# NPT2010

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

Rev. V3

### 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

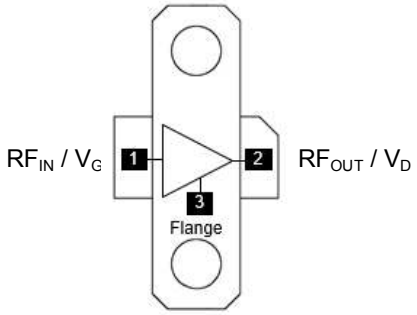
The NPT2010 is a GaN HEMT general purpose amplifier optimized for DC - 2.2 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 100 W (50 dBm) in an industry standard metal-ceramic package with bolt down flange.

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$_{IN}$ / V$_G$ | RF Input / Gate |
| 2 | RF$_{OUT}$ / V$_D$ | RF Output / Drain |
| 3 | Flange[1] | Ground / Source |

1. The Flange 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.

## RF Electrical Specifications: $T_C$ = +25°C, $V_{DS}$ = 48 V, $I_{DQ}$ = 600 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 W | $G_P$ | 13.5 | 15 | - | dB |
| Drain Efficiency | 2.15 GHz, $P_{OUT}$ = 95 W | $\eta$ | 52.5 | 61 | - | % |
| Ruggedness: Output Mismatch | All phase angles | $\Psi$ | VSWR = 10:1, No Device Damage | | | |

## DC Electrical Characteristics: $T_C$ = +25°C

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Drain-Source Leakage Current | $V_{GS}$ = -8 V, $V_{DS}$ = 160 V | $I_{DLK}$ | - | - | 24 | mA |
| Gate-Source Leakage Current | $V_{GS}$ = -8 V, $V_{DS}$ = 0 V | $I_{GLK}$ | - | - | 12 | mA |
| Gate Threshold Voltage | $V_{DS}$ = 48 V, $I_D$ = 24 mA | $V_T$ | -2.5 | -1.5 | -0.5 | V |
| Gate Quiescent Voltage | $V_{DS}$ = 48 V, $I_D$ = 600 mA | $V_{GSQ}$ | -2.1 | -1.2 | -0.3 | V |
| On Resistance | $V_{DS}$ = 2 V, $I_D$ = 180 mA | $R_{ON}$ | - | 0.2 | - | Ω |
| Maximum Drain Current | $V_{DS}$ = 7 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 $T_J \leq 200°C$ will ensure MTTF > 1 x $10^6$ hours.

## Thermal Characteristics[5]

| Parameter | Test Conditions | Symbol | Typical | Units |
|---|---|---|---|---|
| Thermal Resistance | $V_{DS}$ = 48 V, $T_J$ = 200°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

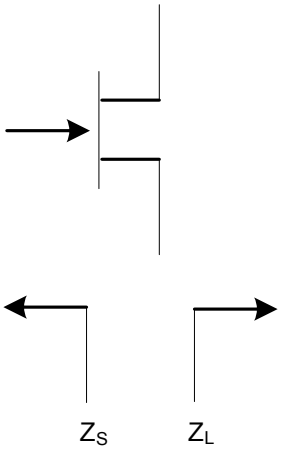
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.

## Load-Pull Performance: $V_{DS}$ = 48 V, $I_{DQ}$ = 600 mA, $T_C$ = 25°C

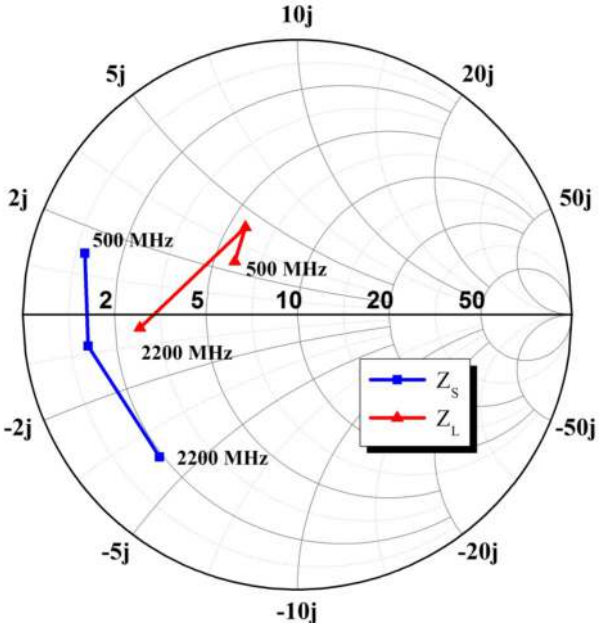
**Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance**

| Frequency (MHz) | $Z_S$ (Ω) | $Z_L$ (Ω) | $P_{SAT}$ (W) | $G_{SS}$ (dB) | Drain Efficiency @ $P_{SAT}$ (%) |
|---|---|---|---|---|---|
| 500 | 1.1 + 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 |

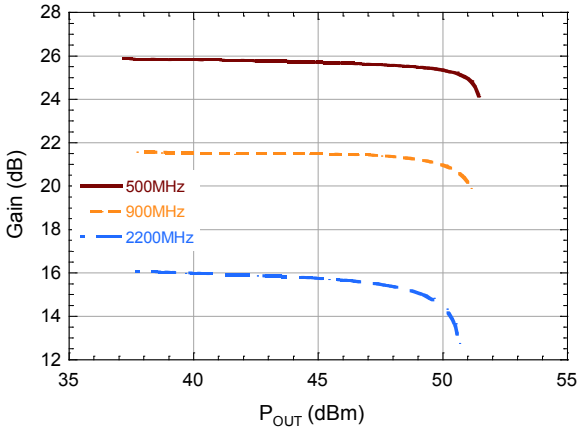
***Impedance Reference***



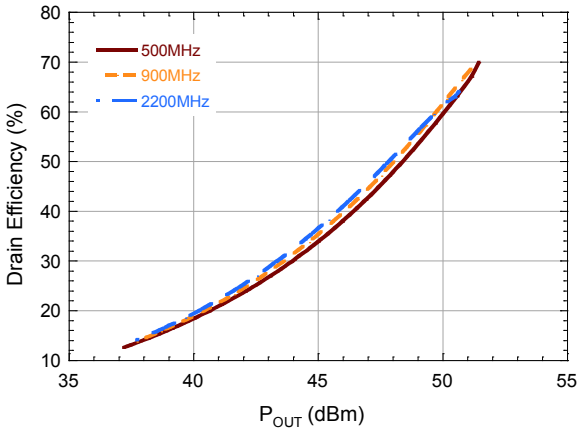

***$Z_S$ and $Z_L$ vs. Frequency***




***Gain vs. Output Power***

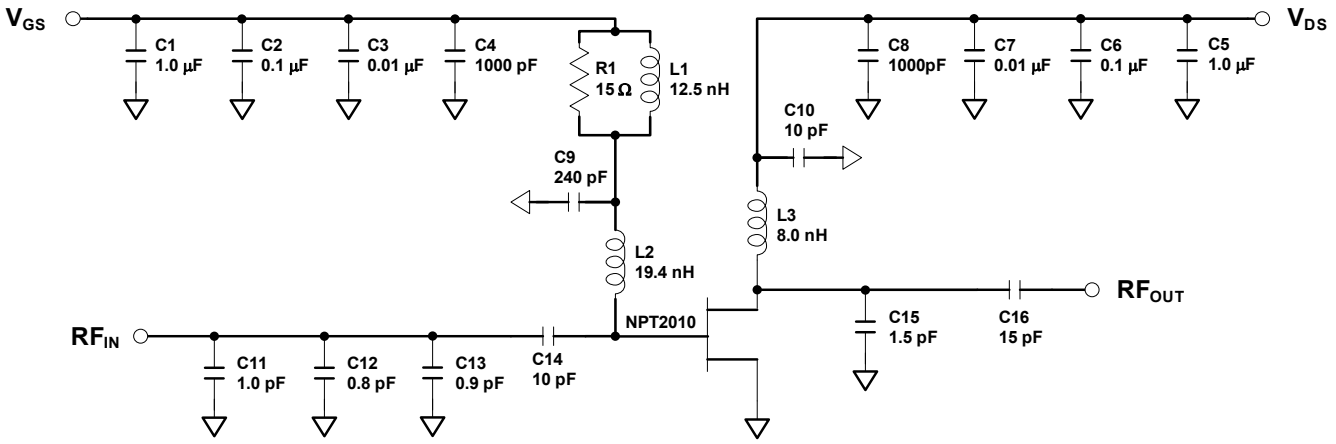



***Drain Efficiency vs. Output Power***



## 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

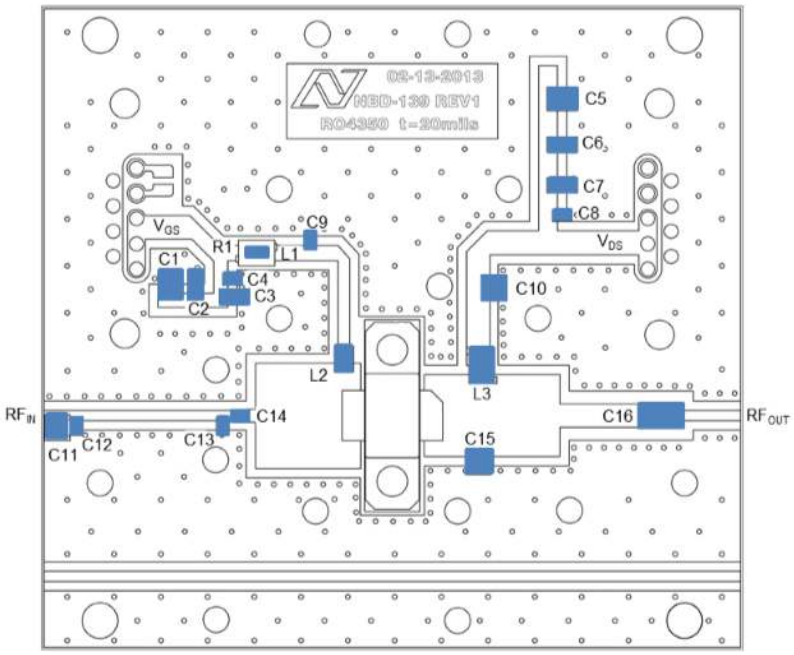
1. Set $V_{GS}$ to the pinch-off ($V_P$), typically -5 V.
2. Turn on $V_{DS}$ to nominal voltage (48 V).
3. Increase $V_{GS}$ until the $I_{DS}$ current is reached.
4. Apply RF power to desired level.

### 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

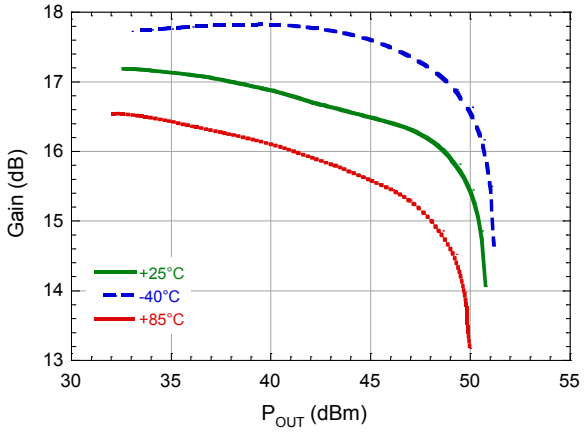



## Parts list

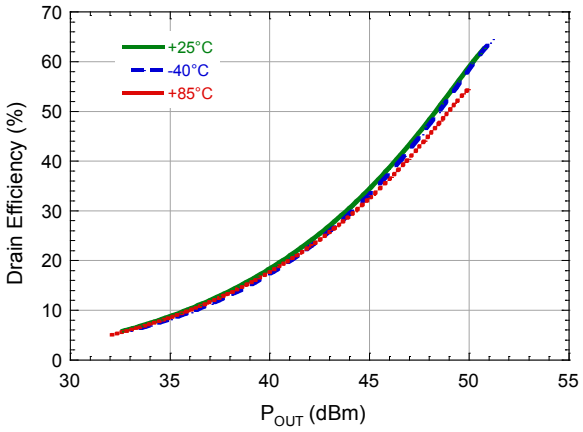
| Reference | Value | Tolerance | Manufacturer | Part Number |
|---|---|---|---|---|
| C1, C5 | 1.0 µF | 10% | AVX | 12101C105KAT2A |
| C2, C6 | 0.1 µF | 10% | Kemet | C1206C104K1RACTU |
| C3, C7 | 0.01 µF | 10% | AVX | 1206C103KAT2A |
| C4, C8 | 1000 pF | 10% | Kemet | C0805C102K1RACTU |
| C9 | 240 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 Ω | 1% | Panasonic | ERJ-2RKF15R0X |
| PCB | Rogers RO4350, $\varepsilon_r$ = 3.5, 20 mil | | | |

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

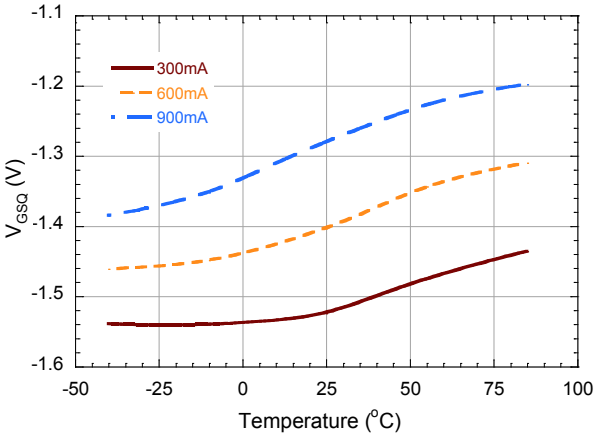
***Gain vs. Output Power over Temperature***




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

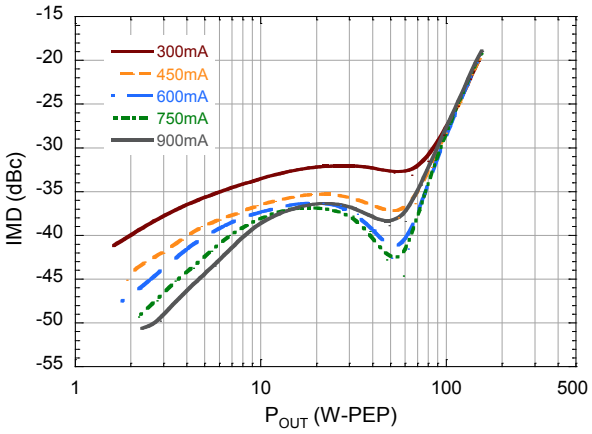



***Quiescent $V_{GS}$ vs. Temperature***

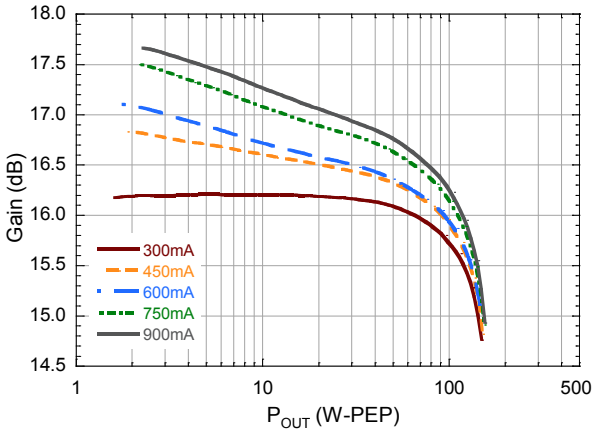


## Typical 2-Tone Performance as measured in the 2.15 GHz evaluation board: 1 MHz Tone Spacing, $V_{DS}$ = 48 V, $I_{DQ}$ = 600 mA, $T_C$ = 25°C (unless noted)

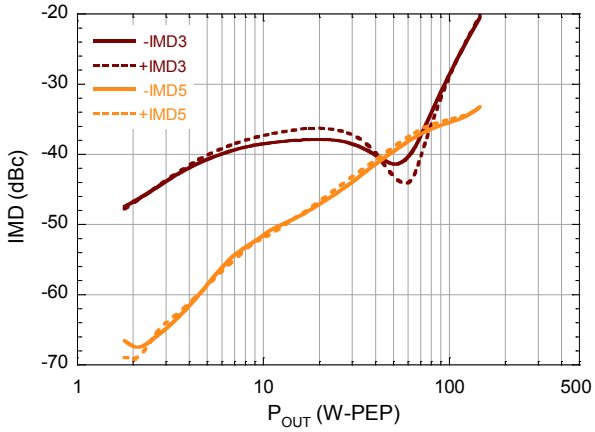
***2-Tone IMD3 vs. Output Power vs. Quiescent Current***




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




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

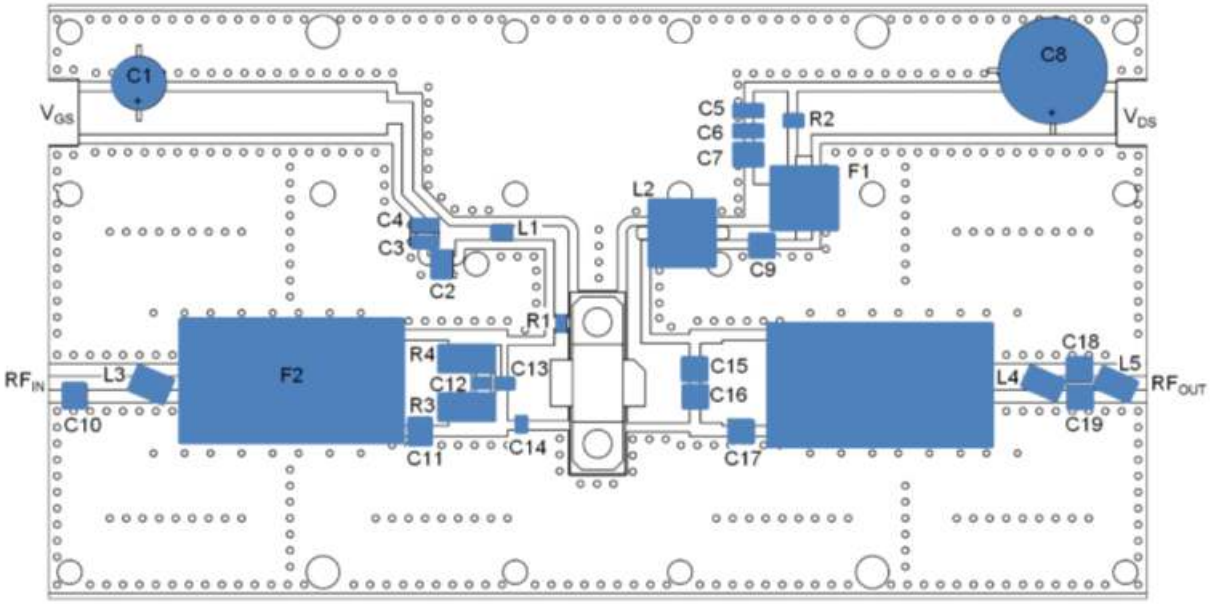


## GaN on Silicon General Purpose Amplifier
## DC - 2.2 GHz, 48 V, 100 W



### Evaluation Board and Recommended Tuning Solution

**100 - 700 MHz Broadband Circuit**




### Parts List

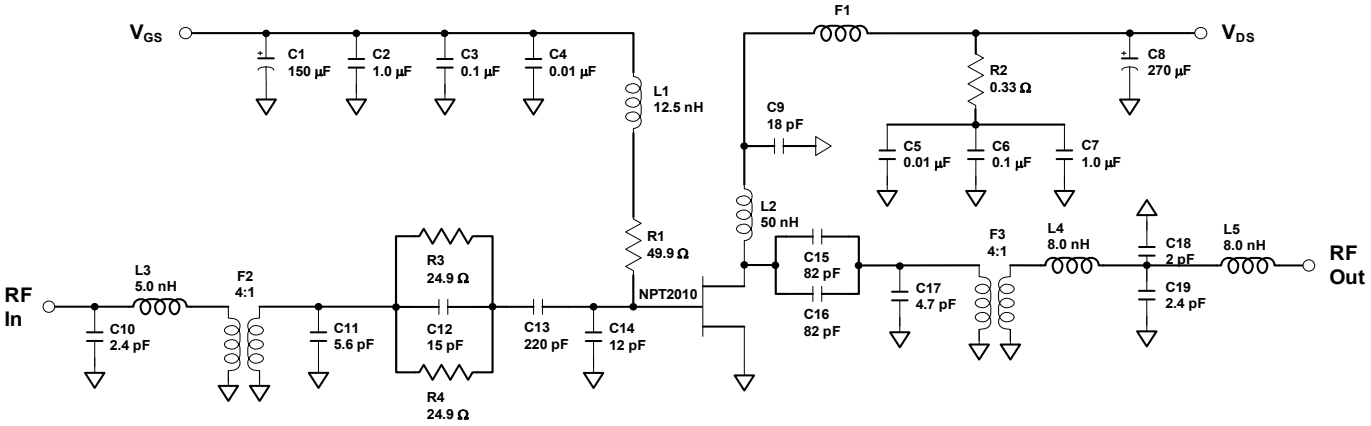
| Reference | Value | Tolerance | Manufacturer | Part Number |
|---|---|---|---|---|
| C1 | 150 µF | 20% | Nichicon | UPW1C151MED |
| C2, C7 | 1.0 µF | 10% | AVX | 12101C105KAT2A |
| C3, C6 | 0.1 µF | 10% | Kemet | C1206C104K1RACTU |
| C4, C5 | 0.01 µF | 10% | AVX | 12061C103KAT2A |
| C8 | 270 µF | 20% | 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 Ω | 1% | Panasonic | ERJ-6ENF49R9V |
| R2 | 0.33 Ω | 1% | Panasonic | ERJ-6RQFR33V |
| R3, R4 | 24.9 Ω | 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, $e_r$=3.5, 20mil | | | |

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

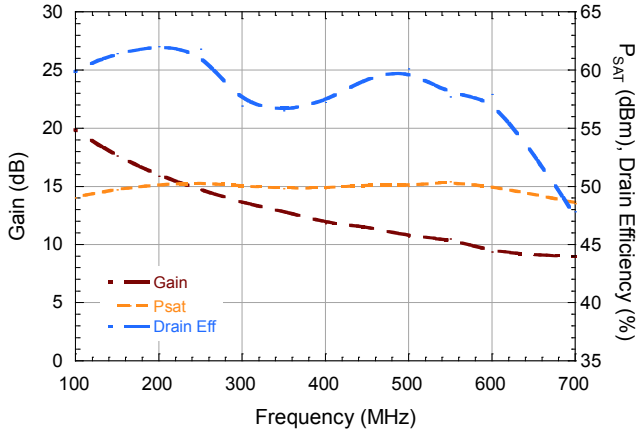


# Evaluation Board and Recommended Tuning Solution

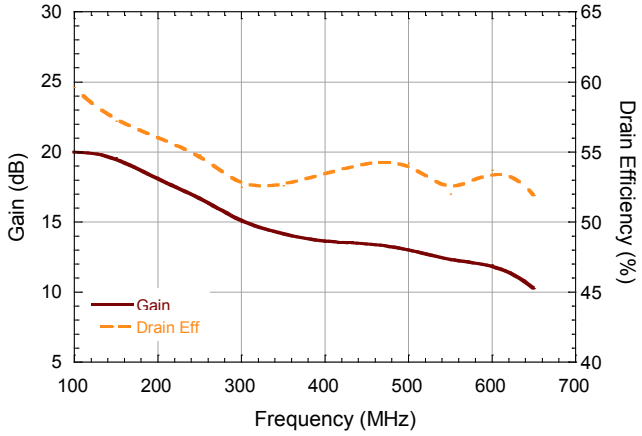
### 100 - 700 MHz Broadband Circuit



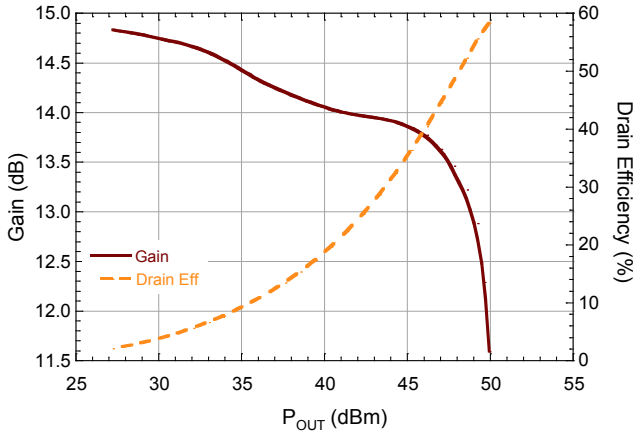

***Performance vs. Frequency at $P_{OUT}$= $P_{SAT}$***



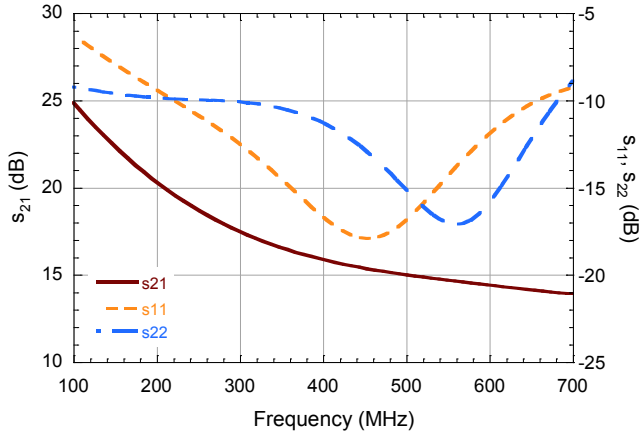

***Performance vs. Frequency at $P_{OUT}$ = 49 dBm***



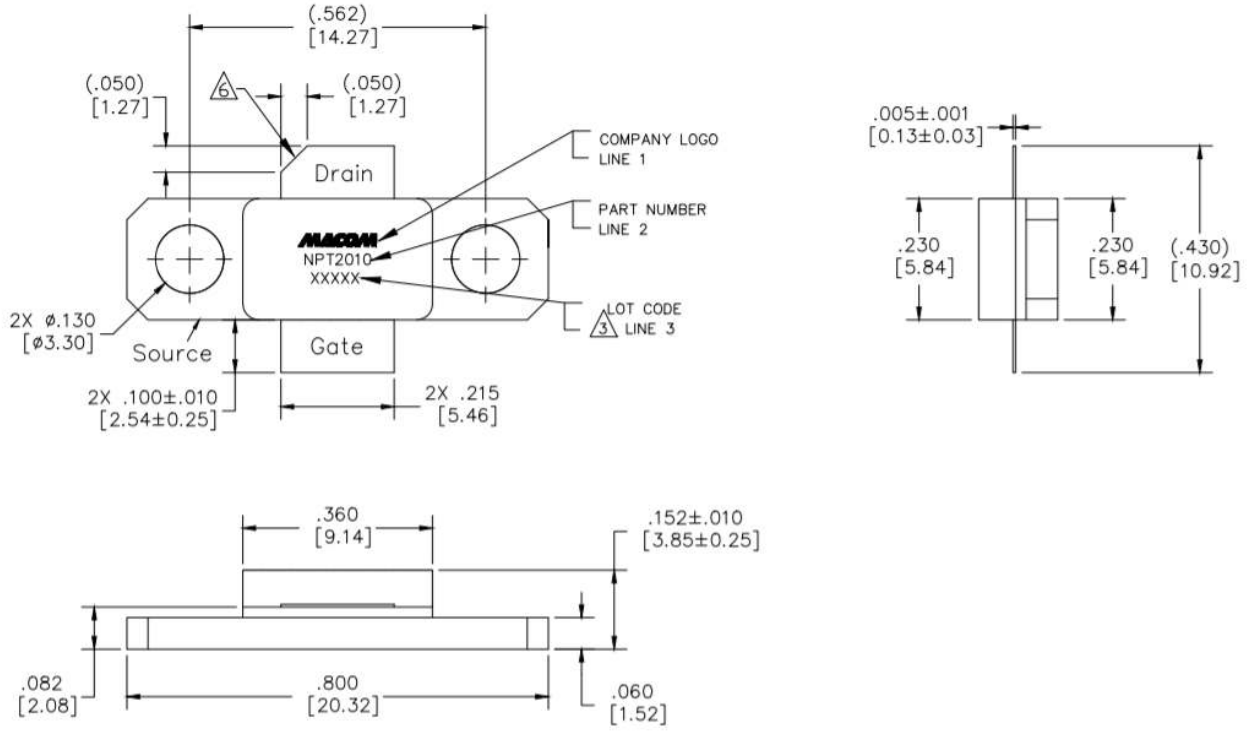

***Performance vs. Output Power (f = 760 MHz)***




***Small Signal s-parameters vs. Frequency***



## AC360B-2 Metal-Ceramic Package




All dimensions shown as inches [millimeters].

† Plating is Ni / Au.