

## Features

- GaN on Si HEMT D-Mode Amplifier
- Suitable for Linear & Saturated Applications
- Tunable from DC - 2.2 GHz
- 48 V Operation
- 15 dB Gain @ 2.15 GHz
- 61% Drain Efficiency @ 2.15 GHz
- 100% RF Tested
- Industry Standard Metal-Ceramic Package
- RoHS\* Compliant

## Description

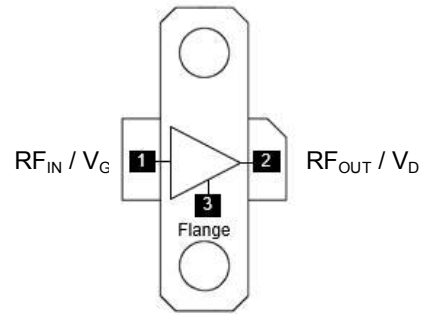
The NPT2010 is a GaN HEMT general purpose amplifier optimized for DC - 2.2 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 100 W (50 dBm) in an industry standard metal-ceramic package with bolt down flange.

The NPT2010 is ideally suited for defense communications, land mobile radio, avionics, wireless infrastructure, ISM applications and VHF/UHF/L/S-band radar.

## Ordering Information

Part Number	Package
NPT2010	bulk quantity
NPT2010-SMBPPR	sample

## Functional Schematic



## 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	Flange <sup>1</sup>	Ground / Source

1. The Flange must be connected to RF and DC ground. This path must also provide a low thermal resistance heat path.

**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, 2.15 GHz	$G_{SS}$	-	17	-	dB
Saturated Output Power	CW, 2.15 GHz	$P_{SAT}$	-	50.5	-	dBm
Drain Efficiency at Saturation	CW, 2.15 GHz	$\eta_{SAT}$	-	64	-	%
Power Gain	2.15 GHz, $P_{OUT} = 95\text{ W}$	$G_P$	13.5	15	-	dB
Drain Efficiency	2.15 GHz, $P_{OUT} = 95\text{ W}$	$\eta$	52.5	61	-	%
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	-1.5	-0.5	V
Gate Quiescent Voltage	$V_{DS} = 48\text{ V}$ , $I_D = 600\text{ mA}$	$V_{GSQ}$	-2.1	-1.2	-0.3	V
On Resistance	$V_{DS} = 2\text{ V}$ , $I_D = 180\text{ mA}$	$R_{ON}$	-	0.2	-	$\Omega$
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	$V_{DS} = 48 \text{ V}, T_J = 200^\circ\text{C}$	$R_{\theta JC}$	1.75	°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 1A devices.

## GaN on Silicon General Purpose Amplifier DC - 2.2 GHz, 48 V, 100 W

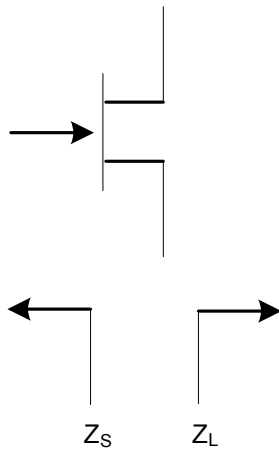
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**Load-Pull Performance:  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 600\text{ mA}$ ,  $T_C = 25^\circ\text{C}$**

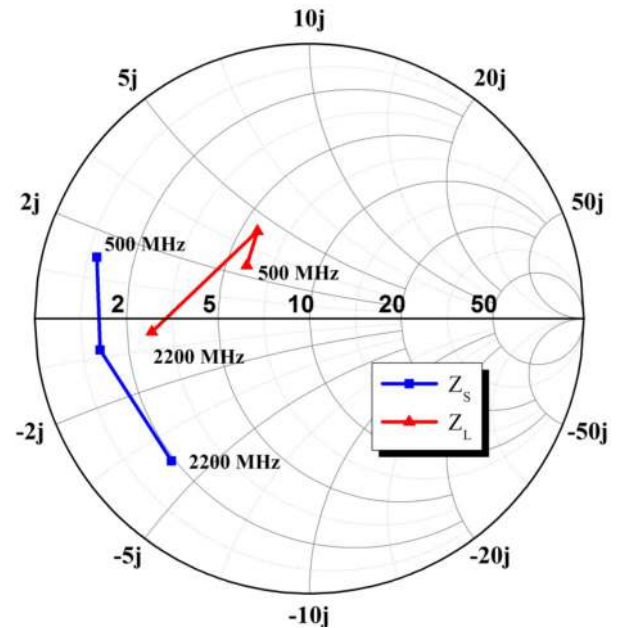
**Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance**

Frequency (MHz)	$Z_S$ ( $\Omega$ )	$Z_L$ ( $\Omega$ )	$P_{SAT}$ (W)	$G_{SS}$ (dB)	Drain Efficiency @ $P_{SAT}$ (%)
500	$1.1 + j1.4$	$5.9 + j2.5$	140	25.9	70
900	$1.3 - j0.7$	$5.7 + j4.2$	130	21.5	69
2200	$1.9 - j4.1$	$2.7 - j0.4$	115	16.1	64

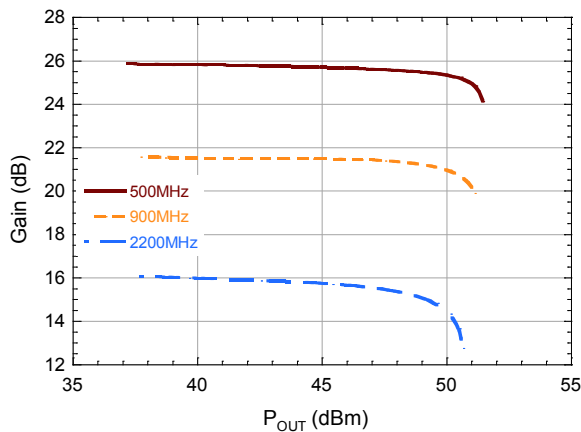
### Impedance Reference



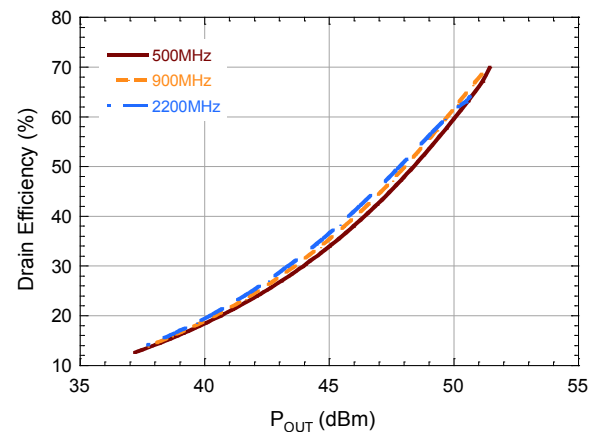
### $Z_S$ and $Z_L$ vs. Frequency



### Gain vs. Output Power

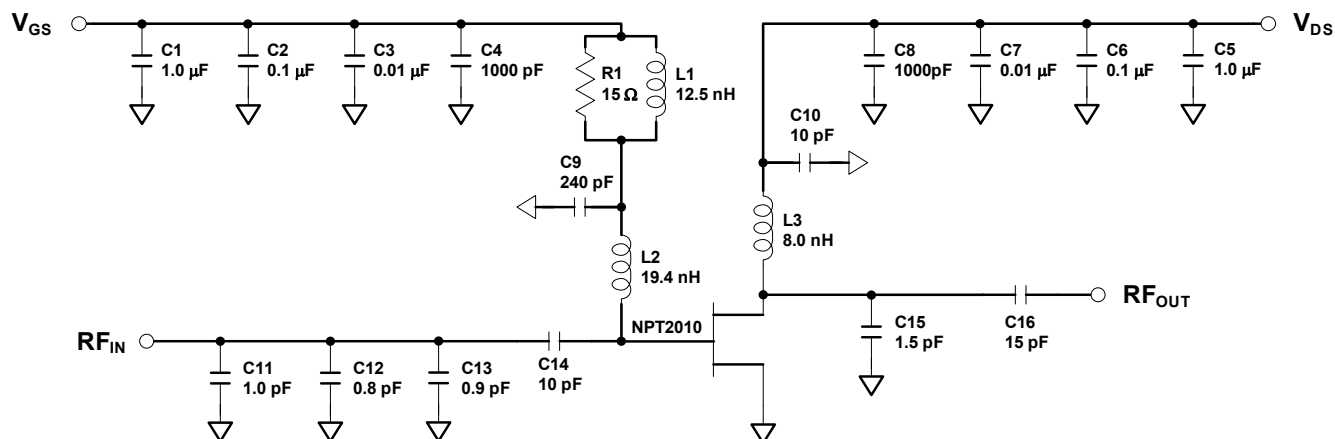


### Drain Efficiency vs. Output Power



## Evaluation Board and Recommended Tuning Solution

### 2.15 GHz Narrowband Circuit



### Description

Parts measured on evaluation board (20-mil thick RO4350). 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

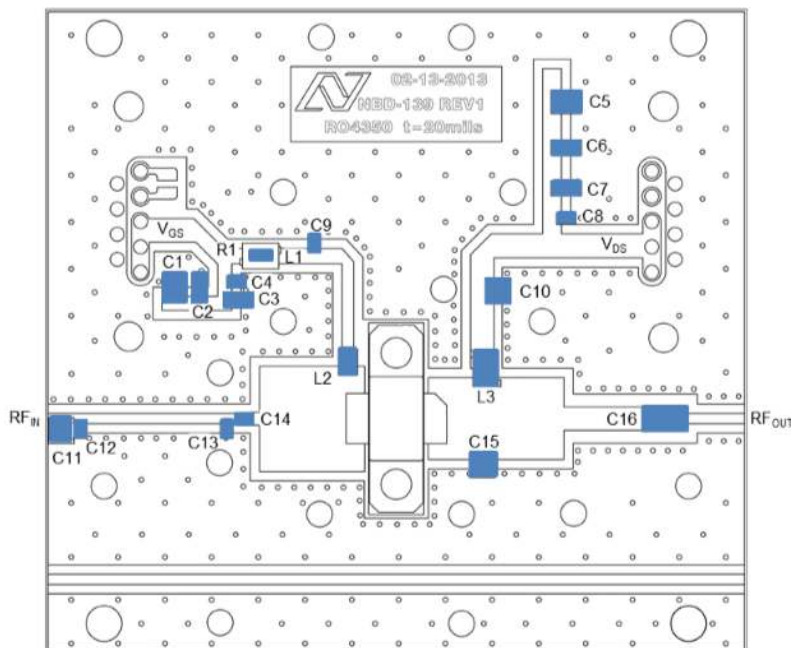
1. Set  $V_{GS}$  to the pinch-off ( $V_P$ ), typically -5 V.
2. Turn on  $V_{DS}$  to nominal voltage (48 V).
3. Increase  $V_{GS}$  until the  $I_{DS}$  current is reached.
4. Apply RF power to desired level.

#### 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

### 2.15 GHz Narrowband Circuit



## Parts list

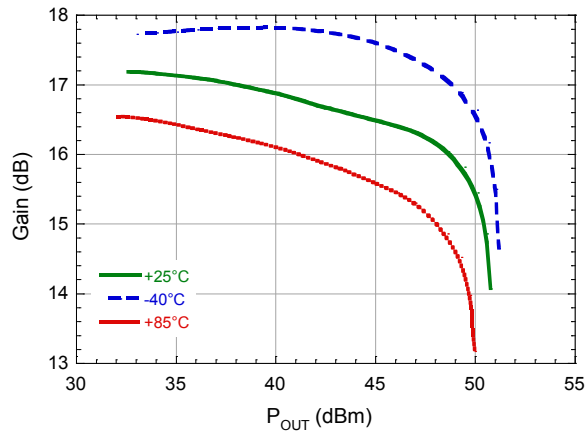
Reference	Value	Tolerance	Manufacturer	Part Number
C1, C5	1.0 $\mu$ F	10%	AVX	12101C105KAT2A
C2, C6	0.1 $\mu$ F	10%	Kemet	C1206C104K1RACTU
C3, C7	0.01 $\mu$ F	10%	AVX	1206C103KAT2A
C4, C8	1000 pF	10%	Kemet	C0805C102K1RACTU
C9	240 pF	0.1 pF	ATC	ATC600F241B
C10	10 pF	0.1 pF	ATC	ATC800B100B
C11	1.0 pF	0.1 pF	ATC	ATC800B1R0B
C12	0.8 pF	0.1 pF	ATC	ATC600F0R8B
C13	0.9 pF	0.1 pF	ATC	ATC600F0R9B
C14	10 pF	0.1 pF	ATC	ATC600F100B
C15	1.5 pF	0.1 pF	ATC	ATC800B1R5B
C16	15 pF	0.1 pF	ATC	ATC800B150B
L1	12.5 nH	5%	CoilCraft	A04TJL
L2	19.4 nH	5%	CoilCraft	0806SQ-19NJL
L3	8.0 nH	5%	CoilCraft	A03TJL
R1	15 $\Omega$	1%	Panasonic	ERJ-2RKF15R0X
PCB	Rogers RO4350, $\epsilon_r = 3.5$ , 20 mil			

## GaN on Silicon General Purpose Amplifier DC - 2.2 GHz, 48 V, 100 W

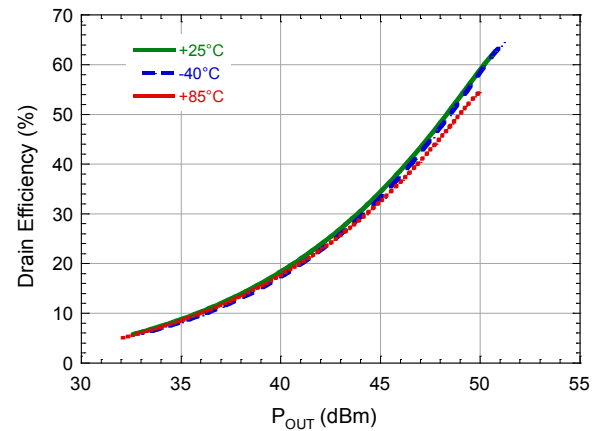
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Typical Performance as measured in the 2.15 GHz evaluation board:  
CW,  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 600\text{ mA}$  (unless noted)

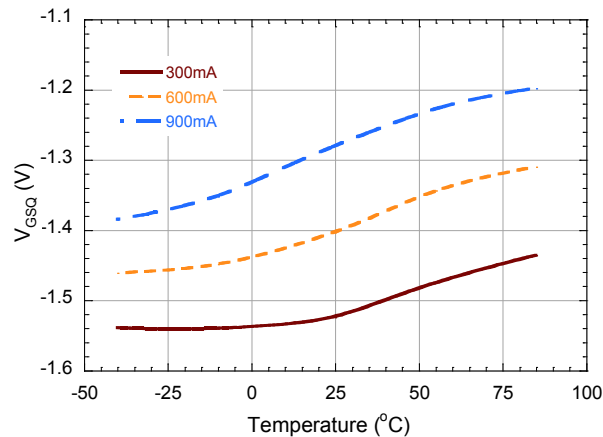
Gain vs. Output Power over Temperature



Drain Efficiency vs. Output Power over Temperature



Quiescent  $V_{GS}$  vs. Temperature

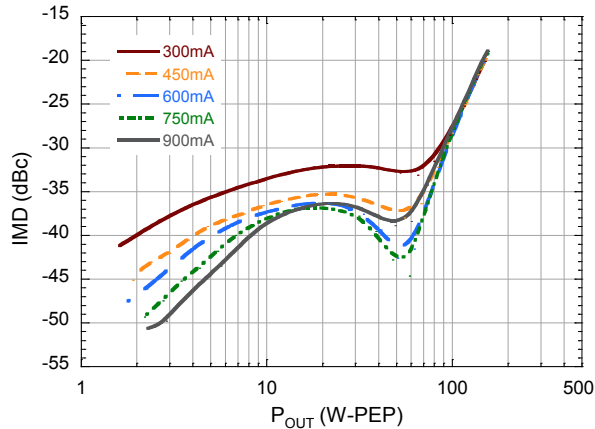


## GaN on Silicon General Purpose Amplifier DC - 2.2 GHz, 48 V, 100 W

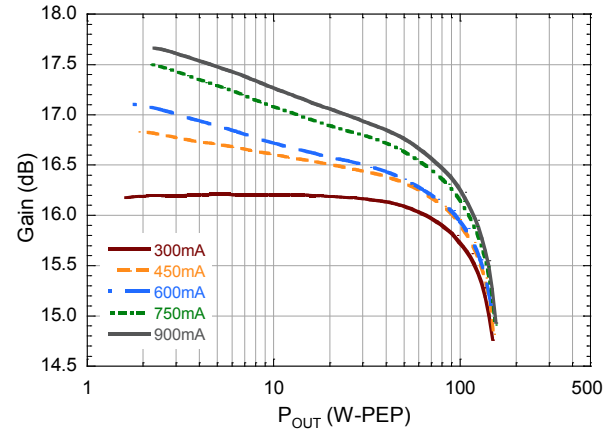
Rev. V3

Typical 2-Tone Performance as measured in the 2.15 GHz evaluation board:  
1 MHz Tone Spacing,  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 600\text{ mA}$ ,  $T_C = 25^\circ\text{C}$  (unless noted)

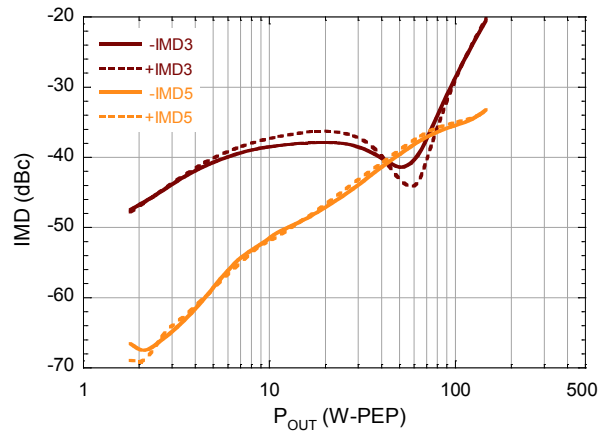
2-Tone IMD3 vs. Output Power vs. Quiescent Current



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



2-Tone IMD vs. Output Power



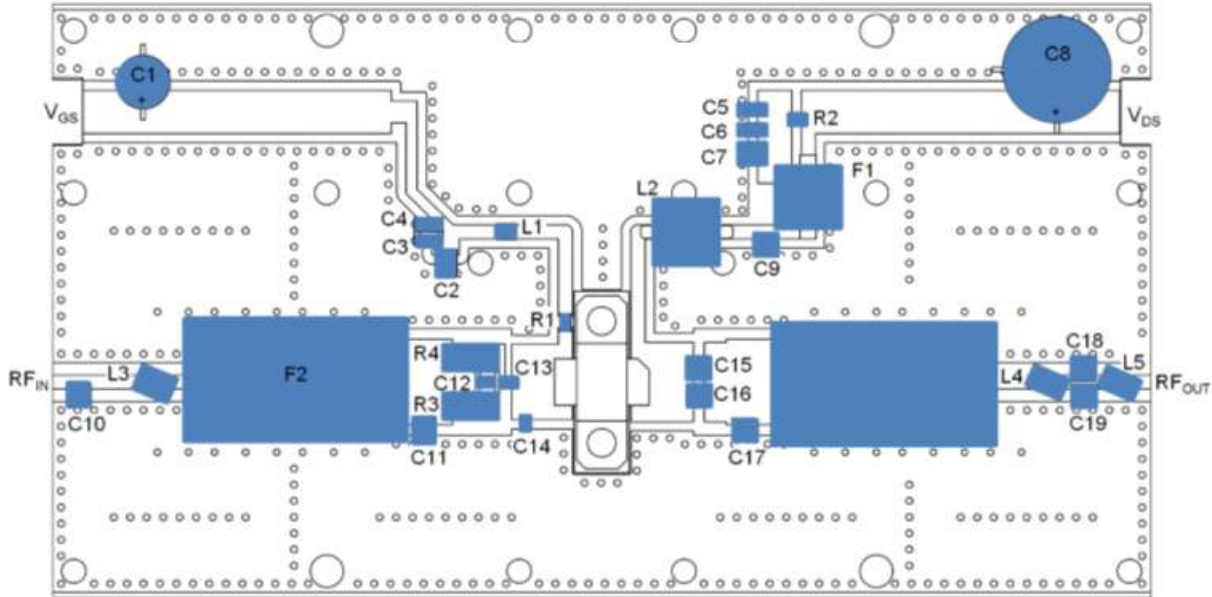


## GaN on Silicon General Purpose Amplifier DC - 2.2 GHz, 48 V, 100 W

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### Evaluation Board and Recommended Tuning Solution

#### 100 - 700 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	12101C105KAT2A
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	1%	ATC	ATC100B180FT
C10, C19	2.4 pF	0.1 pF	ATC	ATC100B2R4BT
C11	5.6 pF	0.1 pF	ATC	ATC100B5R6BT
C12	15 pF	1%	ATC	ATC600F150FT
C13	220 pF	1%	ATC	ATC600F221FT
C14	12 pF	1%	ATC	ATC600F120FT
C15, C16	82 pF	1%	ATC	ATC100B820FT
C17	4.7 pF	0.1 pF	ATC	ATC100B4R7BT
C18	2.0 pF	0.1 pF	ATC	ATC100B2R0BT
R1	49.9 $\Omega$	1%	Panasonic	ERJ-6ENF49R9V
R2	0.33 $\Omega$	1%	Panasonic	ERJ-6RQFR33V
R3, R4	24.9 $\Omega$	1%	Panasonic	ERJ-1TNF24R9U
F1	Material 73	-	Fair-Rite	2673000801
F2, F3	4:1 Transformer	-	Anaren	XMT031B5012
L1	12.5 nH	5%	Coilcraft	A04TJL
L2	~50 nH	-	16 AWG Cu Wire	5 turn, 0.2"ID
L3	5.0 nH	5%	Coilcraft	A02TJL
L4, L5	8.0 nH	5%	Coilcraft	A03TJL
PCB	Rogers RO4350, $\epsilon_r=3.5$ , 20mil			

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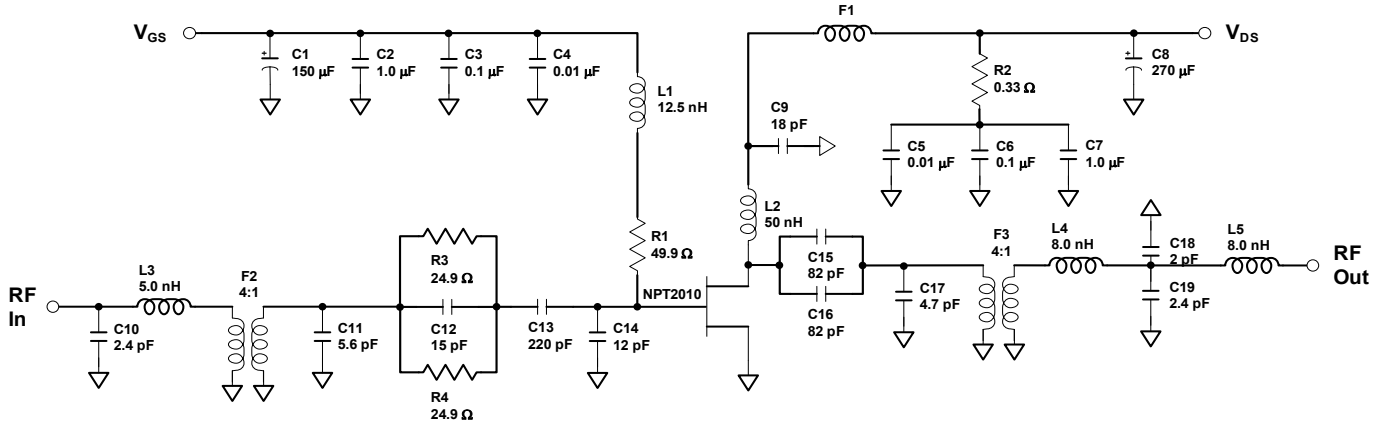
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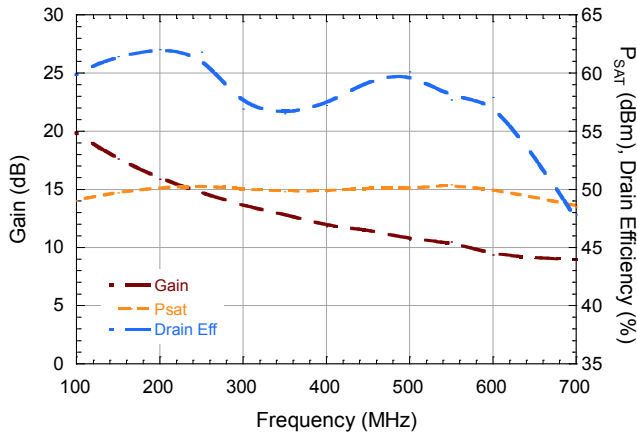
## GaN on Silicon General Purpose Amplifier DC - 2.2 GHz, 48 V, 100 W

Rev. V3

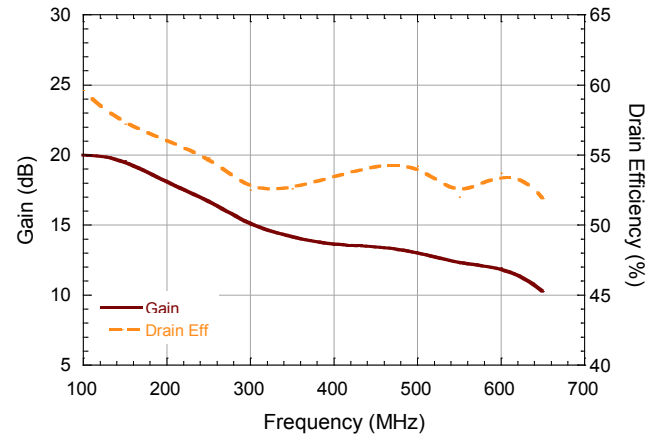
### Evaluation Board and Recommended Tuning Solution 100 - 700 MHz Broadband Circuit



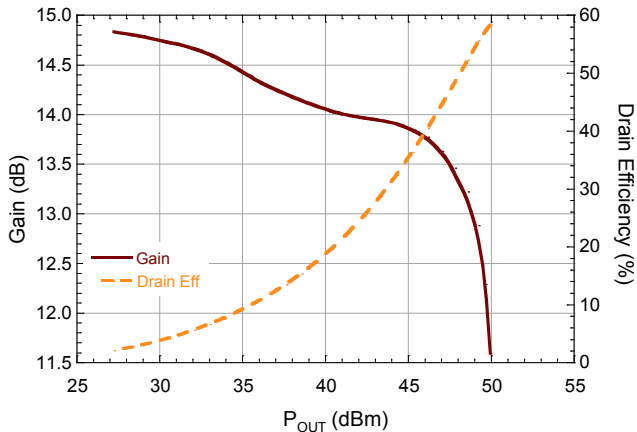
Performance vs. Frequency at  $P_{OUT} = P_{SAT}$



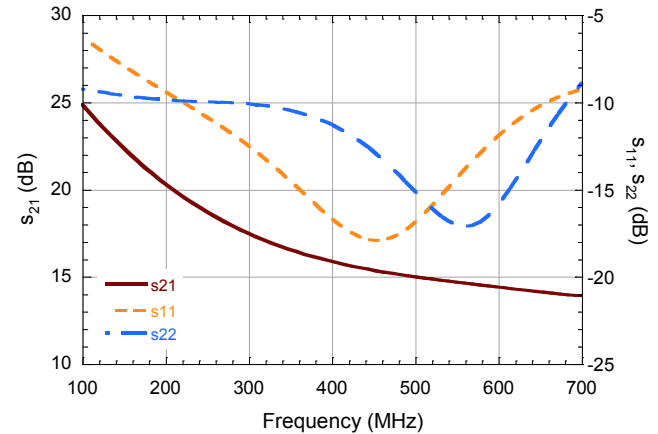
Performance vs. Frequency at  $P_{OUT} = 49$  dBm



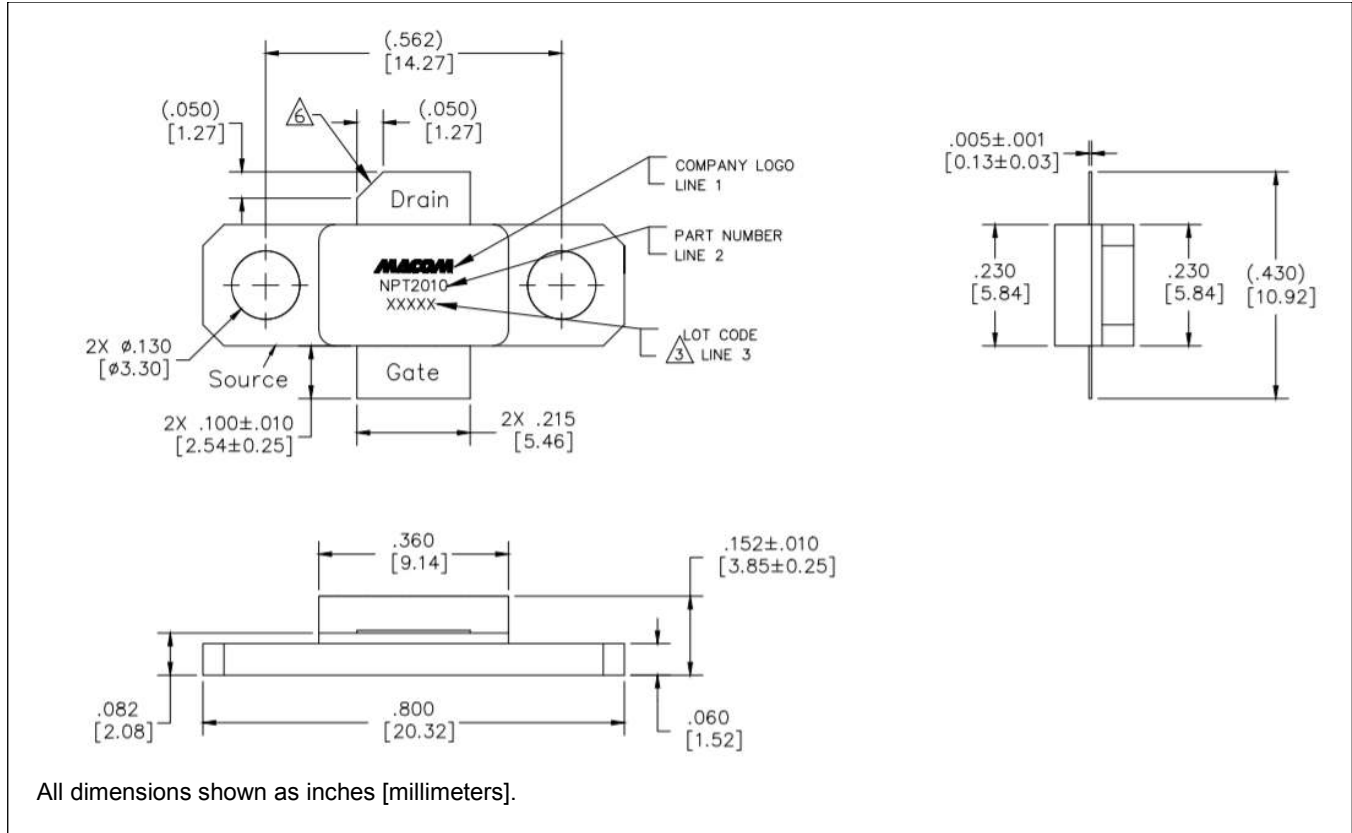
Performance vs. Output Power ( $f = 760$  MHz)



Small Signal s-parameters vs. Frequency



## AC360B-2 Metal-Ceramic Package



† Plating is Ni / Au.

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