

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

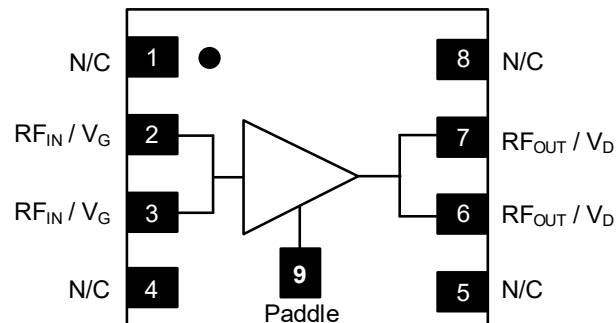
Applications

- 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.

Functional Schematic



Pin Configuration

| Pin # | Pin Name | Function |
|------------|------------------------------------|-------------------|
| 1, 4, 5, 8 | N/C | No Connection |
| 2, 3 | RF _{IN} / V _G | RF Input / Gate |
| 6, 7 | RF _{OUT} / V _D | RF Output / Drain |
| 9 | Paddle ¹ | 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.

Ordering Information

| Part Number | Package |
|----------------|---------------|
| NPTB00004A | bulk quantity |
| NPTB00004A-SMB | sample board |

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

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

| 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 | η_{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, $P_{OUT} = 4\text{ W}$ | η | 45 | 57 | - | % |
| Ruggedness: Output Mismatch | All phase angles | Ψ | 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 | - | Ω |
| Maximum Drain Current | $V_{DS} = 7\text{ V}$ pulsed, pulse width 300 μs | $I_{D,MAX}$ | - | 1.4 | - | A |

Absolute Maximum Ratings^{2,3,4}

| 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 $\text{MTTF} > 1 \times 10^6$ hours.

Thermal Characteristics⁵

| 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.

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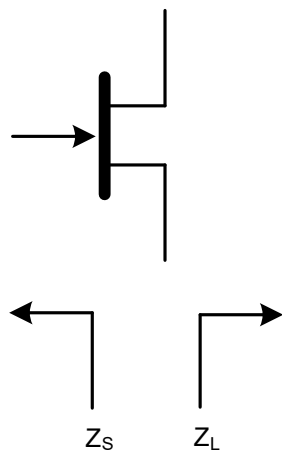
Rev. V2

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

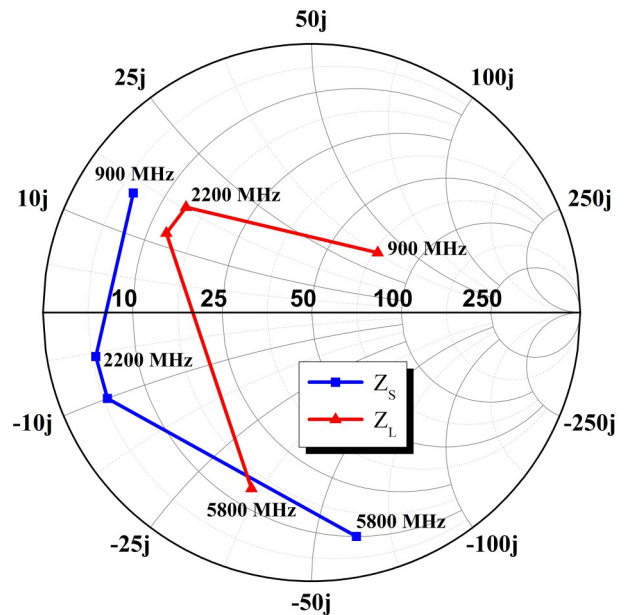
Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance

| Frequency (MHz) | Z_S (Ω) | Z_L (Ω) | 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 | 52 | |

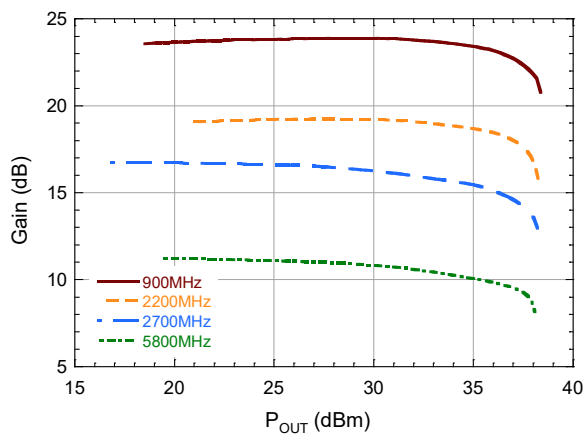
Impedance Reference



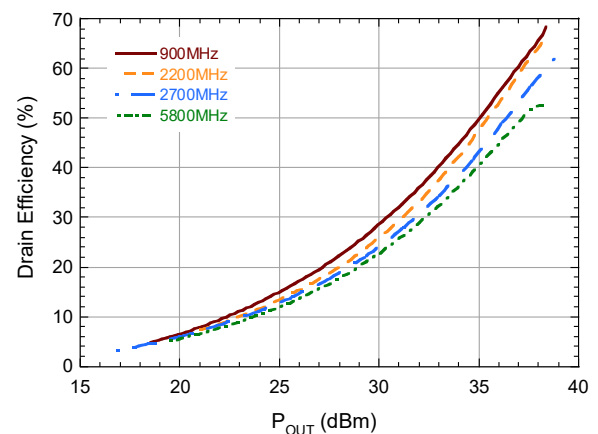
Z_S and Z_L vs. Frequency



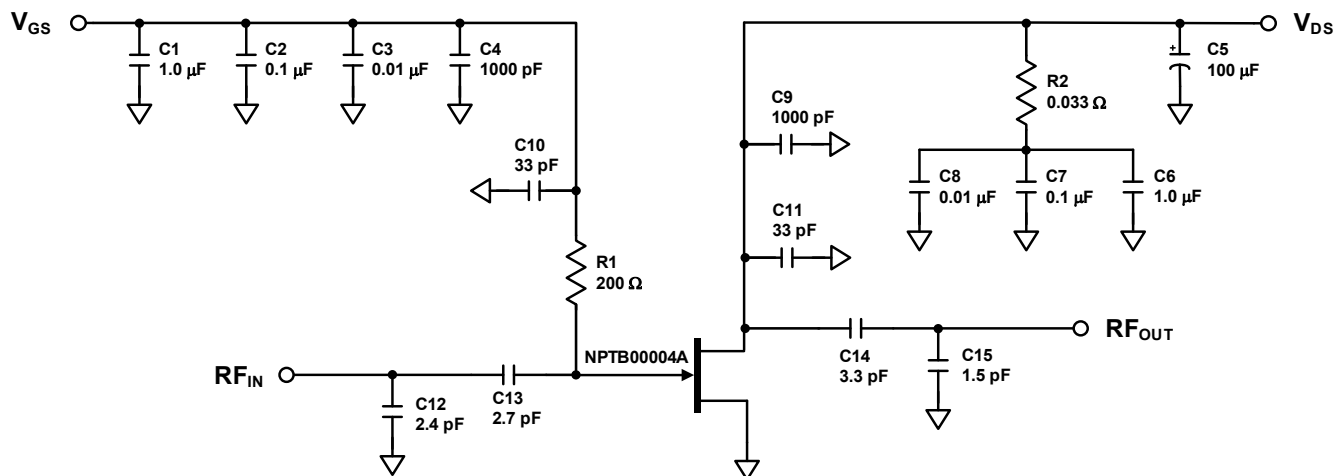
Gain vs. Output Power



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

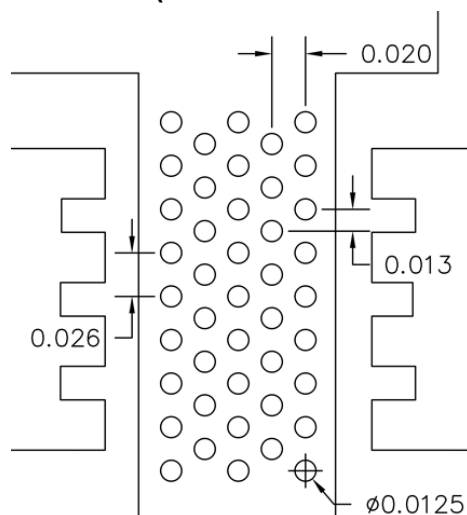
Turning the device ON

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.

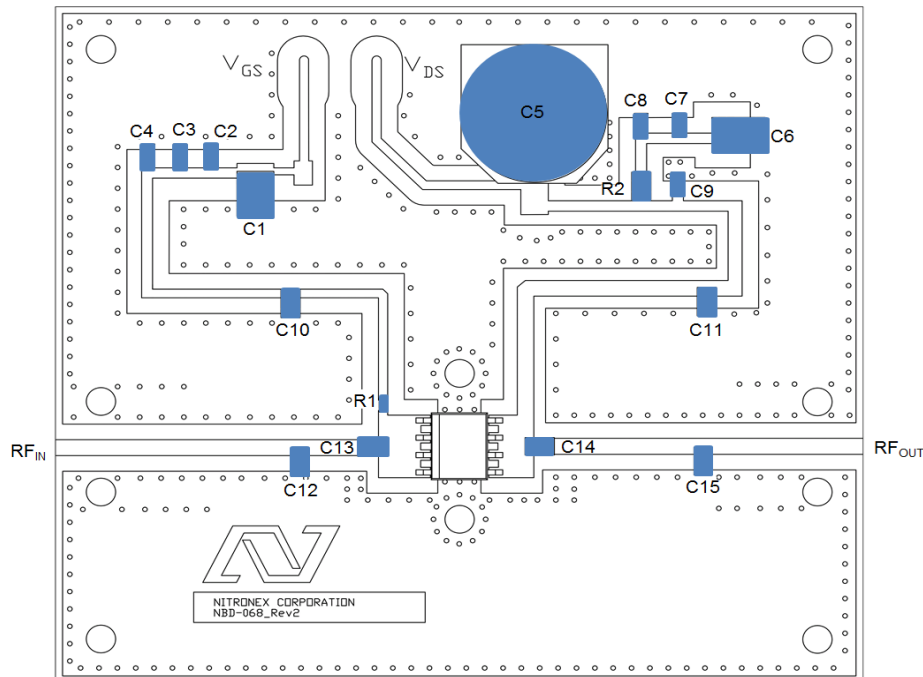
Turning the device OFF

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

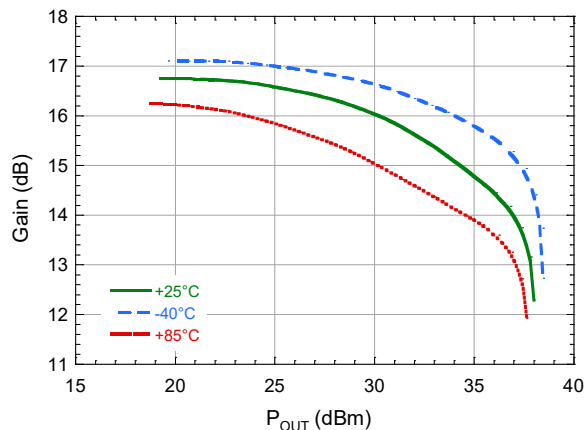


Parts list

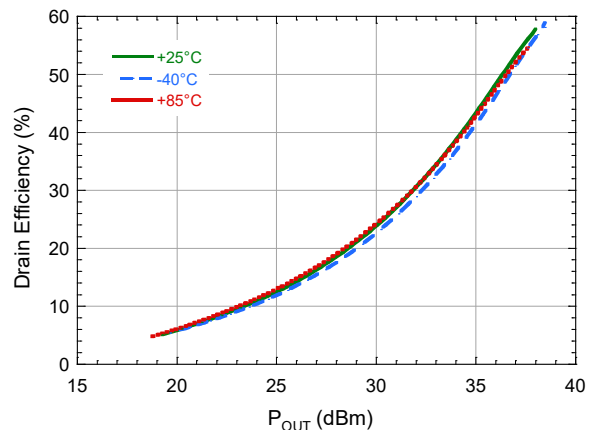
| Reference | Value | Tolerance | Manufacturer | Part Number |
|-----------|--|-----------|--------------|--------------------|
| C1, C6 | 1.0 μ F | 10% | AVX | 12101C105KAT2A |
| C2, C7 | 0.1 μ F | 10% | Murata | GRM188R72A104KA35D |
| C3, C8 | 0.01 μ F | 10% | AVX | 06031C103KAT2A |
| C4, C9 | 1000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

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

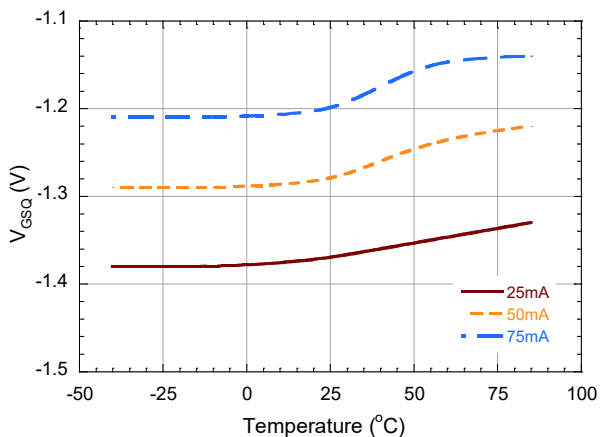
Gain vs. Output Power over Temperature



Drain Efficiency vs. Output Power over Temperature

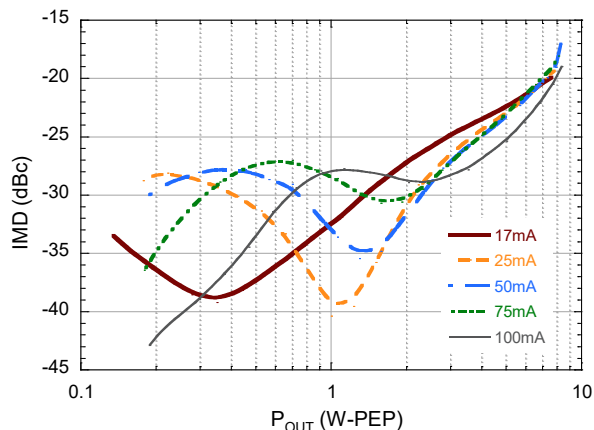


Quiescent V_{GS} vs. Temperature

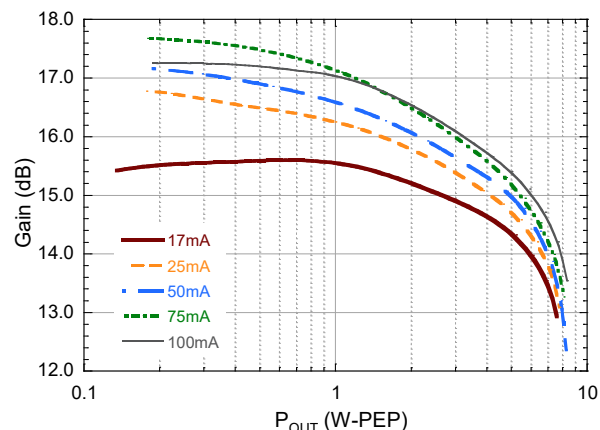


Typical 2-Tone Performance as measured in the 2.5 GHz evaluation board:
1 MHz Tone Spacing, $V_{DS} = 28\text{ V}$, $I_{DQ} = 50\text{ mA}$, $T_C = 25^\circ\text{C}$ (unless noted)

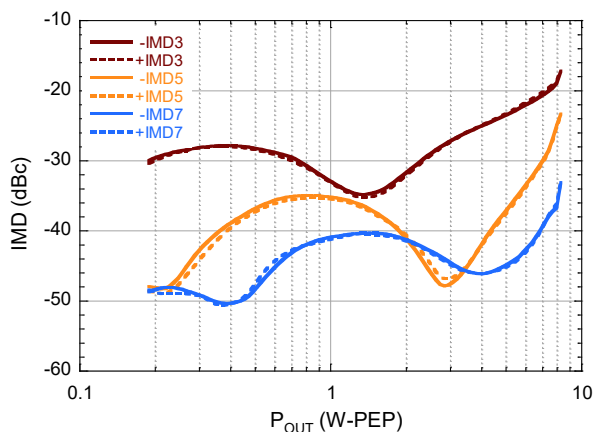
2-Tone IMD3 vs. Output Power vs. Quiescent Current



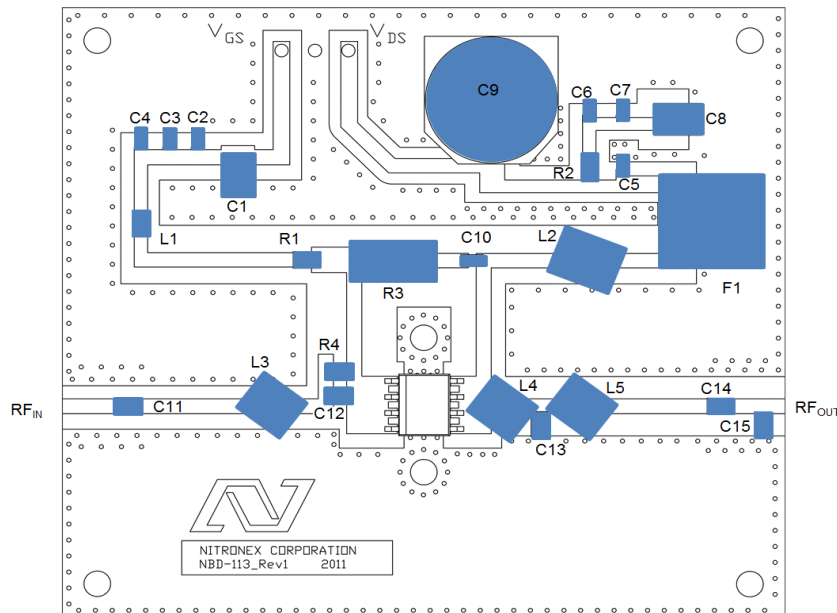
2-Tone Gain vs. Output Power vs. Quiescent Current



2-Tone IMD vs. Output Power



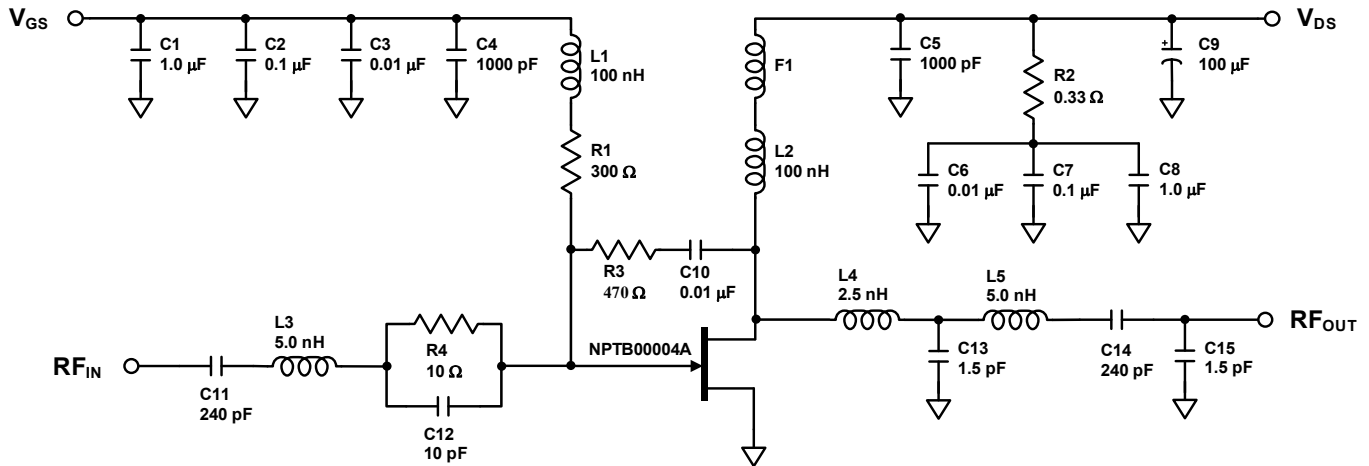
Evaluation Board and Recommended Tuning Solution
100-800 MHz BroadBand Circuit



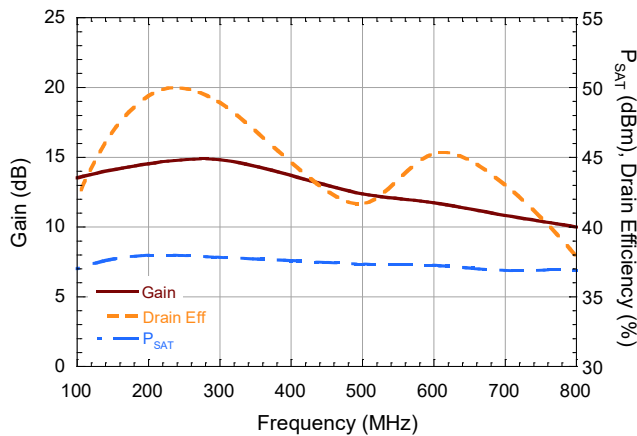
Parts list

| Reference | Value | Tolerance | Manufacturer | Part Number |
|-------------|--|-----------|--------------|--------------------|
| C1, C8 | 1.0 μ F | 10% | AVX | 12101C105KAT2A |
| C2, C7 | 0.1 μ F | 10% | Murata | GRM188R72A104KA35D |
| C3, C6, C10 | 0.01 μ F | 10% | AVX | 06031C103KAT2A |
| C4, C5, | 1000 pF | 10% | AVX | 06031C102KAT2A |
| C9 | 100 μ 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 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, $\epsilon_r=3.5$, 0.020" | | | |

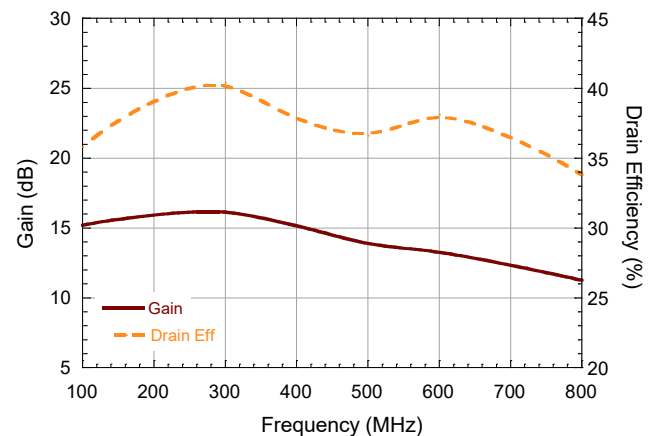
Evaluation Board and Recommended Tuning Solution
100-800 MHz BroadBand Circuit



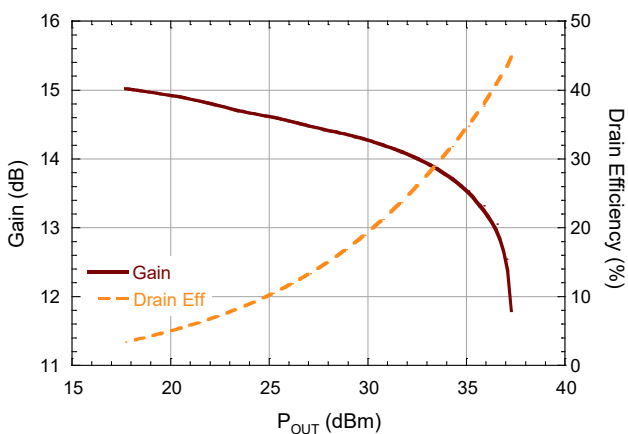
Performance vs. Frequency at $P_{OUT} = P_{SAT}$



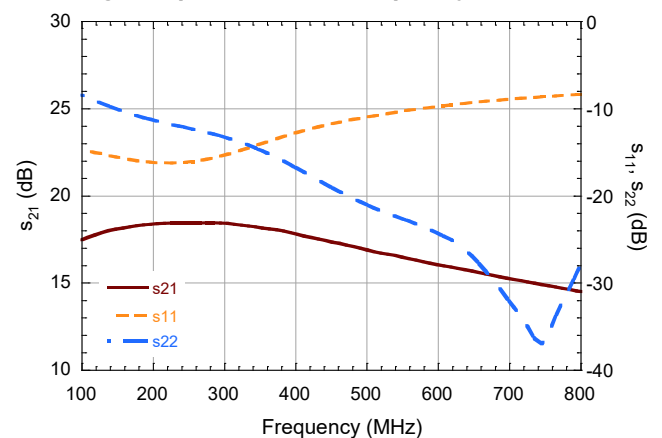
Performance vs. Frequency at $P_{OUT} = 36$ dBm



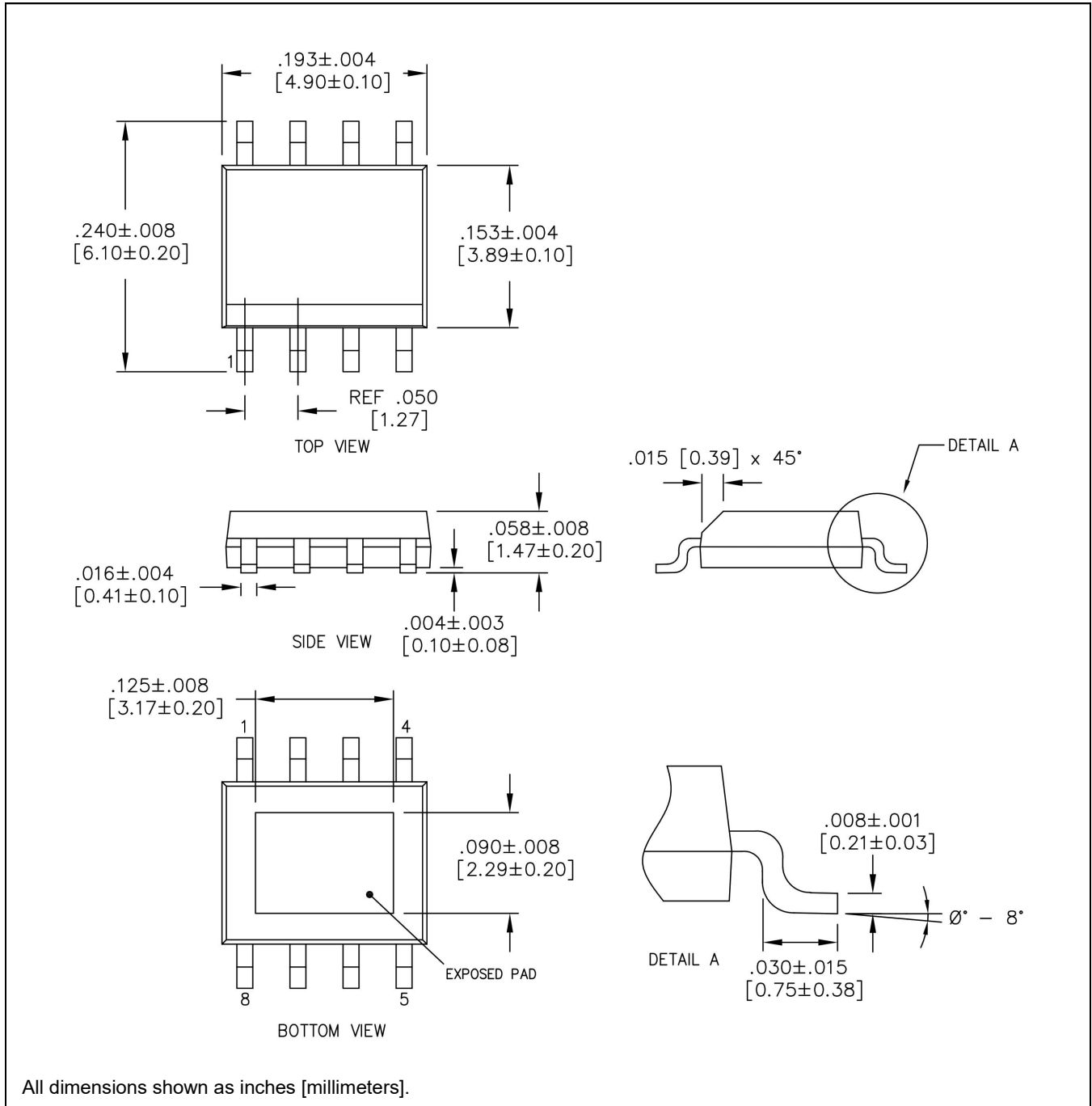
Performance vs. Output Power ($f = 600$ MHz)



Small Signal s-parameters vs Frequency



SOIC 8-Lead Plastic Package[†]



[†] Meets JEDEC moisture sensitivity level 3 requirements.
Plating is Matte Sn.

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