

## 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 and 260°C reflow compatible

## Description

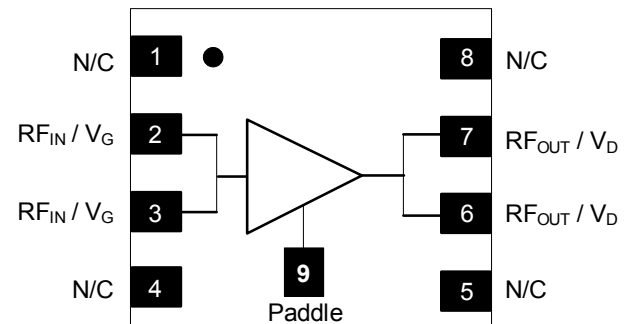
The NPTB00004A GaN HEMT is a wideband transistor optimized for DC - 6 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 5 W (37 dBm) in an industry standard surface mount plastic package.

The NPTB00004A 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       |
|-------------------|---------------|
| NPTB00004A        | bulk quantity |
| NPTB00004A-SMBPPR | sample        |

## Functional Schematic



## Pin Configuration

| Pin No. | Pin Name                           | Function          |
|---------|------------------------------------|-------------------|
| 1       | N/C                                | No Connection     |
| 2       | RF <sub>IN</sub> / V <sub>G</sub>  | RF Input / Gate   |
| 3       | RF <sub>IN</sub> / V <sub>G</sub>  | RF Input / Gate   |
| 4       | N/C                                | No Connection     |
| 5       | N/C                                | No Connection     |
| 6       | RF <sub>OUT</sub> / V <sub>D</sub> | RF Output / Drain |
| 7       | RF <sub>OUT</sub> / V <sub>D</sub> | RF Output / Drain |
| 8       | N/C                                | No Connection     |
| 9       | Paddle <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, European Union Directive 2011/65/EU.

GaN Wideband Transistor 28 V, 5 W  
DC - 6 GHz

Rev. V1

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

| Parameter                      | Test Conditions                 | Symbol       | Min.                          | Typ. | Max. | Units |
|--------------------------------|---------------------------------|--------------|-------------------------------|------|------|-------|
| Small Signal Gain              | CW, 2.5 GHz                     | $G_{SS}$     | -                             | 16   | -    | dB    |
| Saturated Output Power         | CW, 2.5 GHz                     | $P_{SAT}$    | -                             | 37.1 | -    | dBm   |
| Drain Efficiency at Saturation | CW, 2.5 GHz                     | $\eta_{SAT}$ | -                             | 63.7 | -    | %     |
| Power Gain                     | 2.5 GHz, $P_{OUT} = 4\text{ W}$ | $G_P$        | 12.8                          | 14.8 | -    | dB    |
| Drain Efficiency               | 2.5 GHz, $P_{OUT} = 4\text{ W}$ | $\eta$       | 45                            | 57   | -    | %     |
| Ruggedness: Output Mismatch    | All phase angles                | $\Psi$       | VSWR = 15:1, No Device Damage |      |      |       |

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

| Parameter                    | Test Conditions                                             | Symbol      | Min. | Typ. | Max. | Units    |
|------------------------------|-------------------------------------------------------------|-------------|------|------|------|----------|
| Drain-Source Leakage Current | $V_{GS} = -8\text{ V}$ , $V_{DS} = 100\text{ V}$            | $I_{DLK}$   | -    | -    | 2    | mA       |
| Gate-Source Leakage Current  | $V_{GS} = -8\text{ V}$ , $V_{DS} = 0\text{ V}$              | $I_{GLK}$   | -    | -    | 1    | mA       |
| Gate Threshold Voltage       | $V_{DS} = 28\text{ V}$ , $I_D = 2\text{ mA}$                | $V_T$       | -2.5 | -1.6 | -0.5 | V        |
| Gate Quiescent Voltage       | $V_{DS} = 28\text{ V}$ , $I_D = 50\text{ mA}$               | $V_{GSQ}$   | -2.1 | -1.3 | -0.3 | V        |
| On Resistance                | $V_{DS} = 2\text{ V}$ , $I_D = 15\text{ mA}$                | $R_{ON}$    | -    | 1.6  | -    | $\Omega$ |
| Maximum Drain Current        | $V_{DS} = 7\text{ V}$ pulsed, pulse width 300 $\mu\text{s}$ | $I_{D,MAX}$ | -    | 1.4  | -    | A        |

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

| Parameter                      | Absolute Maximum |
|--------------------------------|------------------|
| Drain Source Voltage, $V_{DS}$ | 100 V            |
| Gate Source Voltage, $V_{GS}$  | -10 to 3 V       |
| Gate Current, $I_G$            | 4 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 MTTF >  $1 \times 10^6$  hours.

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

| Parameter          | Test Conditions                                     | Symbol          | Typical | Units |
|--------------------|-----------------------------------------------------|-----------------|---------|-------|
| Thermal Resistance | $V_{DS} = 28 \text{ V}$ , $T_J = 180^\circ\text{C}$ | $R_{\theta JC}$ | 15      | °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 Wideband Transistor 28 V, 5 W DC - 6 GHz

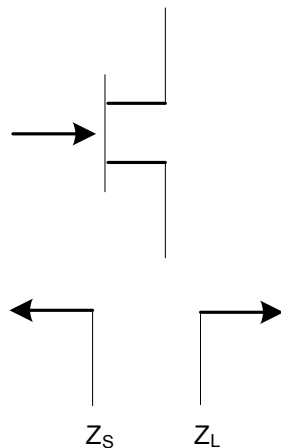
Rev. V1

**Load-Pull Performance:  $V_{DS} = 28$  V,  $I_{DQ} = 50$  mA,  $T_C = 25^\circ\text{C}$**

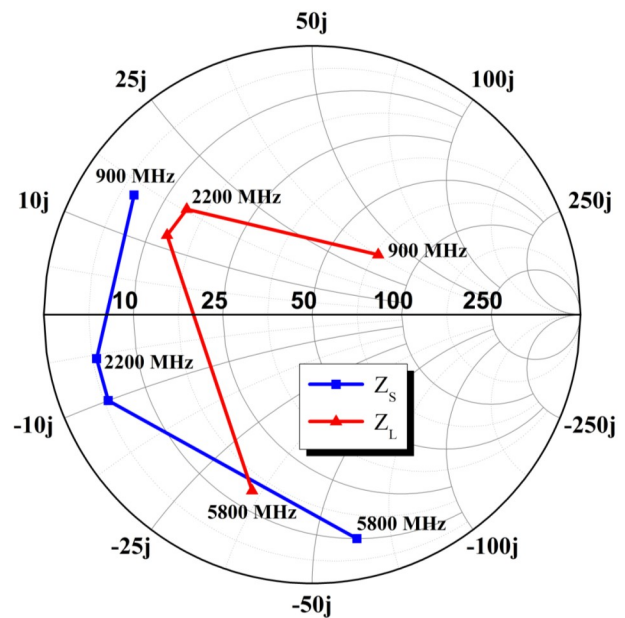
**Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance**

| Frequency (MHz) | $Z_S$ ( $\Omega$ ) | $Z_L$ ( $\Omega$ ) | $P_{SAT}$ (W) | $G_{SS}$ (dB) | Drain Efficiency @ $P_{SAT}$ (%) |
|-----------------|--------------------|--------------------|---------------|---------------|----------------------------------|
| 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                               |

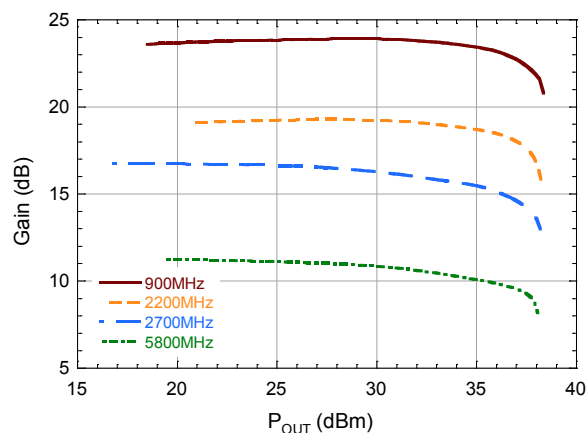
### Impedance Reference



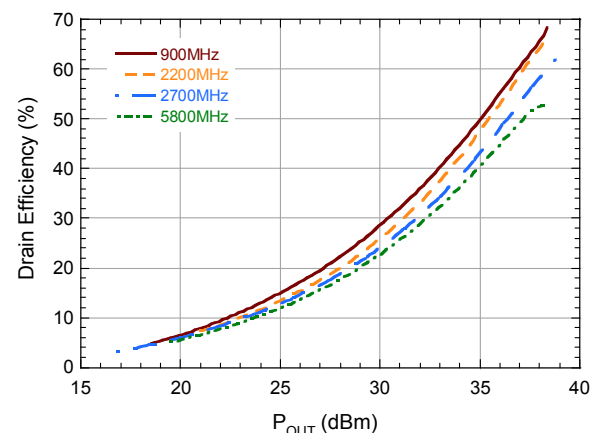
### $Z_S$ and $Z_L$ vs. Frequency



### Gain vs. Output Power

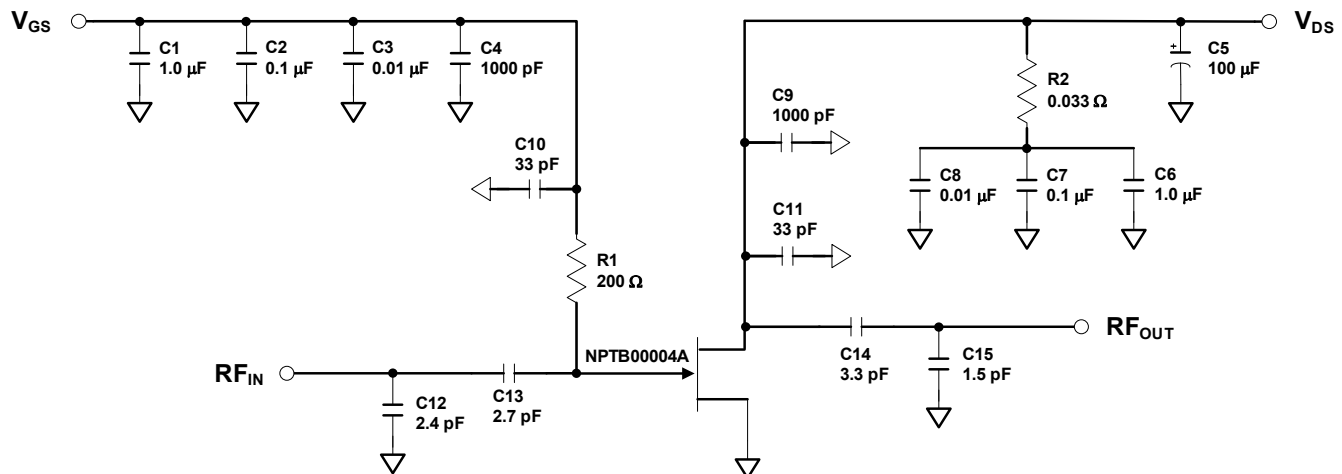


### Drain Efficiency vs. Output Power



## 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

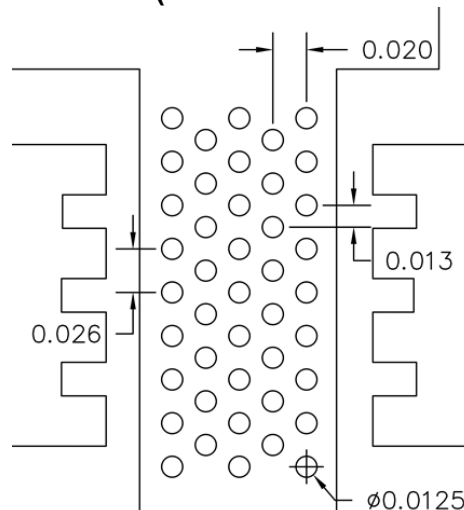
#### Turning the device ON

1. Set  $V_{GS}$  to the pinch-off ( $V_P$ ), typically -5 V.
2. Turn on  $V_{DS}$  to nominal voltage (28 V).
3. Increase  $V_{GS}$  until the  $I_{DS}$  current is reached.
4. Apply RF power to desired level.

#### Turning the device OFF

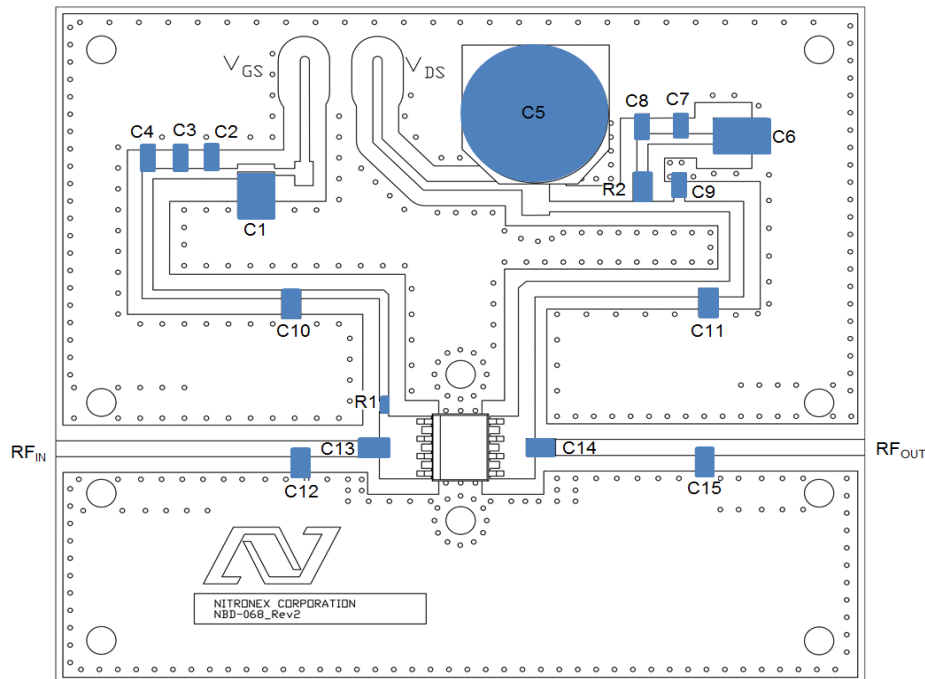
1. Turn the RF power off.
2. Decrease  $V_{GS}$  down to  $V_P$ .
3. Decrease  $V_{DS}$  down to 0 V.
4. Turn off  $V_{GS}$ .

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



## Evaluation Board and Recommended Tuning Solution

### 2.5 GHz Narrowband Circuit



## Parts list

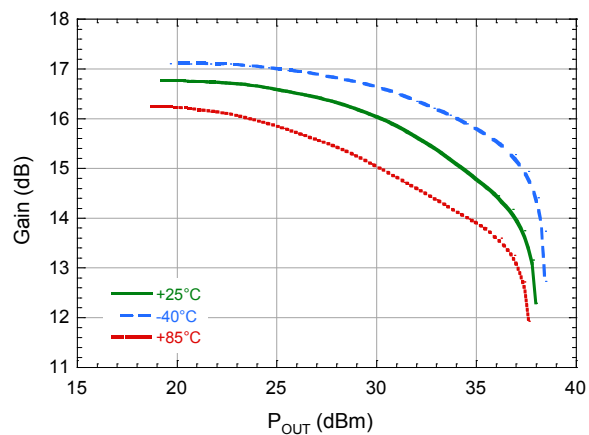
| Reference | Value                                      | Tolerance | Manufacturer | Part Number        |
|-----------|--------------------------------------------|-----------|--------------|--------------------|
| C1, C6    | 1.0 $\mu$ F                                | 10%       | AVX          | 12101C105KAT2A     |
| C2, C7    | 0.1 $\mu$ F                                | 10%       | Murata       | GRM188R72A104KA35D |
| C3, C8    | 0.01 $\mu$ F                               | 10%       | AVX          | 06031C103KAT2A     |
| C4, C9    | 1000 pF                                    | 10%       | AVX          | 06031C102KAT2A     |
| C5        | 100 $\mu$ F                                | 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 $\Omega$                               | 5%        | Panasonic    | ERJ-2GEJ201X       |
| R2        | 0.33 $\Omega$                              | 1%        | Susumu       | RL1220S-R33-F      |
| PCB       | Rogers RO4350, $\epsilon_r = 3.5$ , 20 mil |           |              |                    |

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

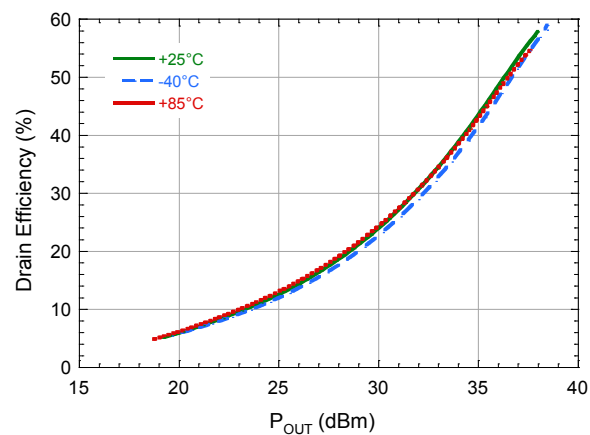
Rev. V1

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

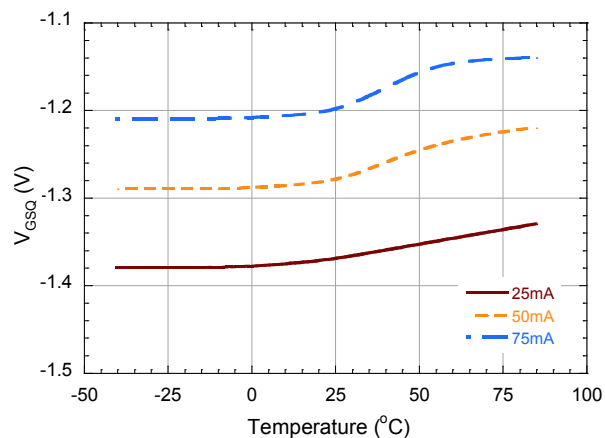
**Gain vs. Output Power over Temperature**



**Drain Efficiency vs. Output Power over Temperature**



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

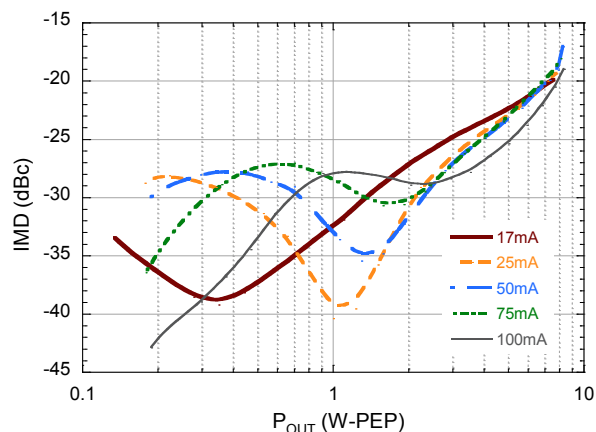


## GaN Wideband Transistor 28 V, 5 W DC - 6 GHz

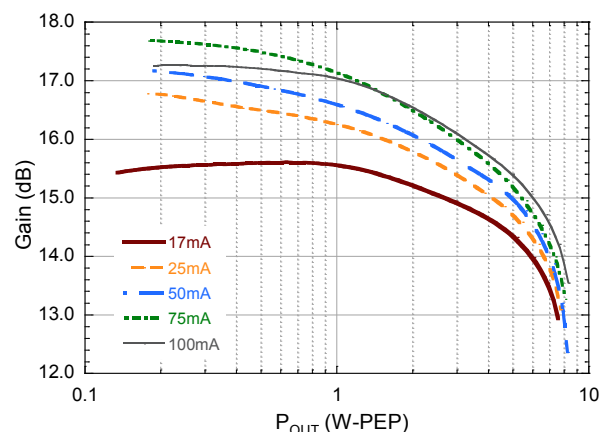
Rev. V1

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

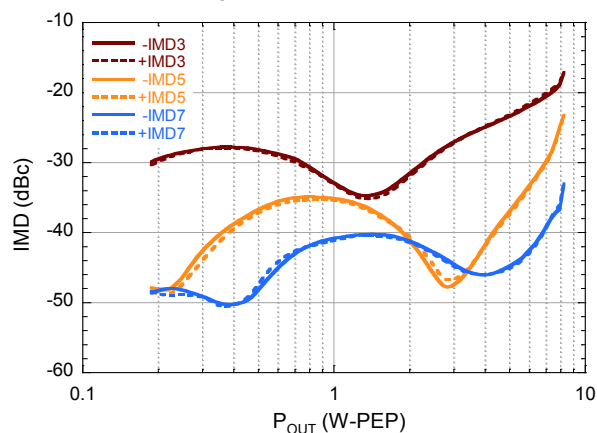
**2-Tone IMD3 vs. Output Power vs. Quiescent Current**



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



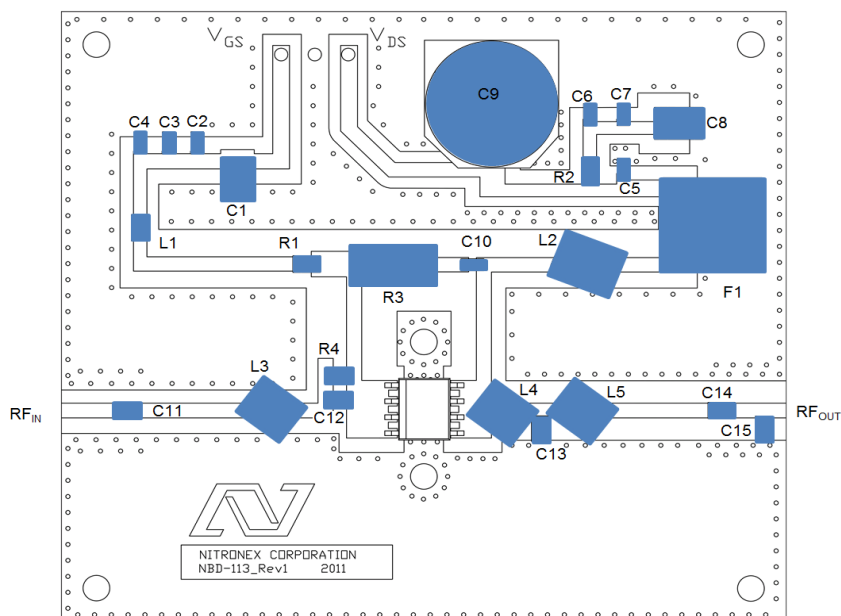
**2-Tone IMD vs. Output Power**





## Evaluation Board and Recommended Tuning Solution

### 100-800 MHz BroadBand Circuit

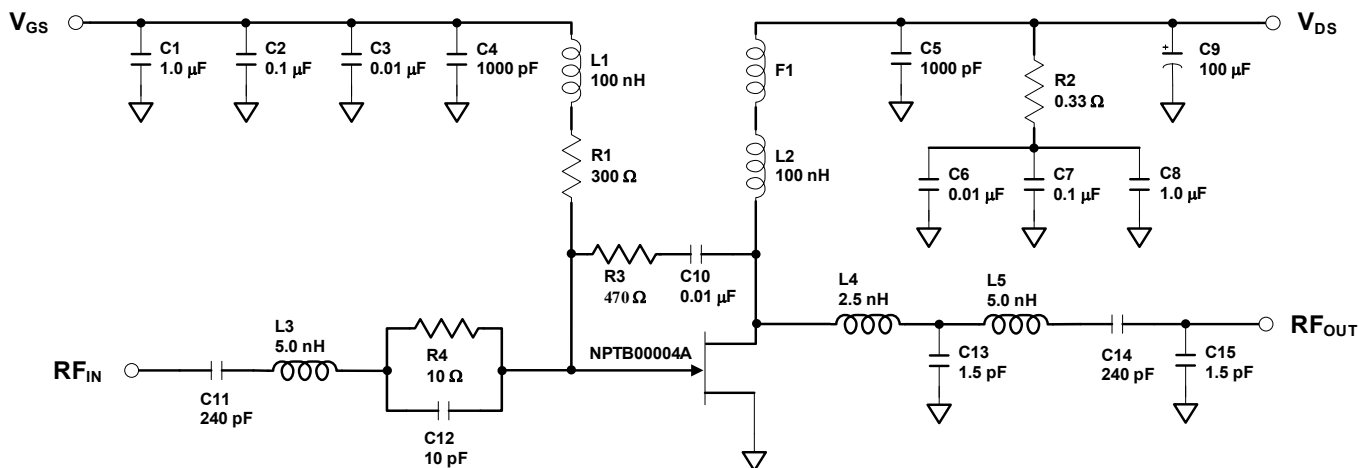


## Parts list

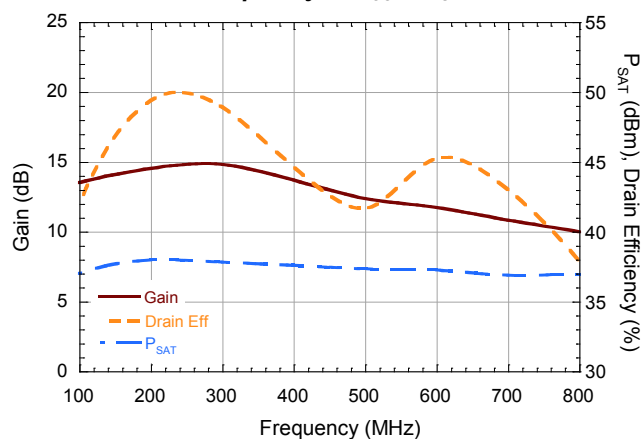
| Reference   | Value                                    | Tolerance | Manufacturer | Part Number        |
|-------------|------------------------------------------|-----------|--------------|--------------------|
| C1, C8      | 1.0 $\mu$ F                              | 10%       | AVX          | 12101C105KAT2A     |
| C2, C7      | 0.1 $\mu$ F                              | 10%       | Murata       | GRM188R72A104KA35D |
| C3, C6, C10 | 0.01 $\mu$ F                             | 10%       | AVX          | 06031C103KAT2A     |
| C4, C5,     | 1000 pF                                  | 10%       | AVX          | 06031C102KAT2A     |
| C9          | 100 $\mu$ F                              | 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 $\Omega$                             | 5%        | Panasonic    | ERJ-14YJ301U       |
| R2          | 0.33 $\Omega$                            | 1%        | Susumu       | RL1220S-R33-F      |
| R3          | 470 $\Omega$                             | 1%        | Stackpole    | RHC2512FT470R      |
| R4          | 10 $\Omega$                              | 5%        | Panasonic    | ERJ-14YJ100U       |
| PCB         | Rogers RO4350, $\epsilon_r=3.5$ , 0.020" |           |              |                    |

## Evaluation Board and Recommended Tuning Solution

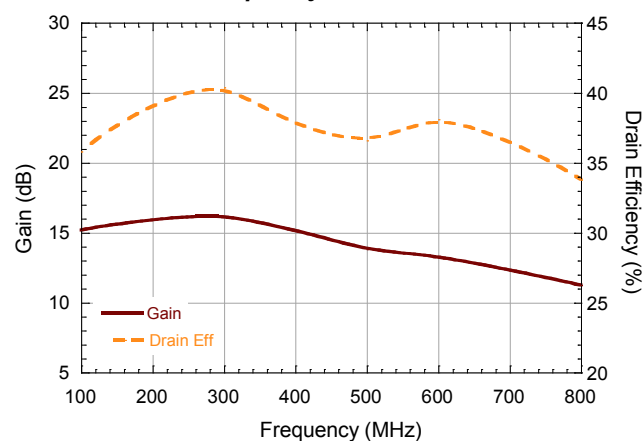
### 100-800 MHz BroadBand Circuit



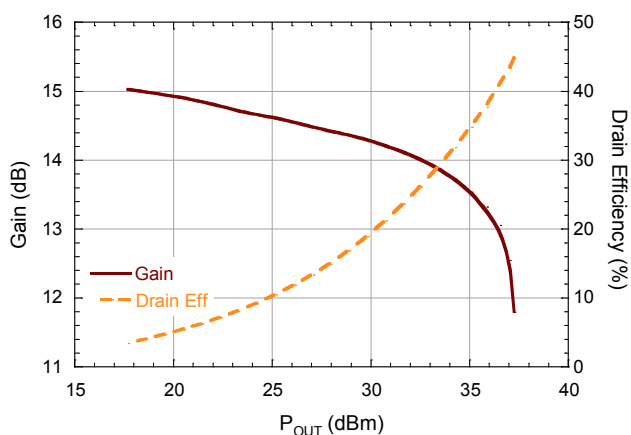
**Performance vs. Frequency at  $P_{OUT} = P_{SAT}$**



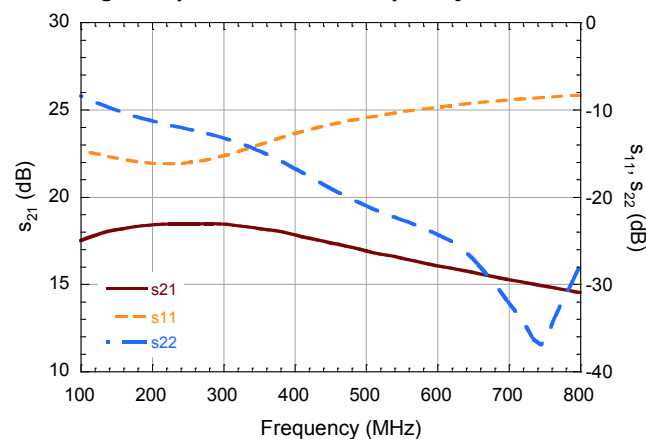
**Performance vs. Frequency at  $P_{OUT} = 36$  dBm**



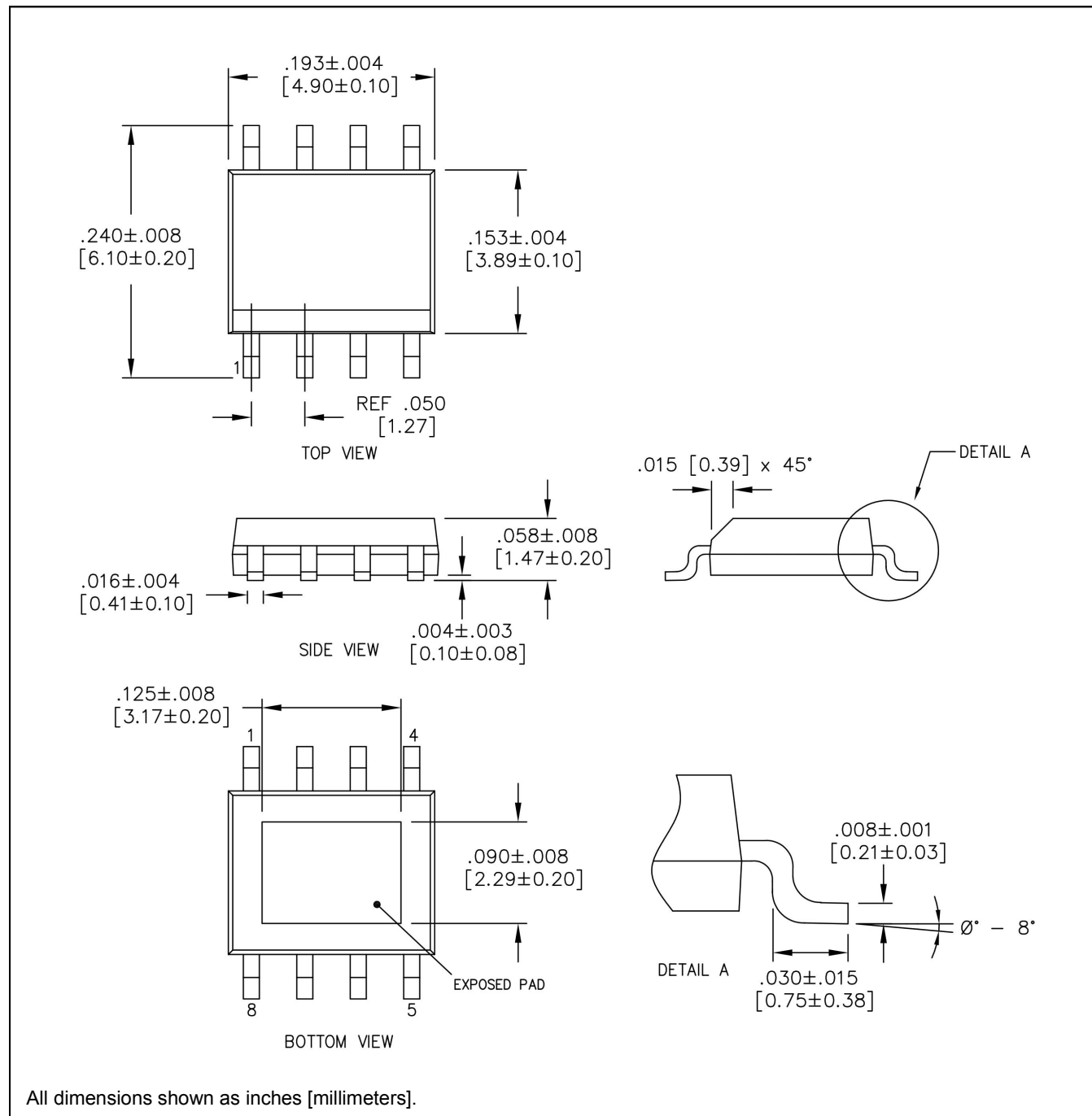
**Performance vs. Output Power ( $f = 600$  MHz)**



**Small Signal s-parameters vs Frequency**



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



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

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