

Features

- GaN on Si HEMT D-Mode Transistor
- Suitable for linear and saturated applications
- Tunable from DC - 2 GHz
- 48 V Operation
- 20 dB Gain @ 900 MHz
- 60 % Drain Efficiency @ 900 MHz
- 100 % RF Tested
- Standard plastic package with bolt down flange
- RoHS* Compliant and 260°C reflow compatible



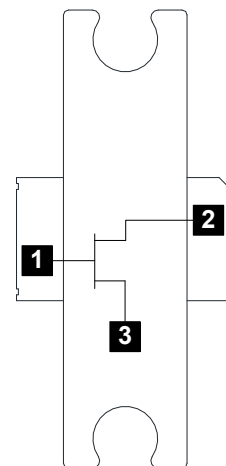
Description

The NPT2022 GaN HEMT is a wideband transistor optimized for DC - 2 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 100 W (50 dBm) in an industry standard plastic package.

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-SMBPPR | Sample Board |

Pin Configuration

| Pin No. | Pin Name | Function |
|---------|------------------------------------|-------------------|
| 1 | RF _{IN} / V _G | RF Input / Gate |
| 2 | RF _{OUT} / V _D | RF Output / Drain |
| 3 | Pad 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.

* Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.

GaN Wideband Transistor 48 V, 100 W DC - 2 GHz

Rev. V1

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 | η_{SAT} | - | 62 | - | % |
| Power Gain | 900 MHz, $P_{OUT} = 100\text{ W}$ | G_P | 19 | 20 | - | dB |
| Drain Efficiency | 900 MHz, $P_{OUT} = 100\text{ W}$ | η | 56 | 58 | - | % |
| Ruggedness: Output Mismatch | All phase angles | Ψ | 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 | - | Ω |
| Maximum Drain Current | $V_{DS} = 7\text{ V}$ pulsed, pulse width 300 μs | $I_{D,MAX}$ | - | 14 | - | A |

Absolute Maximum Ratings^{2,3,4}

| 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 Characteristics⁵

| 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.

GaN Wideband Transistor 48 V, 100 W DC - 2 GHz

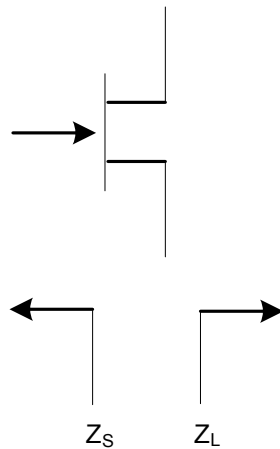
Rev. V1

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

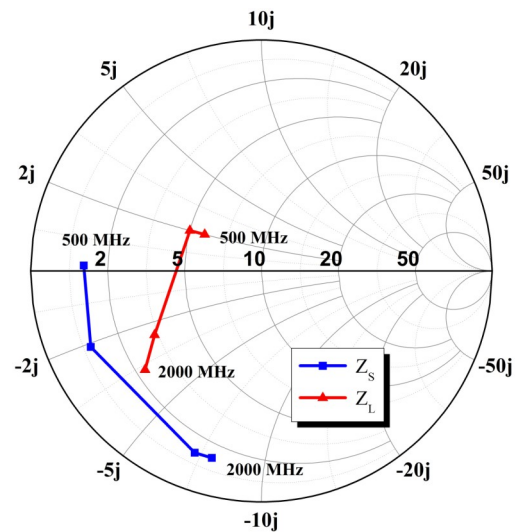
Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance

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

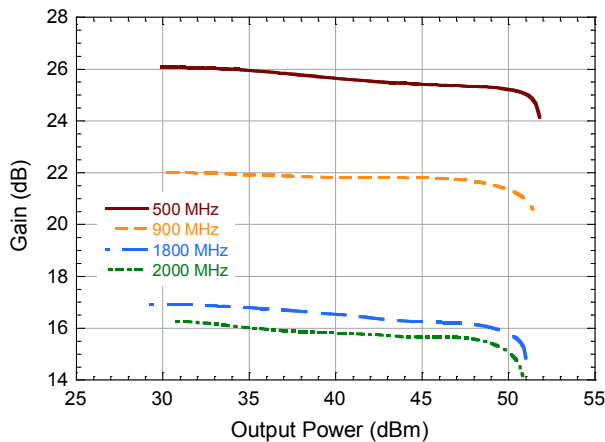
Impedance Reference



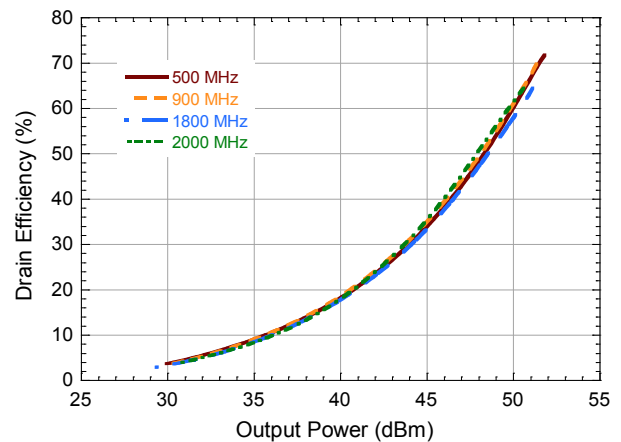
Z_S and Z_L vs. Frequency



Gain vs. Output Power

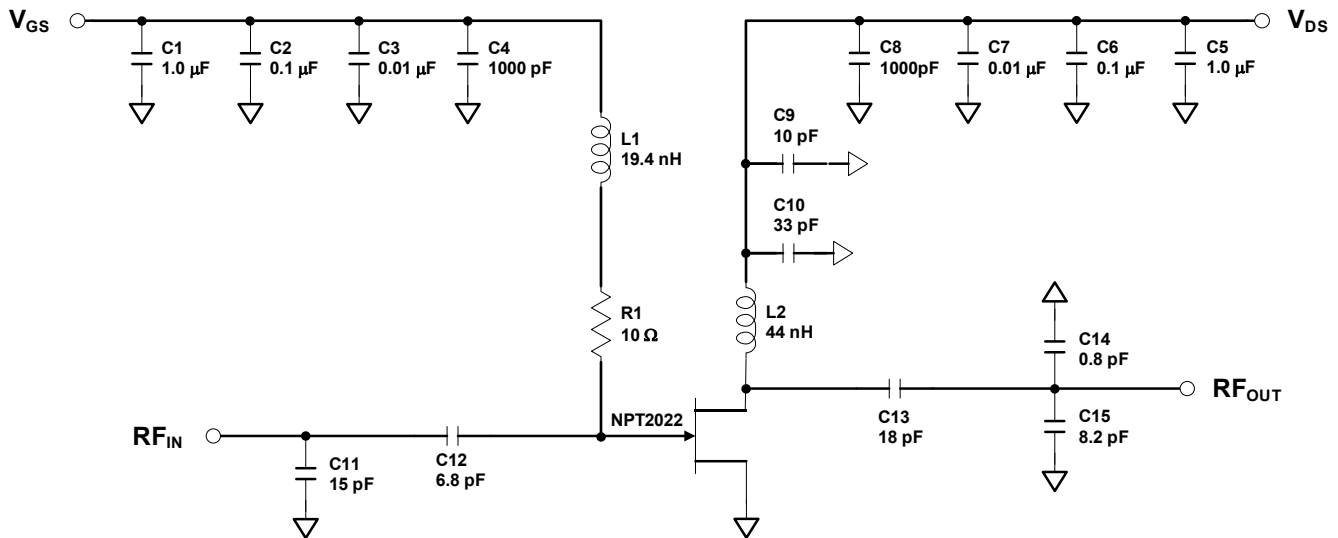


Drain Efficiency vs. Output Power



Evaluation Board and Recommended Tuning Solution

900 MHz Narrowband Circuit



Description

Parts measured on evaluation board (30-mil thick RO4350). 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

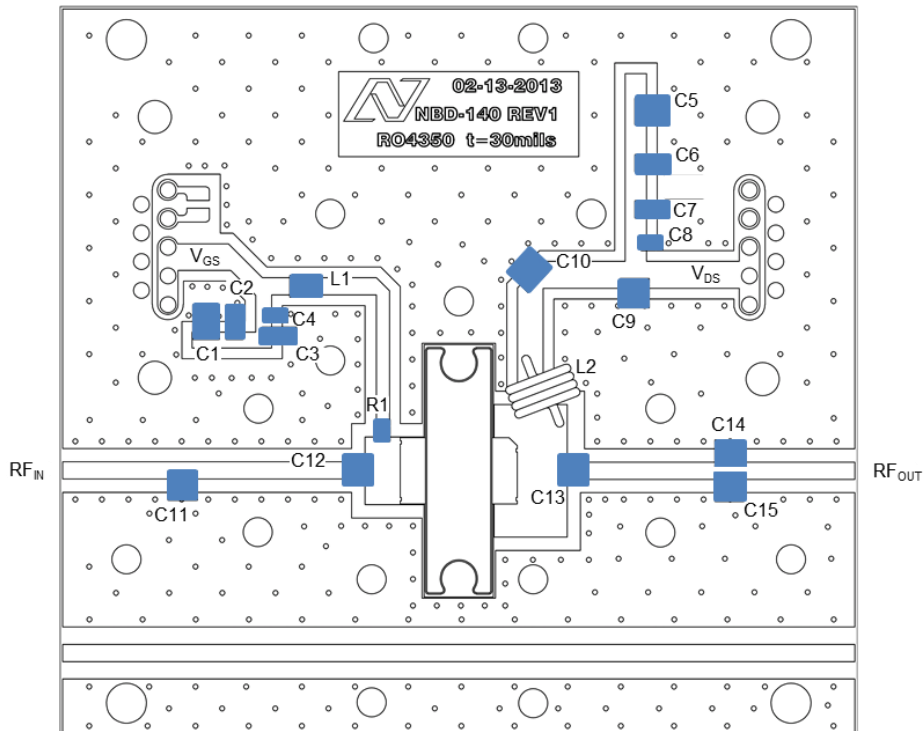
1. Set V_{GS} to the pinch-off (V_P), typically -5 V.
2. Turn on V_{DS} to nominal voltage (48 V).
3. Increase V_{GS} until the I_{DS} current is reached.
4. Apply RF power to desired level.

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

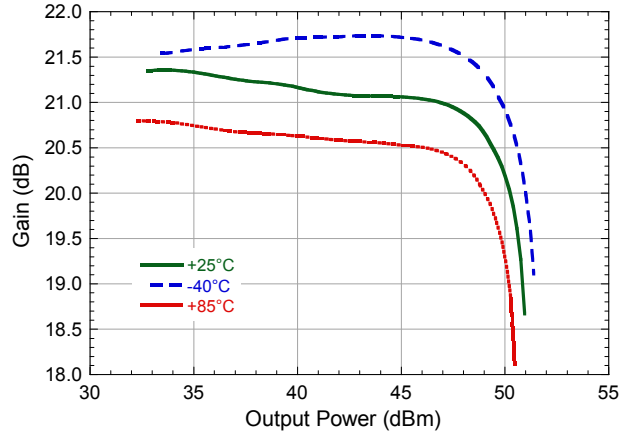
| Reference | Value | Tolerance | Manufacturer | Part Number |
|-----------|--|-----------|----------------|------------------|
| C1, C5 | 1.0 μ F | 10% | AVX | 12101C105KAT2A |
| C2, C6 | 0.1 μ F | 10% | Kemet | C1206C104K1RACTU |
| C3, C7 | 0.01 μ F | 10% | AVX | 12061C103KAT2A |
| C4, C8 | 1000 pF | 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 Ω | 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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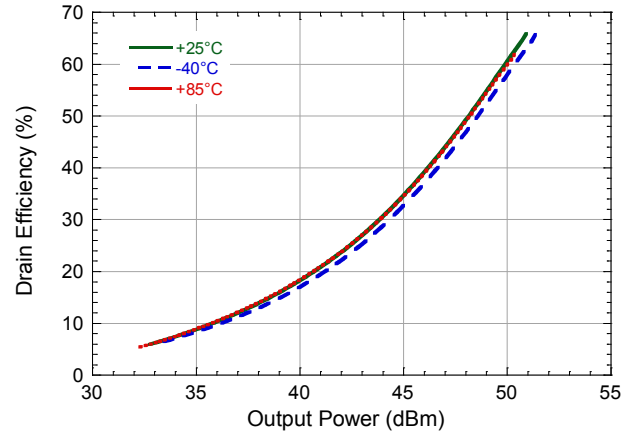
Rev. V1

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

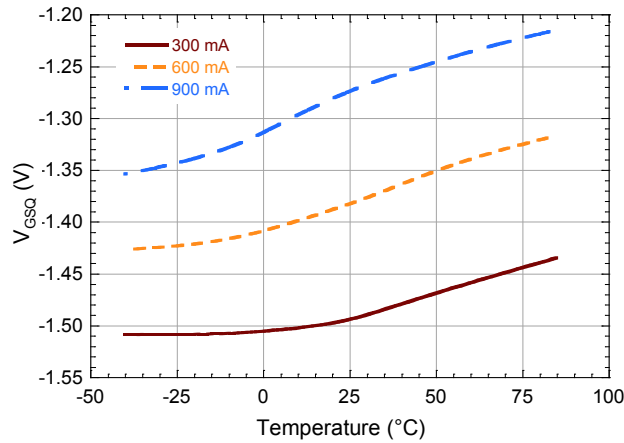
Gain vs. Output Power over Temperature



Drain Efficiency vs. Output Power over Temperature



Quiescent V_{GS} vs. Temperature

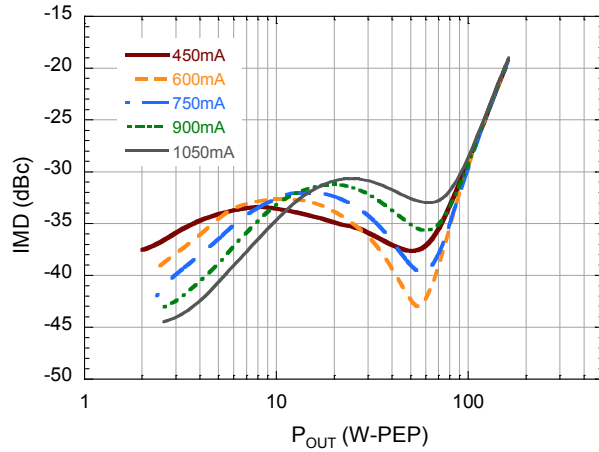


GaN Wideband Transistor 48 V, 100 W DC - 2 GHz

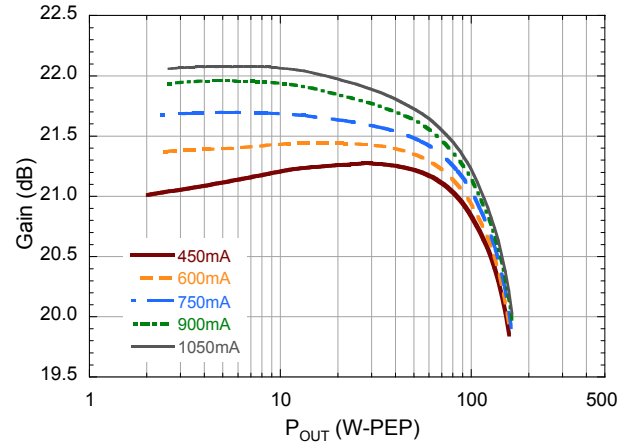
Rev. V1

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)

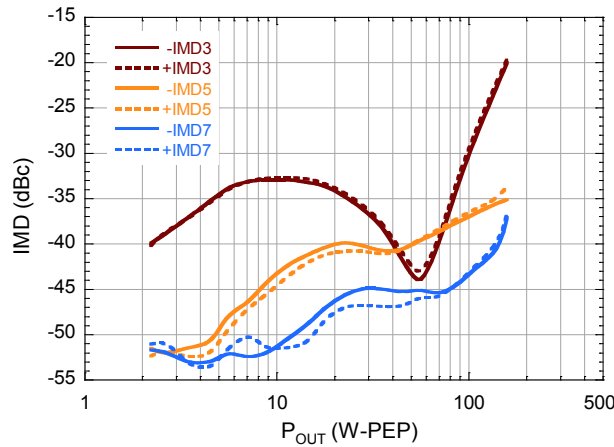
2-Tone IMD3 vs. Output Power vs. Quiescent Current



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

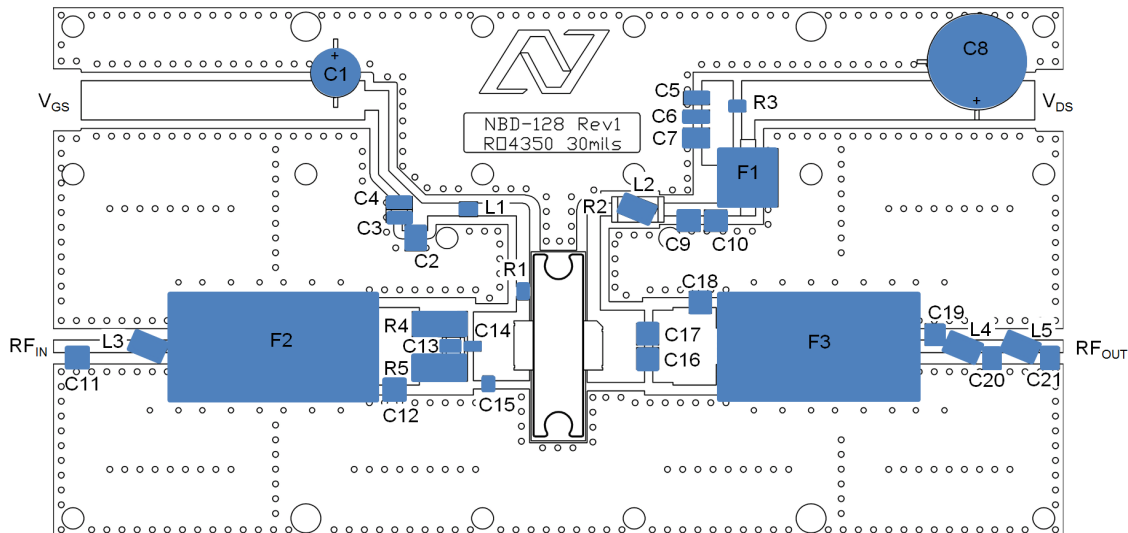


2-Tone IMD vs. Output Power



Evaluation Board and Recommended Tuning Solution

130 - 940 MHz Broadband Circuit



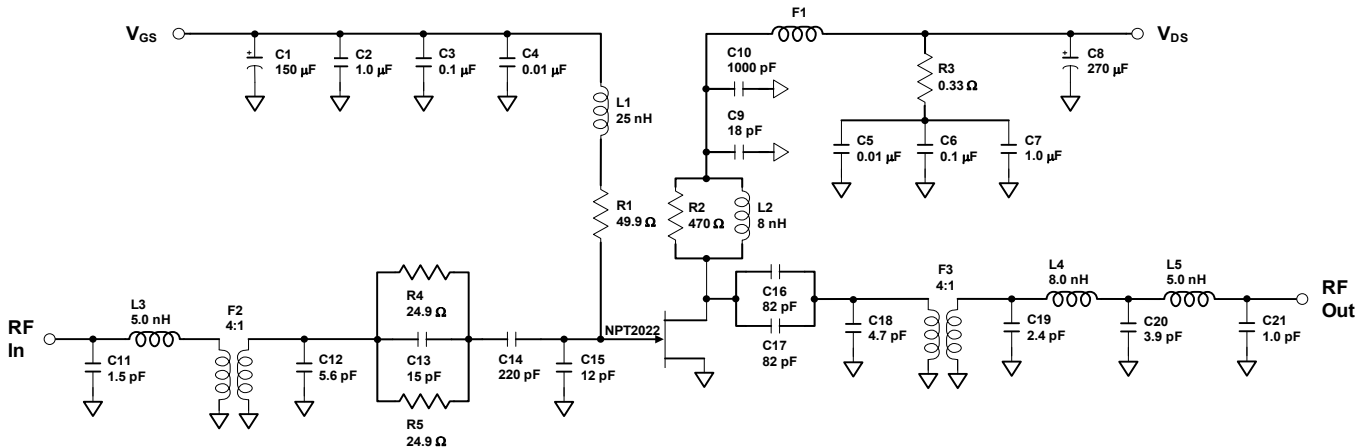
Parts list

| Reference | Value | Tolerance | Manufacturer | Part Number |
|-----------|--|-----------|------------------|---------------------|
| C1 | 150 μ F | 20% | Nichicon | UPW1C151MED |
| C2, C7 | 1.0 μ F | 10% | AVX | 1210C105KAT2A |
| C3, C6 | 0.1 μ F | 10% | Kemet | C1206C104K1RACTU |
| C4, C5 | 0.01 μ F | 10% | AVX | 12061C103KAT2A |
| C8 | 270 μ 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 Ω | 1% | Panasonic | ERJ-6ENF49R9V |
| R2 | 470 Ω | 1% | Panasonic | ERJ-1TNF4700U |
| R3 | 0.33 Ω | 1% | Panasonic | ERJ-6RQFR33V |
| R4, R5 | 24.9 Ω | 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 | | | |

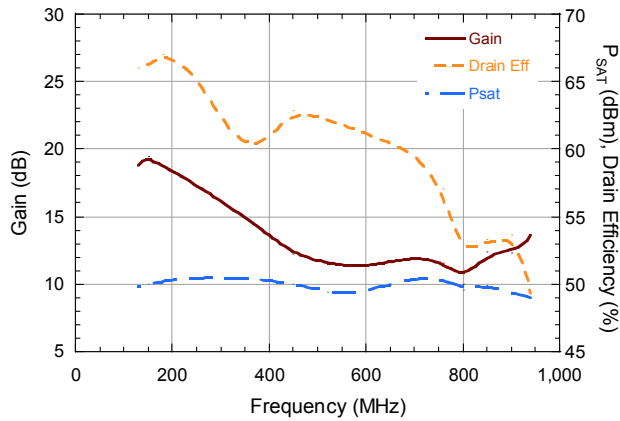
GaN Wideband Transistor 48 V, 100 W DC - 2 GHz

Rev. V1

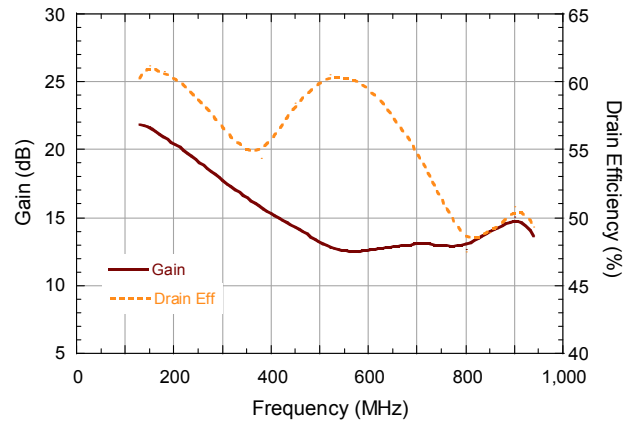
Evaluation Board and Recommended Tuning Solution 130 - 940 MHz Broadband Circuit



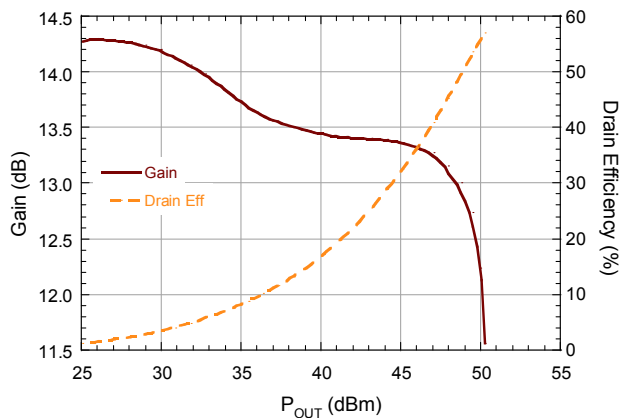
Performance vs. Frequency at $P_{OUT} = P_{SAT}$



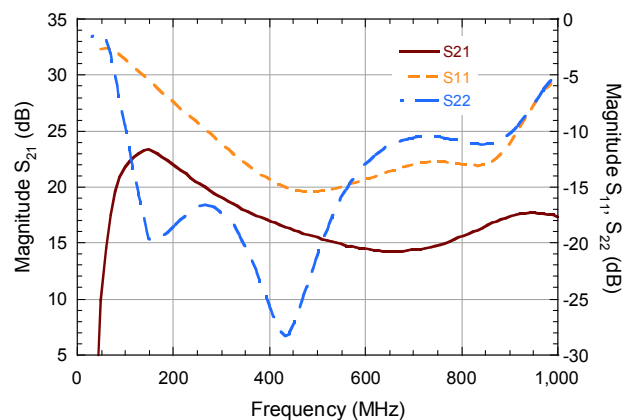
Performance vs. Frequency at $P_{OUT} = 49 \text{ dBm}$



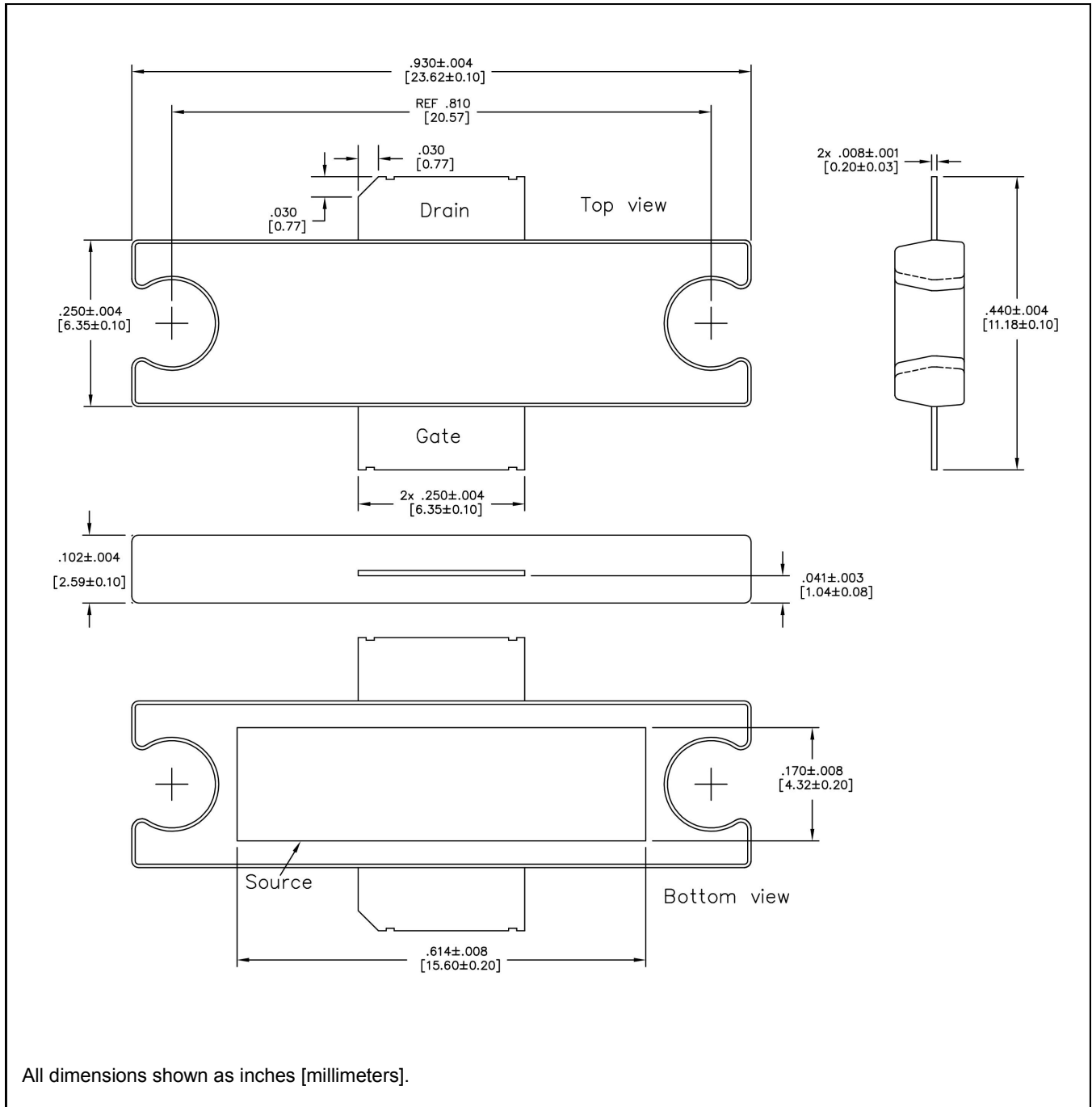
Performance vs. Output Power ($f = 760 \text{ MHz}$)



Small Signal s-parameters vs. Frequency



TO272-2 Plastic Package[†]



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