain
• 26% Efficiency
• Characterized for Operation up to 32 V
• 100% RF Tested
• Thermally Enhanced Industry Standard Package
• High Reliability Gold Metallization Process
• RoHS* Compliant

Applications
• Defense Communications
• Land Mobile Radio
• Avionics
• Wireless Infrastructure
• ISM
• VHF/UHF/L/S-Band Radar

Description
The NPT25100 GaN on silicon HEMT D-Mode amplifier optimized for 2.1 - 2.7 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 125 W in an industry standard plastic package with bolt down flange.

RF Specifications (CW)\(^1\): Freq: = 2500 MHz, \(V_{DS} = 28\) V, \(I_{DQ} = 60\) mA, \(T_{C} = 25^\circ\)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>Average Output Power</td>
<td>3 dB Gain Compression</td>
<td>(P_{3dB})</td>
<td>80</td>
<td>90</td>
<td>—</td>
<td>W</td>
</tr>
<tr>
<td>Small Signal Gain</td>
<td>—</td>
<td>(G_{SS})</td>
<td>14.0</td>
<td>16.5</td>
<td>—</td>
<td>dB</td>
</tr>
<tr>
<td>Drain Efficiency</td>
<td>3 dB Gain Compression</td>
<td>(\eta)</td>
<td>55</td>
<td>62</td>
<td>—</td>
<td>%</td>
</tr>
</tbody>
</table>

1. Measured in test fixture.

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
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Typical 2-Tone Performance:
Freq. = 2500 MHz, $V_{DS} = 28$ V, $I_{DQ} = 600$ mA, Tone spacing = 1 MHz, $T_C = 25^\circ$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>Peak Envelope Power</td>
<td>3 dB Gain Compression</td>
<td>$P_{3\text{dB},\text{PEP}}$</td>
<td>—</td>
<td>125</td>
<td>—</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>1 dB Gain Compression</td>
<td>$P_{1\text{dB},\text{PEP}}$</td>
<td>—</td>
<td>90</td>
<td>—</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>-35 dB Gain Compression</td>
<td>$P_{\text{IMD3}}$</td>
<td>—</td>
<td>80</td>
<td>—</td>
<td>W</td>
</tr>
</tbody>
</table>

2. Measured in Load Pull System (Refer to Table 1 and Figure 1).

Typical OFDM Performance:
Freq. = 2500 - 2700 MHz, $V_{DS} = 28$ V, $I_{DQ} = 600$ mA, $P_{\text{OUT}/\text{Avg.}} = 10$ W, $T_C = 25^\circ$C
Single carrier OFDM waveform 64-QAM 3/4, 8 burst, continuous frame data, 10 MHz channel bandwidth. Peak/Avg = 10.3 dB @ 0.01% probability on CCDF.

<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>Power Gain</td>
<td>—</td>
<td>$G_P$</td>
<td>—</td>
<td>16.5</td>
<td>—</td>
<td>dB</td>
</tr>
<tr>
<td>Drain Efficiency</td>
<td>—</td>
<td>$\eta$</td>
<td>—</td>
<td>26.0</td>
<td>—</td>
<td>%</td>
</tr>
<tr>
<td>Error Vector Magnitude</td>
<td>—</td>
<td>$\text{EVM}$</td>
<td>—</td>
<td>2.0</td>
<td>—</td>
<td>%</td>
</tr>
</tbody>
</table>

DC Electrical Characteristics: $T_A = 25^\circ$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>Off Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain Source Breakdown Voltage</td>
<td>$V_{GS} = -8$ V, $I_D = 36$ mA</td>
<td>$V_{BDS}$</td>
<td>100</td>
<td>—</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>Drain Source Leakage Current</td>
<td>$V_{GS} = -8$ V, $V_{DS} = 60$ V</td>
<td>$I_{DLK}$</td>
<td>—</td>
<td>9</td>
<td>18</td>
<td>mA</td>
</tr>
<tr>
<td>On Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate Threshold Voltage</td>
<td>$V_{DS} = 28$ V, $I_D = 36$ mA</td>
<td>$V_T$</td>
<td>-2.3</td>
<td>-1.8</td>
<td>-1.3</td>
<td>V</td>
</tr>
<tr>
<td>Gate Quiescent Voltage</td>
<td>$V_{DS} = 28$ V, $I_D = 70$ mA</td>
<td>$V_{GSO}$</td>
<td>-2.0</td>
<td>-1.5</td>
<td>-1.0</td>
<td>V</td>
</tr>
<tr>
<td>On Resistance</td>
<td>$V_{GS} = 2$ V, $I_D = 270$ mA</td>
<td>$R_{ON}$</td>
<td>—</td>
<td>0.13</td>
<td>0.14</td>
<td>$\Omega$</td>
</tr>
<tr>
<td>Drain Current</td>
<td>$V_{DS} = 7$ V pulsed, 300 $\mu$s pulse width, 0.2% duty cycle</td>
<td>$I_{D,\text{MAX}}$</td>
<td>—</td>
<td>21.0</td>
<td>—</td>
<td>A</td>
</tr>
</tbody>
</table>
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Absolute Maximum Ratings$^{3,4,5}$

<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 V to +3 V</td>
</tr>
<tr>
<td>Gate Current, $I_G$</td>
<td>180 mA</td>
</tr>
<tr>
<td>Total Power Dissipation, $P_T$</td>
<td>100 W</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>
</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$^6$

<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>$V_{DS} = 48 V, T_J = 145°C$</td>
<td>$R_{JEC}$</td>
<td>1.75</td>
<td>°C/W</td>
</tr>
</tbody>
</table>


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 (>2000 V), MM (>100 V) Class 1B devices.
Load-Pull Performance: \( V_{DS} = 48 \, \text{V}, \, I_{DQ} = 600 \, \text{mA}, \, T_{C} = 25^\circ \text{C} \)
Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>( Z_S ) (Ω)</th>
<th>( Z_L ) (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2140</td>
<td>12.1 - j20.0</td>
<td>2.6 - j2.6</td>
</tr>
<tr>
<td>2300</td>
<td>10.0 - j3.0</td>
<td>2.5 - j2.3</td>
</tr>
<tr>
<td>2400</td>
<td>9.5 - j3.0</td>
<td>2.5 - j2.5</td>
</tr>
<tr>
<td>2500</td>
<td>9.0 - j3.0</td>
<td>2.5 - j2.7</td>
</tr>
<tr>
<td>2600</td>
<td>8.5 - j3.0</td>
<td>2.5 - j3.1</td>
</tr>
<tr>
<td>2700</td>
<td>8.0 - j3.0</td>
<td>2.5 - j3.3</td>
</tr>
</tbody>
</table>

**Impedance Reference**

\( Z_S \) is the source impedance presented to the device.
\( Z_L \) is the load impedance presented to the device.

**Figure 1** - Optimal impedance for CW performance, \( V_{DS} = 28 \, \text{V}, \, I_{DQ} = 600 \, \text{mA} \).
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Typical CW Performance in Loadpull System:

**Drain Efficiency & Gain**
28 V, 600 mA, 2300 - 2700 MHz

**Drain Efficiency & Gain**
28 V & 32 V, 600 mA, 2500 MHz

**P3dB, Drain Efficiency & Gain**
28 V, 600 mA

**Drain Efficiency & Gain**
28 V & 32 V, 600 mA, 2500 MHz, Tone Spacing = 1 MHz
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Typical CW Performance in Loadpull System:

Drain Efficiency, Gain, & IMD3
28 V, 600 mA, 2500 MHz, Tone Spacing = 1 MHz

Drain Efficiency, Gain, & IMD3
28 V, 600 mA, 2500 MHz, Tone Spacing = 1 MHz
10 µs Pulse Width, 1% Duty Cycle

Power
28 V, 600 mA, 2500 MHz, 1% Duty Cycle

Drain Efficiency, Gain, & EVM
28 V & 32 V, 600 mA, 2500 MHz

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

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Typical CW Performance in Loadpull System:

\[
\text{Drain Efficiency, Gain, & EVM}
\]
\[
28 \text{ V} \& 32 \text{ V}, 600 \text{ mA}, 2500 \text{ MHz}
\]
\[
P_{\text{OUT, AVG}} = 10 \text{ W}
\]

Typical Performance:

**Power Derating**

**MTTF**
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Typical Performance in MACOM Evaluation Circuit:

Drain Efficiency, Gain, & EVM
28 V, 500 - 1000 mA, 2500 MHz

Drain Efficiency, Gain, & EVM
28 V, 600 mA, 2110 - 2170 MHz

Drain Efficiency & EVM
28 V, 500 - 1000 mA, 2500 MHz
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Typical Performance in MACOM Evaluation Circuit:

**Gain**
28 V, 500 - 1000 mA, 2500 MHz

![Gain Graph](image)

**Drain Efficiency, Gain, & EVM**
28 V, 600 mA, 2500 MHz

![Drain Efficiency, Gain, & EVM Graph](image)

**S-Parameters**
28 V, 600 mA

![S-Parameters Graph](image)

**Quiescent Gate Voltage**
28 V

![Quiescent Gate Voltage Graph](image)
Evaluation Board and Recommended Tuning Solution
2500 MHz Narrowband Circuit

Description
Parts measured on evaluation board (30-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 (48 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 $V_{GS}$.
GaN Power Amplifier, 28 V, 125 W
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Evaluation Board and Recommended Tuning Solution
2500 MHz 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</td>
<td>3.3 pF</td>
<td>±0.1 pF</td>
<td>ATC</td>
<td>ATC600F3R3B</td>
</tr>
<tr>
<td>C2</td>
<td>1.2 pF</td>
<td>±0.1 pF</td>
<td>ATC</td>
<td>ATC100B1R2BT</td>
</tr>
<tr>
<td>C3</td>
<td>1 µF</td>
<td>20%</td>
<td>Panasonic</td>
<td>ECJ-5YB2A105M</td>
</tr>
<tr>
<td>C4, C7</td>
<td>0.1 µF</td>
<td>10%</td>
<td>Kemet</td>
<td>C1206C104K1RACTU</td>
</tr>
<tr>
<td>C5, C8</td>
<td>0.01 µF</td>
<td>10%</td>
<td>AVX</td>
<td>12061C103KAT2A</td>
</tr>
<tr>
<td>C6</td>
<td>1 µF</td>
<td>10%</td>
<td>Panasonic</td>
<td>ECJ-5YB2A105M</td>
</tr>
<tr>
<td>C9</td>
<td>150 µF</td>
<td>20%</td>
<td>Nichicon</td>
<td>UPW1C151MED</td>
</tr>
<tr>
<td>C10</td>
<td>270 µF</td>
<td>20%</td>
<td>United Chmi-Con</td>
<td>ELXY630ELL271MK25S</td>
</tr>
<tr>
<td>C11, C12</td>
<td>33 pF</td>
<td>5%</td>
<td>ATC</td>
<td>ATC600F330B</td>
</tr>
<tr>
<td>C13</td>
<td>0.9 pF</td>
<td>±0.1 pF</td>
<td>ATC</td>
<td>ATC600F0R9B</td>
</tr>
<tr>
<td>C14</td>
<td>1.8 pF</td>
<td>±0.1 pF</td>
<td>ATC</td>
<td>ATC600F1R8B</td>
</tr>
<tr>
<td>C15</td>
<td>Do Not Place</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>C16</td>
<td>0.8 pF</td>
<td>±0.1 pF</td>
<td>ATC</td>
<td>ATC600F0R8B</td>
</tr>
<tr>
<td>PA1</td>
<td>—</td>
<td>—</td>
<td>MACOM</td>
<td>NPT25100B</td>
</tr>
<tr>
<td>R1</td>
<td>10 Ω</td>
<td>1%</td>
<td>Panasonic</td>
<td>ERJ-2RKF10R0X</td>
</tr>
<tr>
<td>R2</td>
<td>0.033 Ω</td>
<td>5%</td>
<td>Coilcraft</td>
<td>ERJ-6RQFR33V</td>
</tr>
<tr>
<td>PCB</td>
<td>—</td>
<td>—</td>
<td>Rogers RO4350, εr=3.5, 30 mil</td>
<td>—</td>
</tr>
</tbody>
</table>
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Outline Drawing NPT25100B†

† Reference Application Note AN3025 for mounting/soldering recommendations.
Meets JEDEC moisture sensitivity level 1 requirements.
Plating is Ni/Au.
GaN  Power Amplifier, 28 V, 125 W
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Outline Drawing NPT25100P†

† Reference Application Note AN3025 for mounting/soldering recommendations. Meets JEDEC moisture sensitivity level 1 requirements. Plating is Ni/Au.
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