

# GaN on Silicon General Purpose Amplifier

## DC - 2 GHz, 48 V, 100 W



NPT2022

Rev. V3

### Features

- GaN on Si HEMT D-Mode Amplifier
- Suitable for Linear & Saturated Applications
- Tunable from DC - 2 GHz
- 48 V Operation
- 20 dB Gain @ 900 MHz
- 60% Drain Efficiency @ 900 MHz
- 100% RF Tested
- TO-272 Package
- RoHS\* Compliant and 260°C Reflow Compatible



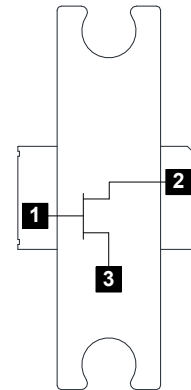
### Description

The NPT2022 GaN on silicon HEMT D-Mode amplifier optimized for DC - 2 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 100 W in an industry standard plastic package with bolt down flange.

The NPT2022 is ideally suited for defense communications, land mobile radio, avionics, wireless infrastructure, ISM applications and VHF/UHF/L/S-band radar.

Built using the SIGANTIC® process - a proprietary GaN-on-Silicon technology.

### Functional Schematic



### Ordering Information

Part Number	Package
NPT2022	Bulk Quantity
NPT2022-SMB1	Sample Board
NPT2022-TR0250	Tape & Reel

### Pin Configuration

Pin #	Pin Name	Function
1	RF <sub>IN</sub> / V <sub>G</sub>	RF Input / Gate
2	RF <sub>OUT</sub> / V <sub>D</sub>	RF Output / Drain
3	Pad <sup>1</sup>	Ground / Source

1. 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.

\* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

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### RF Electrical Specifications: $T_C = 25^\circ\text{C}$ , $V_{DS} = 48\text{ V}$ , $I_{DQ} = 600\text{ mA}$

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	CW, 900 MHz	$G_{SS}$	-	21	-	dB
Saturated Output Power	CW, 900 MHz	$P_{SAT}$	-	50.5	-	dBm
Drain Efficiency at Saturation	CW, 900 MHz	$\eta_{SAT}$	-	62	-	%
Power Gain	900 MHz, $P_{OUT} = 100\text{ W}$	$G_P$	19	20	-	dB
Drain Efficiency	900 MHz, $P_{OUT} = 100\text{ W}$	$\eta$	56	58	-	%
Ruggedness: Output Mismatch	All phase angles	$\Psi$	VSWR = 10:1, No Device Damage			

### DC Electrical Characteristics: $T_C = 25^\circ\text{C}$

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Drain-Source Leakage Current	$V_{GS} = -8\text{ V}$ , $V_{DS} = 160\text{ V}$	$I_{DLK}$	-	-	24	mA
Gate-Source Leakage Current	$V_{GS} = -8\text{ V}$ , $V_{DS} = 0\text{ V}$	$I_{GLK}$	-	-	12	mA
Gate Threshold Voltage	$V_{DS} = 48\text{ V}$ , $I_D = 24\text{ mA}$	$V_T$	-2.5	-1.6	-0.5	V
Gate Quiescent Voltage	$V_{DS} = 48\text{ V}$ , $I_D = 600\text{ mA}$	$V_{GSQ}$	-2.1	-1.4	-0.3	V
On Resistance	$V_{DS} = 2\text{ V}$ , $I_D = 180\text{ mA}$	$R_{ON}$	-	0.2	-	W
Maximum Drain Current	$V_{DS} = 7\text{ V}$ pulsed, pulse width 300 $\mu\text{s}$	$I_{D,MAX}$	-	14	-	A

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

Parameter	Absolute Maximum
Drain Source Voltage, $V_{DS}$	160 V
Gate Source Voltage, $V_{GS}$	-10 to 3 V
Gate Current, $I_G$	48 mA
Junction Temperature, $T_J$	+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  $T_J \leq 200^\circ\text{C}$  will ensure  $\text{MTTF} > 1 \times 10^6$  hours.

**Thermal Characteristics<sup>5</sup>**

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance	$V_{DS} = 48 \text{ V}, T_J = 200^\circ\text{C}$	$R_{\theta JC}$	1.3	°C/W

5. Junction temperature ( $T_J$ ) 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 1B devices.

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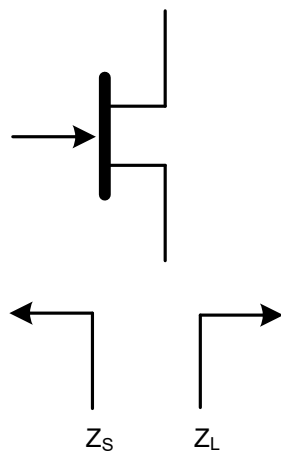
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**Load-Pull Performance:  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 600\text{ mA}$ ,  $T_C = 25^\circ\text{C}$**

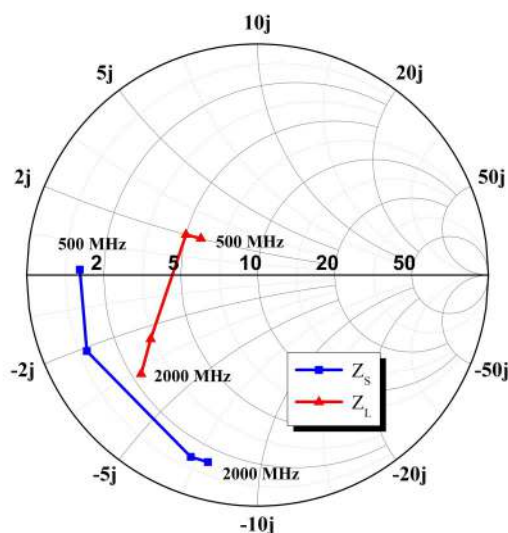
Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance

Frequency (MHz)	$Z_S$ (W)	$Z_L$ (W)	$P_{SAT}$ (W)	$G_{SS}$ (dB)	Drain Efficiency @ $P_{SAT}$ (%)
500	$1.3 + j0.8$	$5.8 + j2.5$	152	26	71
900	$1.1 - j1.3$	$5.0 + j2.8$	139	22	70
1800	$1.3 - j5.7$	$3.2 - j1.4$	133	17	66
2000	$1.4 - j6.3$	$2.3 - j2.3$	119	16	66

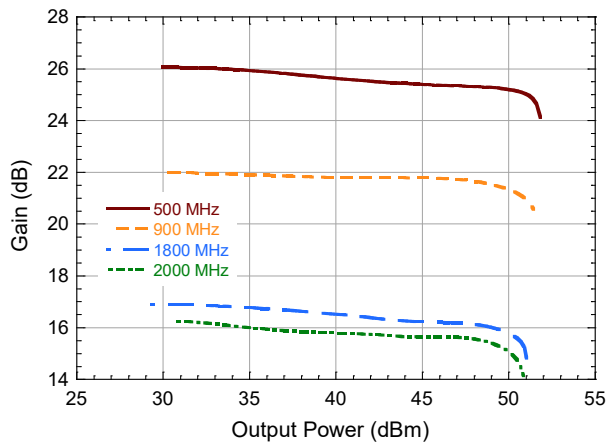
### Impedance Reference



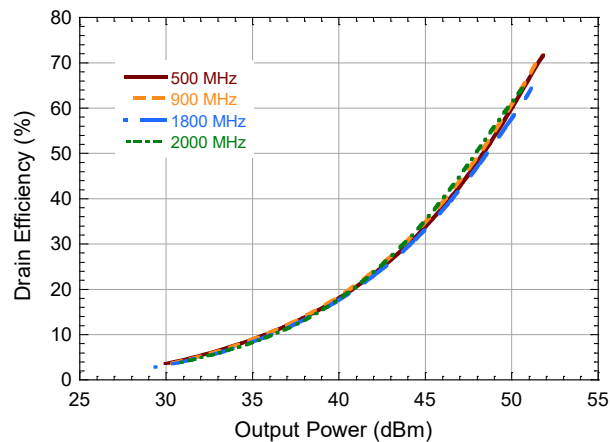
### $Z_S$ and $Z_L$ vs. Frequency



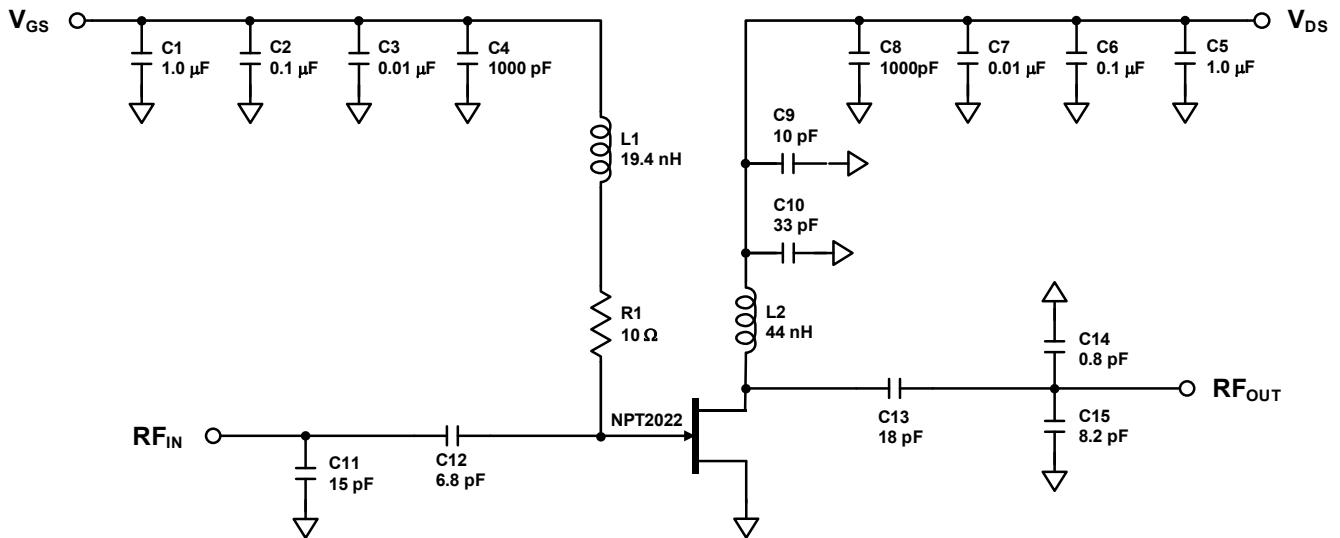
### Gain vs. Output Power



### Drain Efficiency vs. Output Power



Evaluation Board and Recommended Tuning Solution  
900 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**

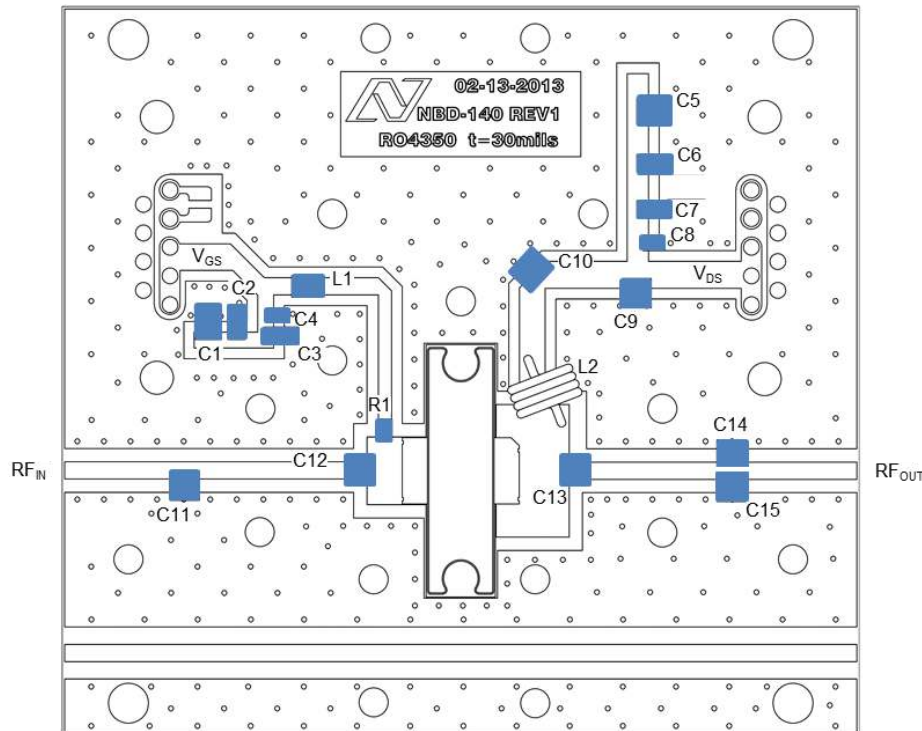
1. Set  $V_{GS}$  to the pinch-off ( $V_P$ ), typically -5 V.
2. Turn on  $V_{DS}$  to nominal voltage (48 V).
3. Increase  $V_{GS}$  until the  $I_{DS}$  current is reached.
4. Apply RF power to desired level.

**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  $V_{GS}$ .

**Evaluation Board and Recommended Tuning Solution**

**900 MHz Narrowband Circuit**



**Parts list**

Reference	Value	Tolerance	Manufacturer	Part Number
C1, C5	1.0 $\mu$ F	10%	AVX	12101C105KAT2A
C2, C6	0.1 $\mu$ F	10%	Kemet	C1206C104K1RACTU
C3, C7	0.01 $\mu$ F	10%	AVX	12061C103KAT2A
C4, C8	1000 pF	10%	Kemet	C0805C102K1RACTU
C9	10 pF	5%	ATC	ATC800B100J
C10	33 pF	10%	ATC	ATC800B330K
C11	15 pF	10%	ATC	ATC800B150K
C12	6.8 pF	0.1 pF	ATC	ATC800B6R8B
C13	18 pF	10%	ATC	ATC800B180K
C14	0.8 pF	0.1 pF	ATC	ATC800B0R8B
C15	8.2 pF	0.1 pF	ATC	ATC800B8R2B
R1	10 $\Omega$	1%	Panasonic	ERJ-2RKF10R0X
L1	19.4 nH	5%	Coilcraft	0806SQ-19NJLB
L2	~44 nH	10%	20 AWG Cu Wire	4 turn, 5mm ID
PCB	Rogers RO4350, $\epsilon_r=3.5$ , 30 mil			

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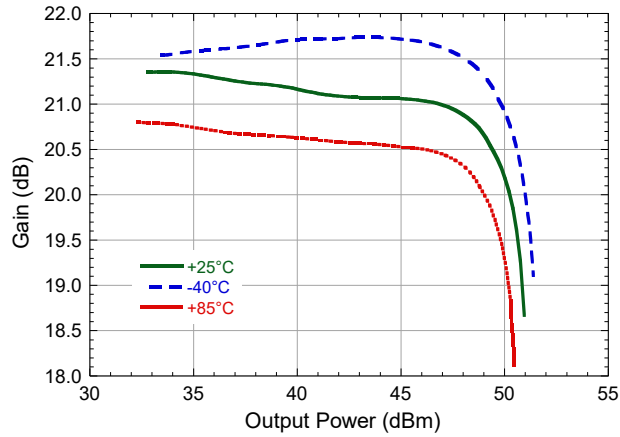


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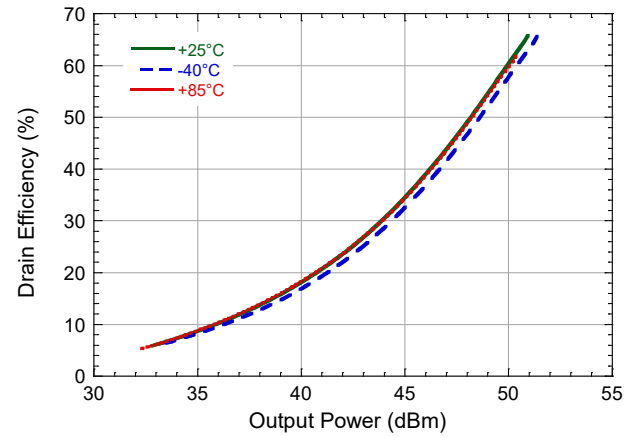
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Typical performance as measured in the 900 MHz evaluation board:  
 CW,  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 600\text{ mA}$  (unless noted)

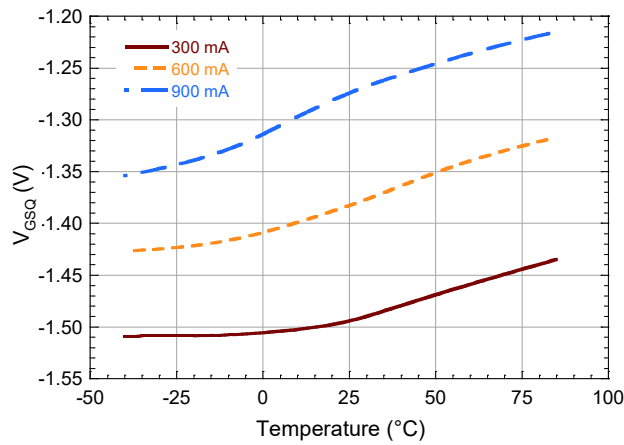
Gain vs. Output Power over Temperature



Drain Efficiency vs. Output Power over Temperature

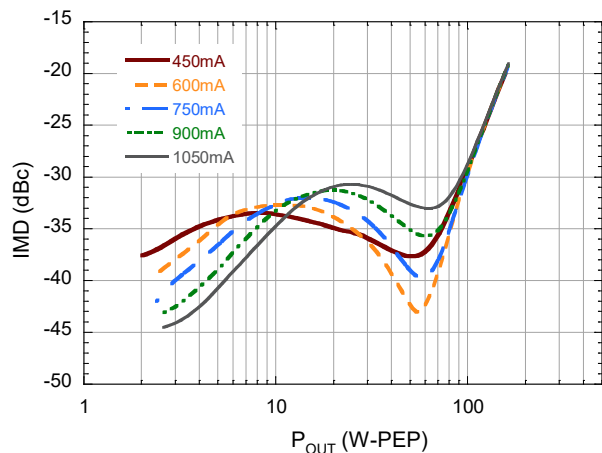


Quiescent  $V_{GS}$  vs. Temperature

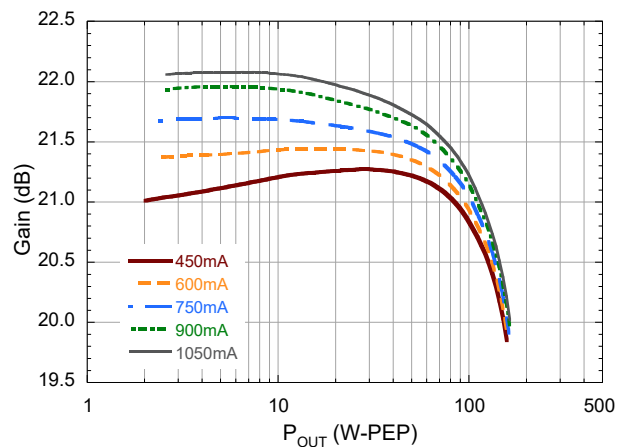


Typical 2-Tone performance as measured in the 900 MHz evaluation board:  
 1 MHz Tone Spacing,  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 600\text{ mA}$ ,  $T_C = 25^\circ\text{C}$  (unless noted)

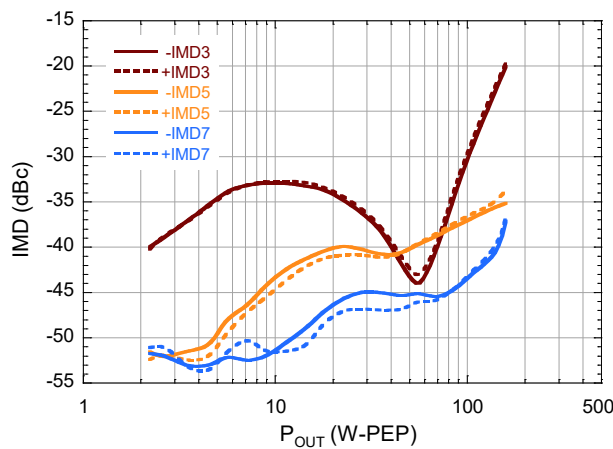
2-Tone IMD3 vs. Output Power vs. Quiescent Current



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



2-Tone IMD vs. Output Power





# GaN on Silicon General Purpose Amplifier

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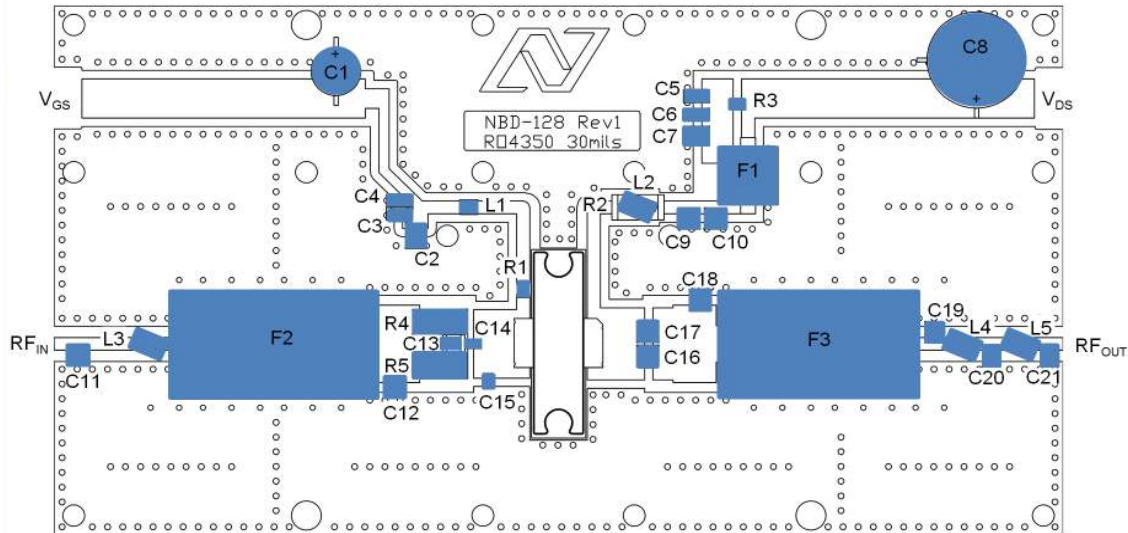


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### Evaluation Board and Recommended Tuning Solution

#### 130 - 940 MHz Broadband Circuit



#### Parts list

Reference	Value	Tolerance	Manufacturer	Part Number
C1	150 $\mu$ F	20%	Nichicon	UPW1C151MED
C2, C7	1.0 $\mu$ F	10%	AVX	1210C105KAT2A
C3, C6	0.1 $\mu$ F	10%	Kemet	C1206C104K1RACTU
C4, C5	0.01 $\mu$ F	10%	AVX	12061C103KAT2A
C8	270 $\mu$ F	20%	United Chemi-Con	ELXY 630ELL271MK25S
C9	18 pF	5%	ATC	ATC100B180J
C10	1000 pF	5%	ATC	ATC100B102J
C11	1.5 pF	0.1 pF	ATC	ATC100B1R5B
C12	5.6 pF	0.1 pF	ATC	ATC100B5R6B
C13	15 pF	5%	ATC	ATC100B150J
C14	220 pF	5%	ATC	ATC600F221J
C15	12 pF	2%	ATC	ATC600F120F
C16, C17	82 pF	10%	ATC	ATC100B820K
C18	4.7 pF	0.1 pF	ATC	ATC100B4R7B
C19	2.4 pF	0.1 pF	ATC	ATC100B2R4B
C20	3.9 pF	0.1 pF	ATC	ATC100B3R9B
C21	1.0 pF	0.1 pF	ATC	ATC100B1R0B
R1	49.9 $\Omega$	1%	Panasonic	ERJ-6ENF49R9V
R2	470 $\Omega$	1%	Panasonic	ERJ-1TNF4700U
R3	0.33 $\Omega$	1%	Panasonic	ERJ-6RQFR33V
R4, R5	24.9 $\Omega$	1%	Panasonic	ERJ-1TNF24R9U
F1	Material 73	-	Fair-Rite	2673000801
F2, F3	4:1 Transformer	-	Anaren	XMT031B5012
L1	25 nH	5%	Coilcraft	0908SQ-25NJL
L2, L4	8.0 nH	5%	Coilcraft	A03TJL
L3, L5	5.0 nH	5%	Coilcraft	A02TJL
PCB	Rogers RO4350, $\epsilon_r=3.5$ , 30 mil			

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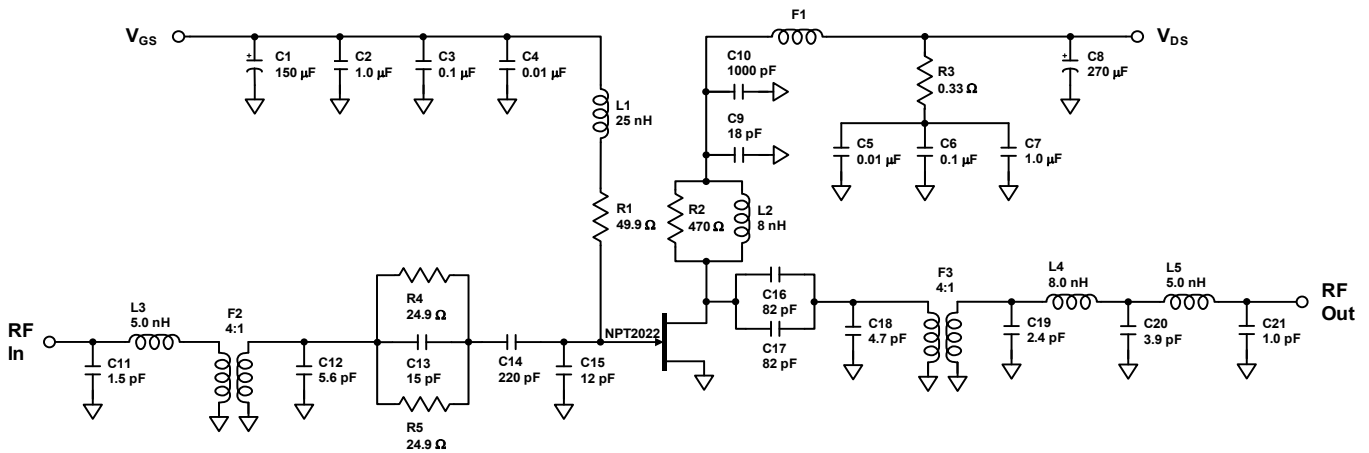
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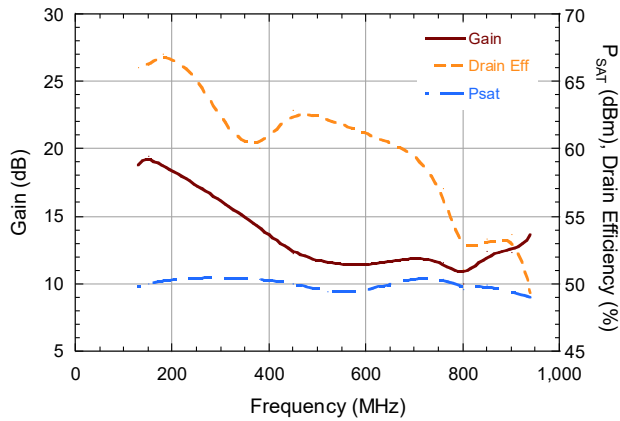
DC-0006486

### Evaluation Board and Recommended Tuning Solution

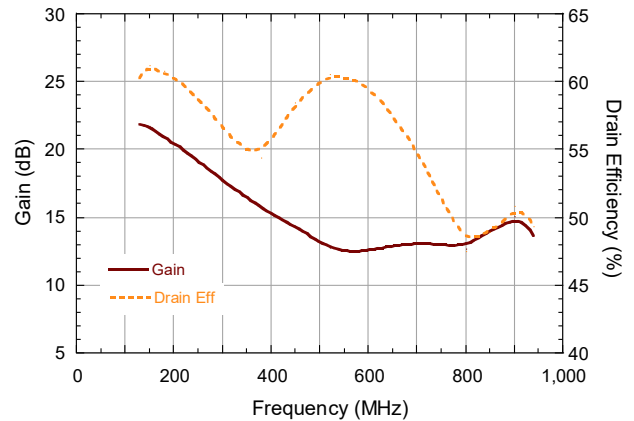
#### 130 - 940 MHz Broadband Circuit



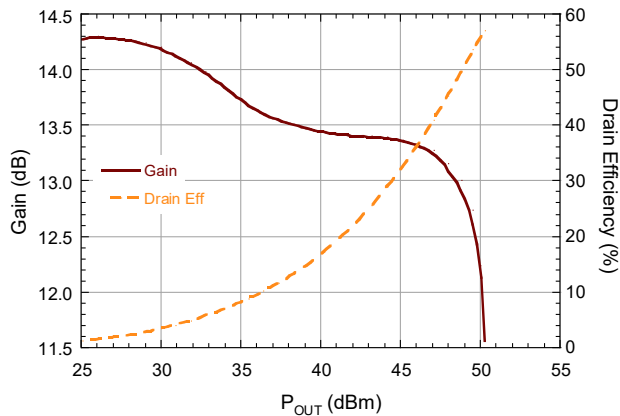
Performance vs. Frequency at  $P_{OUT} = P_{SAT}$



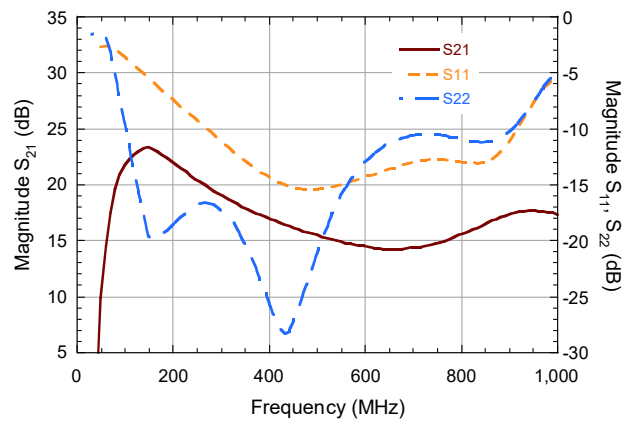
Performance vs. Frequency at  $P_{OUT} = 49 \text{ dBm}$



Performance vs. Output Power ( $f = 760 \text{ MHz}$ )



Small Signal s-parameters vs. Frequency



# GaN on Silicon General Purpose Amplifier

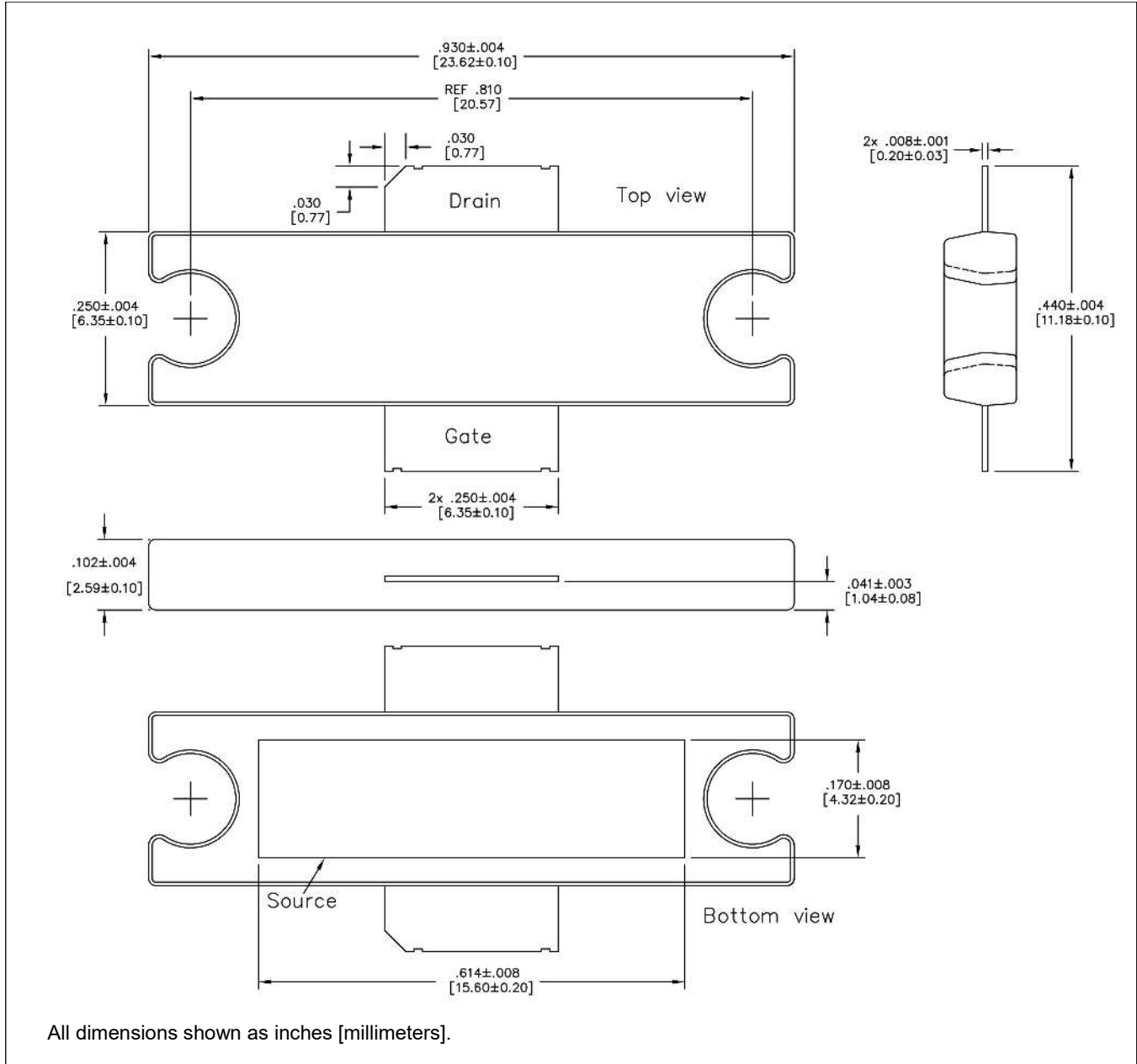
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### TO-272-2 Plastic Package<sup>†</sup>



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

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