# GaN Power Transistor, 28 V, 5 W DC - 6 GHz



### NPTB00004A

Rev. V2

### **Features**

- GaN on Si HEMT D-Mode Transistor
- Suitable for linear and saturated applications
- Tunable from DC 6 GHz
- 28 V Operation
- 14.8 dB Gain @ 2.5 GHz
- 57 % Drain Efficiency @ 2.5 GHz
- 100 % RF Tested
- · Industry standard SOIC plastic package
- RoHS\* Compliant

### **Applications**

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

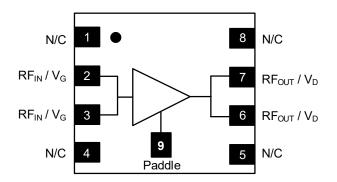
### **Description**

The NPTB00004A GaN HEMT is a power transistor optimized for DC - 6 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 5 W (37 dBm) in an industry standard surface mount plastic package.

### **Ordering Information**

Part Number	Package
NPTB00004A	bulk quantity
NPTB00004A-SMB	sample board

### **Functional Schematic**



### **Pin Configuration**

Pin#	Pin Name	Function				
1, 4, 5, 8	N/C	No Connection				
2, 3	RF <sub>IN</sub> / V <sub>G</sub>	RF Input / Gate				
6, 7	RF <sub>OUT</sub> / V <sub>D</sub>	RF Output / Drain				
9	Paddle <sup>1</sup>	Ground / Source				

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, compliant to current RoHS EU directive.



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### RF Electrical Specifications: $T_C = 25^{\circ}C$ , $V_{DS} = 28 \text{ V}$ , $I_{DQ} = 50 \text{ mA}$

Parameter	Test Conditions	Symbol	Min.	Тур.	Max.	Units
Small Signal Gain	CW, 2.5 GHz	G <sub>SS</sub>	-	16	-	dB
Saturated Output Power	CW, 2.5 GHz	P <sub>SAT</sub>	-	37.1	-	dBm
Drain Efficiency at Saturation	CW, 2.5 GHz	η <sub>SAT</sub>	-	63.7	-	%
Power Gain	2.5 GHz, P <sub>OUT</sub> = 4 W	G <sub>P</sub>	12.8	14.8	-	dB
Drain Efficiency	2.5 GHz, P <sub>OUT</sub> = 4 W	η	45	57	-	%
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 15:1, No Device Damage			amage

### DC Electrical Characteristics: 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	-1.6	-0.5	V
Gate Quiescent Voltage	V <sub>DS</sub> = 28 V, I <sub>D</sub> = 50 mA	$V_{GSQ}$	-2.1	-1.3	-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	$V_{DS}$ = 7 V pulsed, pulse width 300 µs	I <sub>D,MAX</sub>	-	1.4	-	Α



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### Absolute Maximum Ratings<sup>2,3,4</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

- 2. Exceeding any one or combination of these limits may cause permanent damage to this device.
- 3. MACOM does not recommend sustained operation near these survivability limits.
- 4. Operating at nominal conditions with  $T_J \le 200$ °C will ensure MTTF > 1 x  $10^6$  hours.

### Thermal Characteristics<sup>5</sup>

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance	V <sub>DS</sub> = 28 V, T <sub>J</sub> = 180°C	$R_{ heta JC}$	15	°C/W

<sup>5.</sup> 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.

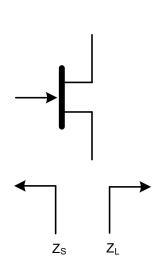


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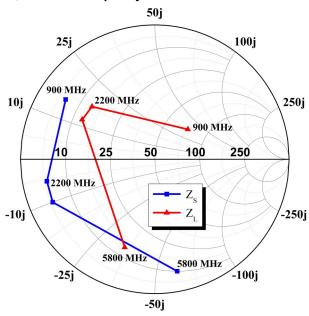
### Load-Pull Performance: $V_{DS} = 28 \text{ V}$ , $I_{DQ} = 50 \text{ mA}$ , $T_C = 25^{\circ}\text{C}$ Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance

Frequency (MHz)	Z <sub>s</sub> (Ω)	Z <sub>L</sub> (Ω)	P <sub>SAT</sub> (W)	G <sub>SS</sub> (dB)	Drain Efficiency @ P <sub>SAT</sub> (%)
900	6.1 + j15	72 + j36	7.0	23.0	68
2200	5.0 - j5.0	14 + j17	6.7	19.0	66
2700	5.0 - j10	13 + j12	6.7	17.0	62
5800	10 - j60	14 - j34	6.5	11.0	52

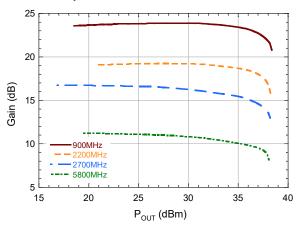
### Impedance Reference



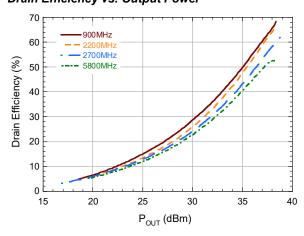
### Z<sub>S</sub> and Z<sub>L</sub> vs. Frequency



### Gain vs. Output Power



### Drain Efficiency vs. Output Power



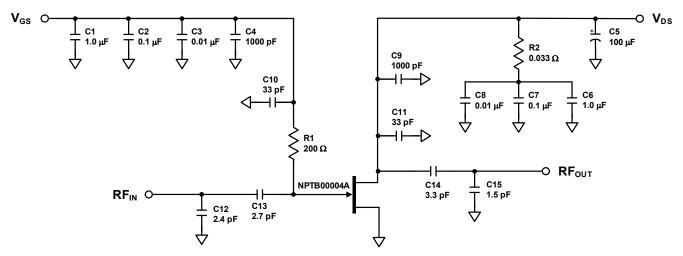
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## **Evaluation Board and Recommended Tuning Solution** 2.5 GHz Narrowband Circuit



### 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**

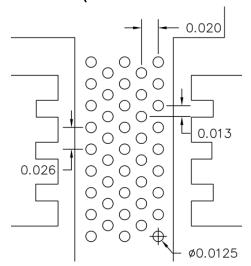
### **Turning the device ON**

- 1. Set  $V_{GS}$  to the pinch-off  $(V_P)$ , typically -5 V.
- 2. Turn on V<sub>DS</sub> 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  $V_{GS}$ .

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



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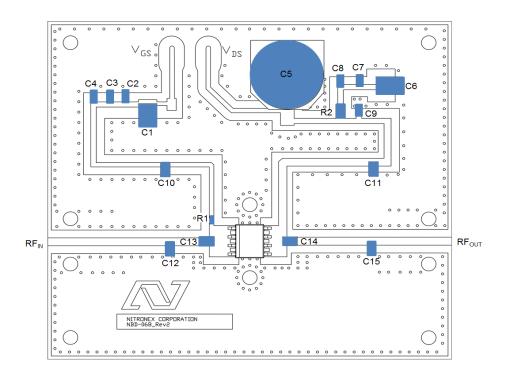
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### **Evaluation Board and Recommended Tuning Solution**

### 2.5 GHz Narrowband Circuit



### **Parts list**

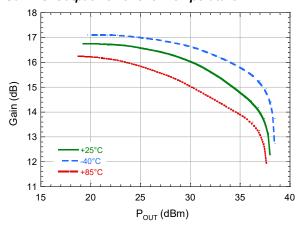
Reference	Value	Tolerance	Manufacturer	Part Number	
C1, C6	1.0 µF	10%	AVX	12101C105KAT2A	
C2, C7	0.1 μF	10%	Murata	GRM188R72A104KA35D	
C3, C8	0.01 μF	10%	AVX	06031C103KAT2A	
C4, C9	1000 pF	10%	AVX	06031C102KAT2A	
C5	100 μF	20%	Panasonic	ECE-V1JA101P	
C10, C11	33 pF	5%	ATC	ATC600F330JT	
C12	2.4 pF	5%	ATC	ATC600F2R4JT	
C13	2.7 pF	5%	ATC	ATC600F2R7JT	
C14	3.3 pF	5%	ATC	ATC600F3R3JT	
C15	1.5 pF	5%	ATC	ATC600F1R5JT	
R1	200 Ω	5%	Panasonic	ERJ-2GEJ201X	
R2	0.33 Ω	1%	Susumu	RL1220S-R33-F	
PCB	Rogers RO4350, $\varepsilon_r$ = 3.5, 20 mil				



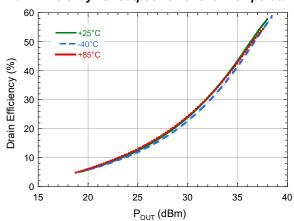
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## Typical Performance as measured in the 2.5 GHz evaluation board: CW, $V_{DS}$ = 28 V, $I_{DQ}$ = 50 mA (unless noted)

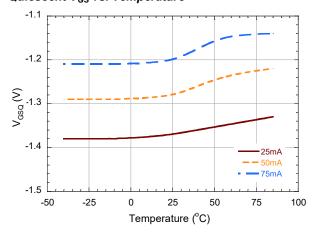
Gain vs. Output Power over Temperature



### Drain Efficiency vs. Output Power over Temperature



### Quiescent $V_{GS}$ vs. Temperature

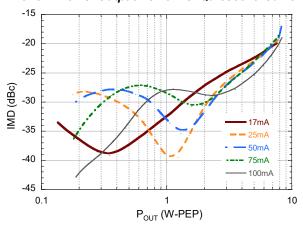




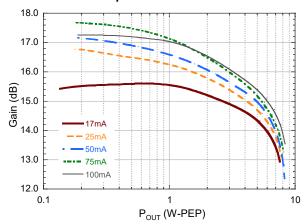
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## Typical 2-Tone Performance as measured in the 2.5 GHz evaluation board: 1 MHz Tone Spacing, $V_{DS} = 28 \text{ V}$ , $I_{DQ} = 50 \text{ mA}$ , $T_{C} = 25^{\circ}\text{C}$ (unless noted)

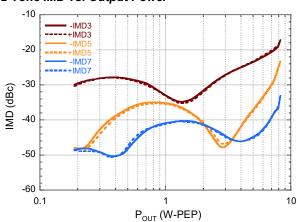
### 2-Tone IMD3 vs. Output Power vs. Quiescent Current



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



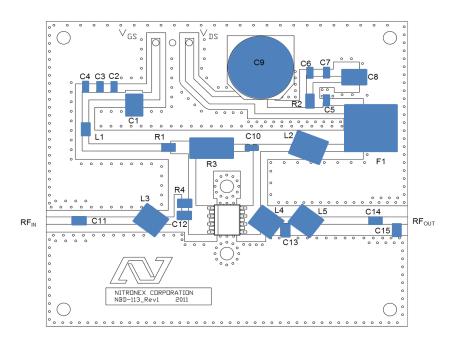
### 2-Tone IMD vs. Output Power





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## **Evaluation Board and Recommended Tuning Solution** 100-800 MHz BroadBand Circuit



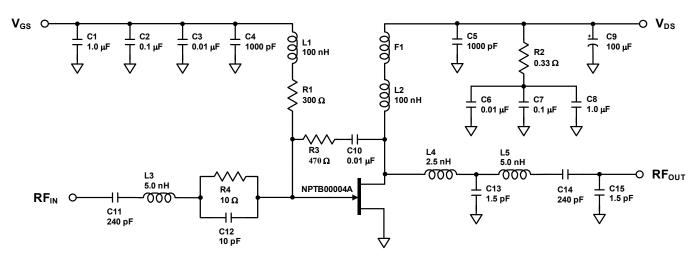
### **Parts list**

Reference	Value	Tolerance	Manufacturer	Part Number
C1, C8	1.0 µF	10%	AVX	12101C105KAT2A
C2, C7	0.1 µF	10%	Murata	GRM188R72A104KA35D
C3, C6, C10	0.01 µF	10%	AVX	06031C103KAT2A
C4, C5,	1000 pF	10%	AVX	06031C102KAT2A
C9	100 μF	20%	Panasonic	ECE-V1JA101P
C11, C14	240 pF	0.1 pF	ATC	ATC600F241F
C12	10 pF	0.1 pF	ATC	ATC600F100B
C13, C15	1.5 pF	5%	ATC	ATC600F1R5J
F1	Material 73	-	Fair-Rite	2673000801
L1	100 nH	5%	Coilcraft	0805CS-101XJ
L2	100 nH	5%	Coilcraft	1812SMS-R10
L3, L5	5 nH	10%	Coilcraft	A02TKLJ
L4	2.5 nH	10%	Coilcraft	A01TKLJ
R1	300 Ω	5%	Panasonic	ERJ-14YJ301U
R2	0.33 Ω	1%	Susumu	RL1220S-R33-F
R3	470 Ω	1%	Stackpole	RHC2512FT470R
R4	10 Ω	5%	Panasonic	ERJ-14YJ100U
PCB	Rogers RO4350, ε <sub>r</sub> =3.5, 0.020"			

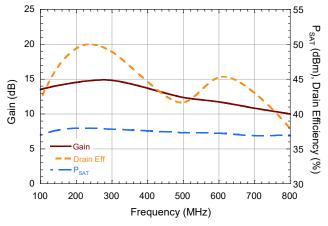


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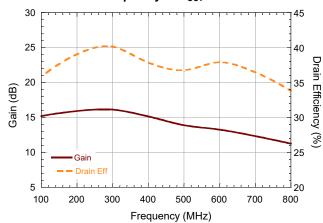
## **Evaluation Board and Recommended Tuning Solution**100-800 MHz BroadBand Circuit



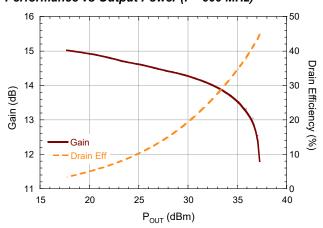
### Performance vs. Frequency at $P_{OUT} = P_{SAT}$



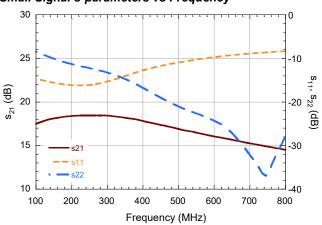
### Performance vs. Frequency at $P_{OUT}$ = 36 dBm



### Performance vs Output Power (f = 600 MHz)



### Small Signal s-parameters vs Frequency



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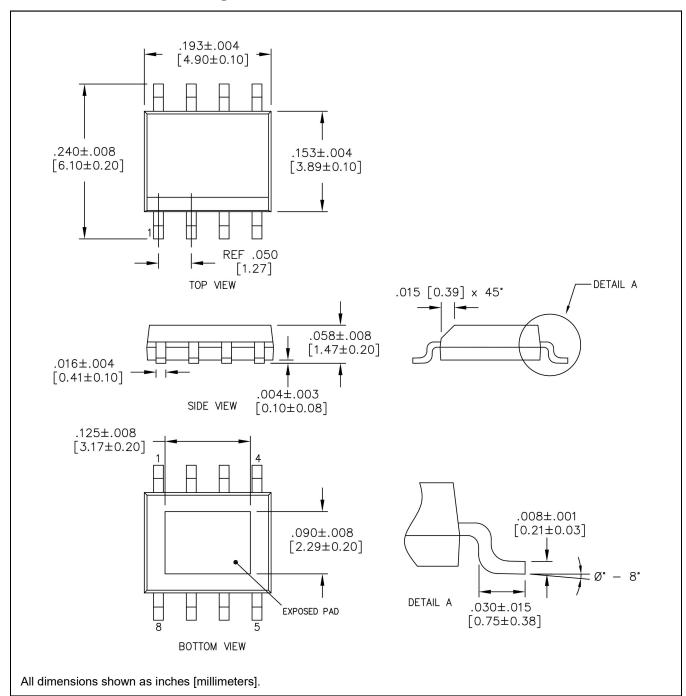
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### SOIC 8-Lead Plastic Package<sup>†</sup>



<sup>†</sup> Meets JEDEC moisture sensitivity level 3 requirements. Plating is Matte Sn.

# GaN Power Transistor, 28 V, 5 W DC - 6 GHz



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