

# GaN Wideband Power Amplifier, 28 V, 5 W 20 - 1500 MHz

Rev. V1

#### **Features**

- · GaN on Si HEMT D-Mode Amplifier
- Suitable for linear and saturated applications
- Broadband operation from 20 1500 MHz
- 28 V Operation
- 16 dB Gain @ 1 GHz
- 42% PAE @ 1 GHz
- 100% RF Tested
- 50 Ω Input / Output Matched
- Lead-Free 4 mm 16-lead QFN plastic Package
- RoHS\* Compliant and 260°C Reflow Compatible

#### **Description**

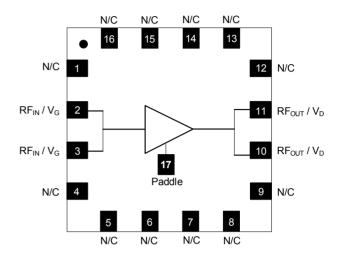
The NPA1003QA is a wideband GaN power amplifier optimized for 20 - 1500 MHz operation. This amplifier has been designed for saturated and linear operation with output levels to 5 W (37 dBm) assembled in a lead-free 4 mm 16-lead QFN plastic package.

The NPA1003QA is ideally suited for broadband general purpose, test and measurement, defense communications, land mobile radio and wireless infrastructure.

#### **Ordering Information**

Part Number	Package
NPA1003QA	Bulk
NPA1003QA-SMBPPR	sample

#### **Functional Schematic**



### Pin Designations<sup>1,2</sup>

Pin No.	Pin Name	Function
1	N/C	No Connection
2	RF <sub>IN</sub> / V <sub>G</sub>	RF Input / Gate Voltage
3	RF <sub>IN</sub> / V <sub>G</sub>	RF Input / Gate Voltage
4	N/C	No Connection
5-8	N/C	No Connection
9	N/C	No Connection
10	RF <sub>OUT</sub> / V <sub>D</sub>	RF Output / Drain Voltage
11	RF <sub>OUT</sub> / V <sub>D</sub>	RF Output / Drain Voltage
12	N/C	No Connection
13-16	N/C	No Connection
17	Paddle <sup>2</sup>	Ground

<sup>1.</sup> All no connection pins may be left floating or grounded.

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.

<sup>\*</sup>Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.



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### RF Electrical Specifications: $T_C = +25^{\circ}C$ , $V_{DS} = 28 \text{ V}$ , $I_{DQ} = 100 \text{ mA}$

Parameter	Test Conditions	Symbol	Min.	Тур.	Max.	Units
Small Signal Gain	CW, 1000 MHz	G <sub>SS</sub>	_	18	_	dB
Saturated Output Power	CW, 1000 MHz	P <sub>SAT</sub>	_	38.5	_	dBm
Drain Efficiency at Saturation	CW, 1000 MHz	η <sub>SAT</sub>	_	50	_	%
Noise Figure	CW, 1000 MHz	NF		2.0	_	dB
Power Gain	CW, 1000 MHz, P <sub>OUT</sub> = 5 W	$G_P$	14	16	_	%
Power Added Efficiency	CW, 1000 MHz, P <sub>OUT</sub> = 5 W	PAE	38	42	_	%
Ruggedness	All phase angles	Ψ	VSWR	=10:1, No	Device Da	amage

### DC Electrical Specifications: T<sub>c</sub> = +25°C

Parameter	Test Conditions	Symbol	Min.	Тур.	Max.	Units
Drain-Source Leakage Current	V <sub>GS</sub> = -8 V, V <sub>DS</sub> = 100 V	I <sub>DLK</sub>	_	_	2	mA
Gate-Source Leakage Current	V <sub>GS</sub> = -8 V, V <sub>DS</sub> = 0 V	I <sub>GLK</sub>	_	_	1	mA
Gate Threshold Voltage	V <sub>DS</sub> = 28 V, I <sub>D</sub> = 2 mA	V <sub>T</sub>	-2.5	-1.5	-0.5	V
Gate Quiescent Voltage	V <sub>DS</sub> = 28 V, I <sub>D</sub> = 88 mA	$V_{GSQ}$	-2.1	-1.2	-0.3	V
On Resistance	V <sub>DS</sub> = 2 V, I <sub>D</sub> = 15 mA	R <sub>ON</sub>	_	1.6	_	Ω
Maximum Drain Current	V <sub>DS</sub> = 7 V pulsed, pulse width 300 μs	I <sub>D</sub> , <sub>MAX</sub> .	_	1.5	_	Α



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### **Absolute Maximum Ratings**<sup>3,4,5</sup>

Parameter	Absolute Maximum		
Drain Source Voltage, V <sub>DS</sub>	100 V		
Gate Source Voltage, V <sub>GS</sub>	-10 to 3 V		
Gate Current, I <sub>G</sub>	4 mA		
Junction Temperature, T <sub>J</sub>	+200°C		
Operating Temperature	-40°C to +85°C		
Storage Temperature	-65°C to +150°C		

- 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  $T_J \le 180^{\circ}$ C will ensure MTTF > 1 x  $10^{6}$  hours.

#### Thermal Characteristics<sup>6</sup>

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance	V <sub>DS</sub> = 28 V, T <sub>J</sub> = 180 °C	$R_{ heta JC}$	12	°C/W

Junction temperature (T<sub>J</sub>) measured using IR Microscopy. Case temperature measured using thermocouple embedded in heat-sink.

#### **Handling Procedures**

Please observe the following precautions to avoid damage:

#### Static Sensitivity

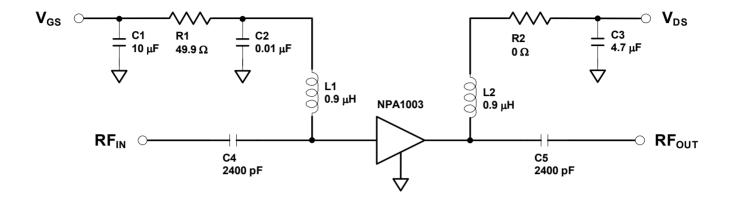
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.



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### **Evaluation Board and Recommended Tuning Solution** 20-1500 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**

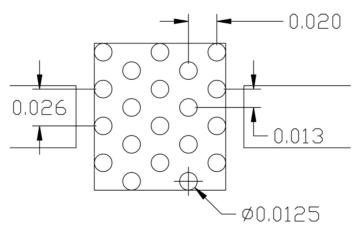
#### **Turning the device ON**

- 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  $V_{\text{GS}}$  until the  $I_{\text{DS}}$  current is reached.
- 4. Apply RF power to desired level.

#### **Turning the device OFF**

- 1. Turn the RF power off.
- 2. Decrease V<sub>GS</sub> down to V<sub>P</sub>.
- 3. Decrease V<sub>DS</sub> down to 0 V.
- 4. Turn off V<sub>GS</sub>.

### Recommended Via Pattern (All dimensions shown as inches)



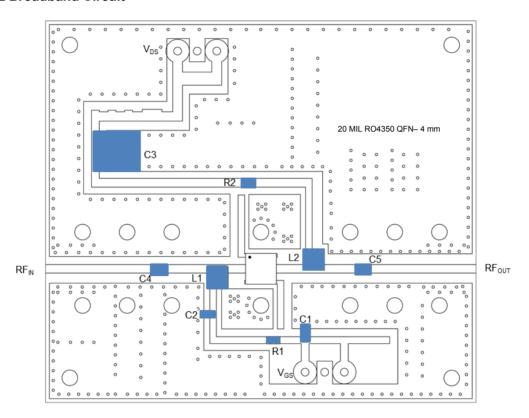
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# **Evaluation Board and Recommended Tuning Solution** 20-1500 MHz Broadband Circuit



#### **Parts list**

Reference	Value	Tolerance	Manufacturer	Part Number
C1	10 μF	20%	TDK	C2012X5R1C106M085AC
C2	0.01 μF	5%	AVX	06031C103JAT2A
C3	4.7 µF	10%	TDK	C5750X7R2A475K230KA
C4, C5	2400 pF	-	Dielectric Labs, Inc.	C08BL242X-5UN-X0
R1	49.9 Ω	1%	Panasonic	ERJ-6ENF49R9V
R2	0 Ω	-	Panasonic	ERJ-3GEY0R00V
L1, L2	0.9 μΗ	10%	Coilcraft	1008AF-901XJLC
PCB	Rogers RO4350, $\varepsilon_r$ =3.5, 0.020"			

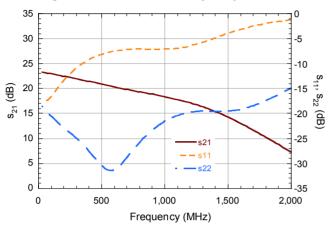


# GaN Wideband Power Amplifier, 28 V, 5 W 20 - 1500 MHz

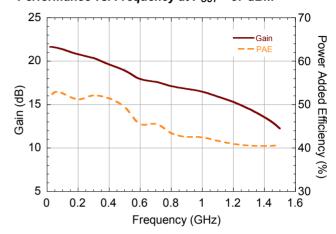
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# Typical Performance as measured in the broadband evaluation board: CW, $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA (unless noted)

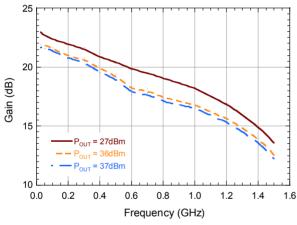
#### Small Signal s-Parameters vs. Frequency



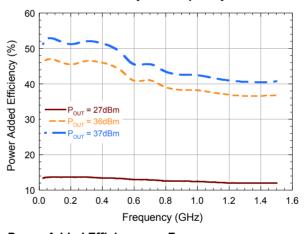
#### Performance vs. Frequency at $P_{OUT} = 37 \text{ dBm}$



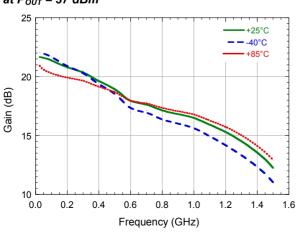
#### Gain vs. Frequency



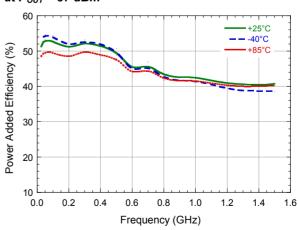
Power Added Efficiency vs. Frequency



### Gain vs. Frequency at P<sub>OUT</sub> = 37 dBm



Power Added Efficiency vs. Frequency at P<sub>OUT</sub> = 37 dBm



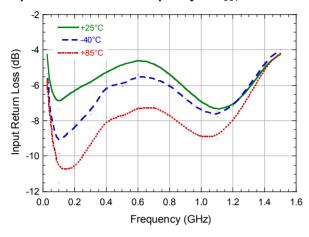


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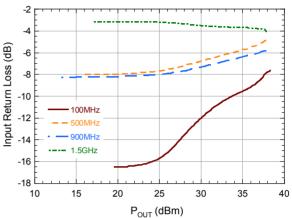
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# Typical Performance as measured in the broadband evaluation board: CW, $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA (unless noted)

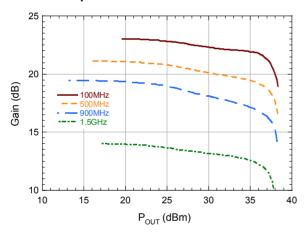
#### Input Return Loss vs. Frequency at $P_{OUT} = 37 \text{ dBm}$



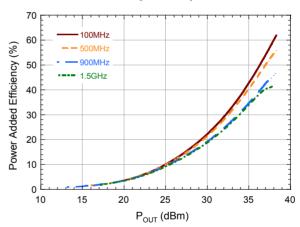
### Input Return Loss vs. Output Power



#### Gain vs. Output Power



#### Power Added Efficiency vs. Output Power



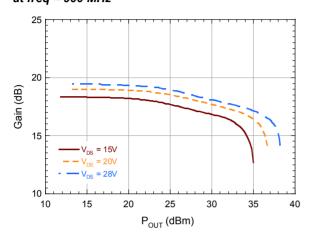


# GaN Wideband Power Amplifier, 28 V, 5 W 20 - 1500 MHz

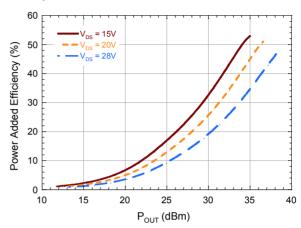
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# Typical Performance as measured in the broadband evaluation board: CW, $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA (unless noted)

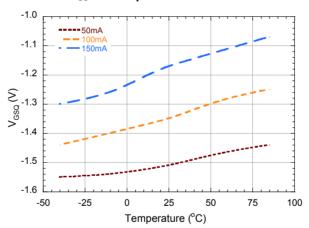
Gain vs. Output Power at freg = 900 MHz



### Power Added Efficiency vs. Output Power at freq = 900 MHz



#### Quiescent V<sub>GS</sub> vs. Temperature



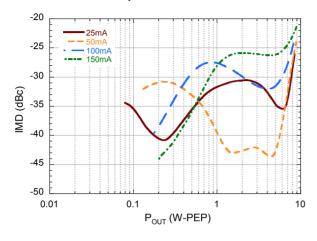


# GaN Wideband Power Amplifier, 28 V, 5 W 20 - 1500 MHz

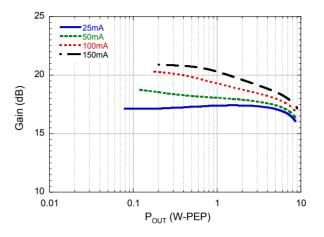
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# Typical 2-Tone Performance as measured in the broadband evaluation board: 1 MHz Tone Spacing, f = 500 MHz, $V_{DS} = 28$ V, $I_{DQ} = 100$ mA (unless noted)

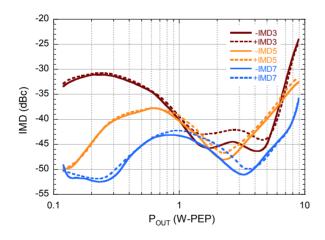
#### 2-Tone IMD3 vs. Output Power vs. Quiescent Current



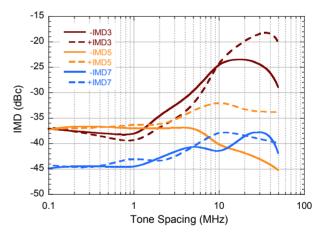
#### 2-Tone Gain vs. Output Power vs. Quiescent Current



#### 2-Tone IMD vs. Output Power



### 2-Tone IMD vs. Tone Spacing at $P_{OUT} = 6$ W-PEP, $I_{DQ} = 6$ mA

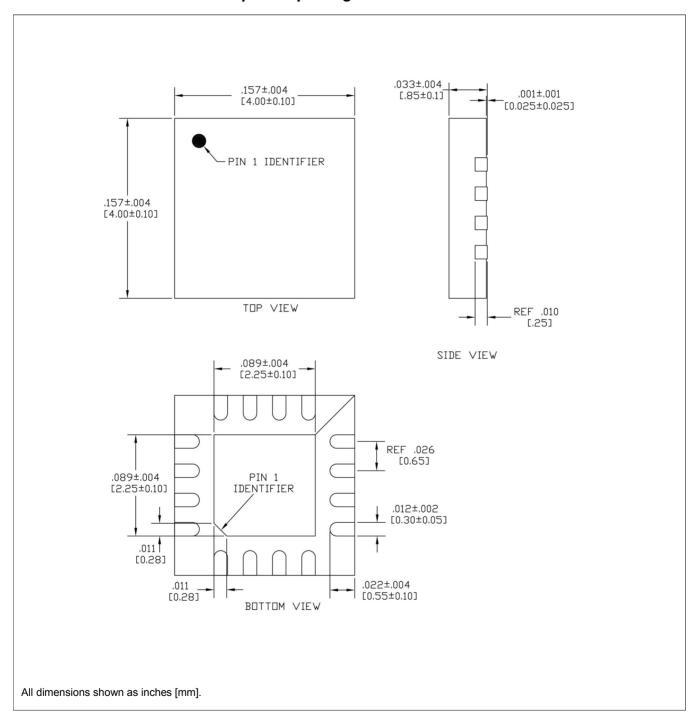




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### Lead-Free 4 mm QFN 16-lead plastic package



<sup>&</sup>lt;sup>†</sup> Meets JEDEC moisture sensitivity level 3 requirements. Plating is 100% matte tin over copper.



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