# NPA1003QA

## GaN on Silicon Power Amplifier
## 20 - 1500 MHz, 28 V, 5 W

Rev. V2

### Features

- GaN on Si HEMT D-Mode Amplifier
- Suitable for Linear & Saturated Applications
- Broadband Operation from 20 - 1500 MHz
- 28 V Operation
- 16 dB Gain @ 1 GHz
- 42% PAE @ 1 GHz
- 100% RF Tested
- 50 Ω Input / Output Matched
- Lead-Free 4 mm 16-lead QFN plastic Package
- RoHS* Compliant and 260°C Reflow Compatible

### Description

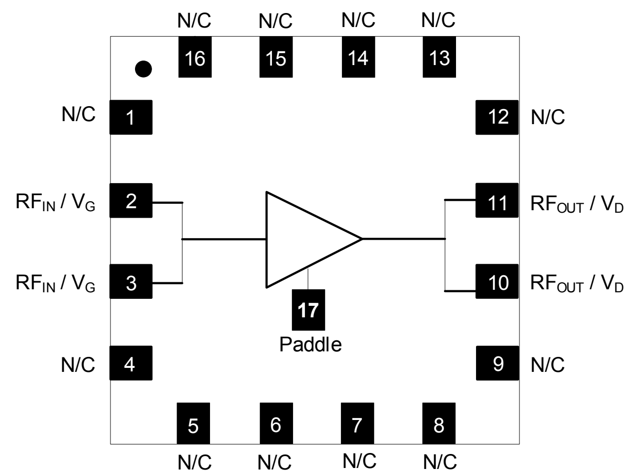
The NPA1003QA is a GaN on silicon power amplifier optimized for 20 - 1500 MHz operation. This amplifier has been designed for saturated and linear operation with output levels to 5 W (37 dBm) assembled in a lead-free 4 mm 16-lead QFN plastic package.

The NPA1003QA is ideally suited for broadband general purpose, test and measurement, defense communications, land mobile radio and wireless infrastructure.

### Ordering Information

| Part Number | Package |
|---|---|
| NPA1003QA | Bulk |
| NPA1003QA-SMBPPR | sample |

### Functional Schematic




### Pin Designations[1,2]

| Pin # | Pin Name | Function |
|---|---|---|
| 1 | N/C | No Connection |
| 2, 3 | $RF_{IN}$ / $V_G$ | RF Input / Gate Voltage |
| 4 - 9 | N/C | No Connection |
| 10, 11 | $RF_{OUT}$ / $V_D$ | RF Output / Drain Voltage |
| 12 - 16 | N/C | No Connection |
| 17 | Paddle[2] | Ground |

1. All no connection pins may be left floating or grounded.
2. 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, compliant to current RoHS EU directive.

## RF Electrical Specifications: $T_C$ = +25°C , $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Small Signal Gain | CW, 1000 MHz | $G_{SS}$ | — | 18 | — | dB |
| Saturated Output Power | CW, 1000 MHz | $P_{SAT}$ | — | 38.5 | — | dBm |
| Drain Efficiency at Saturation | CW, 1000 MHz | $\eta_{SAT}$ | — | 50 | — | % |
| Noise Figure | CW, 1000 MHz | NF | — | 2.0 | — | dB |
| Power Gain | CW, 1000 MHz, $P_{OUT}$ = 5 W | $G_P$ | 14 | 16 | — | % |
| Power Added Efficiency | CW, 1000 MHz, $P_{OUT}$ = 5 W | PAE | 38 | 42 | — | % |
| Ruggedness | All phase angles | $\Psi$ | VSWR=10:1, No Device Damage | | | |

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

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Drain-Source Leakage Current | $V_{GS}$ = -8 V, $V_{DS}$ = 100 V | $I_{DLK}$ | — | — | 2 | mA |
| Gate-Source Leakage Current | $V_{GS}$ = -8 V, $V_{DS}$ = 0 V | $I_{GLK}$ | — | — | 1 | mA |
| Gate Threshold Voltage | $V_{DS}$ = 28 V, $I_D$ = 2 mA | $V_T$ | -2.5 | -1.5 | -0.5 | V |
| Gate Quiescent Voltage | $V_{DS}$ = 28 V, $I_D$ = 88 mA | $V_{GSQ}$ | -2.1 | -1.2 | -0.3 | V |
| On Resistance | $V_{DS}$ = 2 V, $I_D$ = 15 mA | $R_{ON}$ | — | 1.6 | — | Ω |
| Maximum Drain Current | $V_{DS}$ = 7 V pulsed, pulse width 300 μs | $I_{D,\ MAX.}$ | — | 1.5 | — | A |

## Absolute Maximum Ratings[3,4,5]

| 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 |

3. Exceeding any one or combination of these limits may cause permanent damage to this device.
4. MACOM does not recommend sustained operation near these survivability limits.
5. Operating at nominal conditions with $T_J \leq 180°C$ will ensure MTTF > $1 \times 10^6$ hours.

## Thermal Characteristics[6]

| Parameter | Test Conditions | Symbol | Typical | Units |
|---|---|---|---|---|
| Thermal Resistance | $V_{DS}$ = 28 V, $T_J$ = 180 °C | $R_{\theta JC}$ | 12 | °C/W |

6. Junction temperature ($T_J$) measured using IR Microscopy. Case temperature measured using thermocouple embedded in heat-sink.

## Handling Procedures

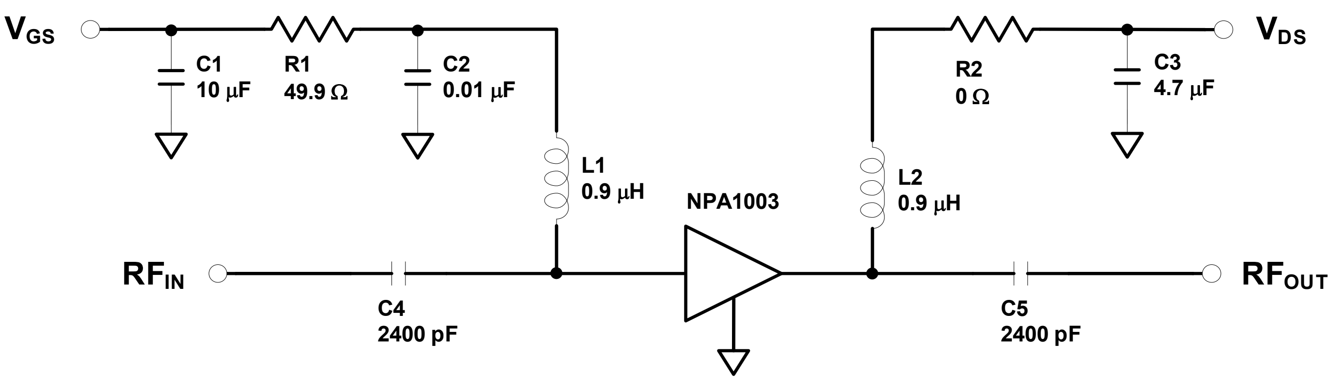
Please observe the following precautions to avoid damage:

## 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.

## Evaluation Board and Recommended Tuning Solution

**20 - 1500 MHz Broadband 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

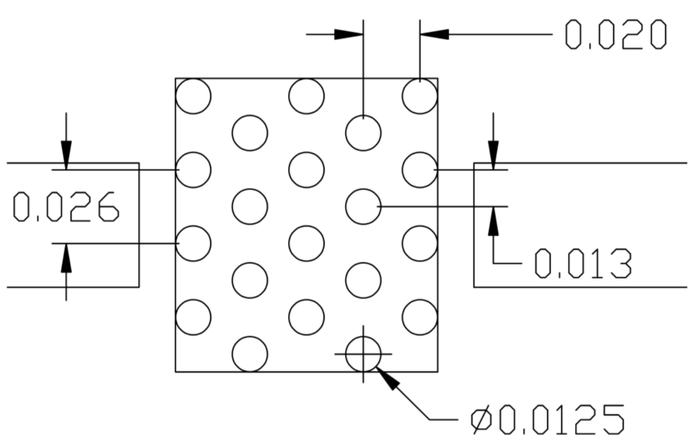
### Turning the device ON

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

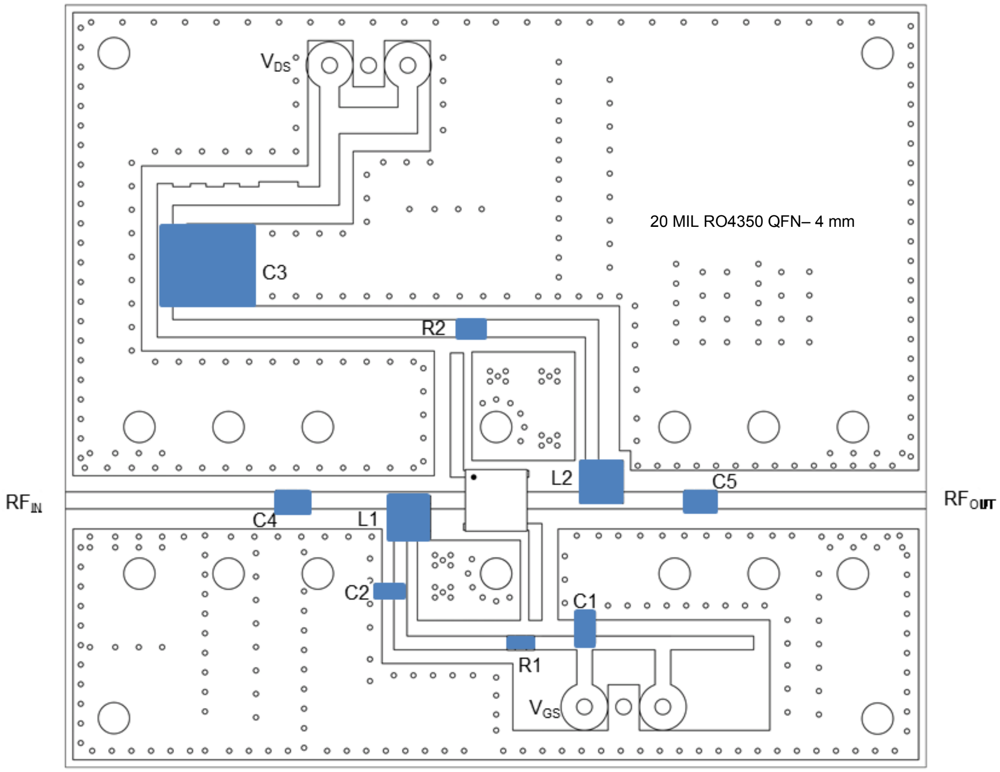
1. Turn the RF power off.
2. Decrease $V_{GS}$ down to $V_P$.
3. Decrease $V_{DS}$ down to 0 V.

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



## Evaluation Board and Recommended Tuning Solution

### 20 - 1500 MHz Broadband Circuit

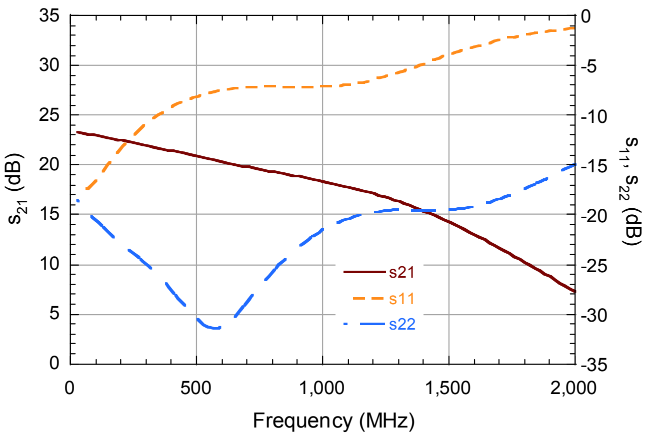



## Parts list

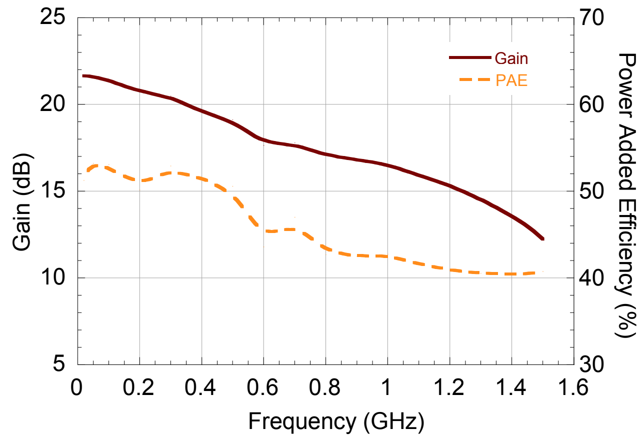
| Reference | Value | Tolerance | Manufacturer | Part Number |
|---|---|---|---|---|
| C1 | 10 µF | 20% | TDK | C2012X5R1C106M085AC |
| C2 | 0.01 µF | 5% | AVX | 06031C103JAT2A |
| C3 | 4.7 µF | 10% | TDK | C5750X7R2A475K230KA |
| C4, C5 | 2400 pF | - | Dielectric Labs, Inc. | C08BL242X-5UN-X0 |
| R1 | 49.9 Ω | 1% | Panasonic | ERJ-6ENF49R9V |
| R2 | 0 Ω | - | Panasonic | ERJ-3GEY0R00V |
| L1, L2 | 0.9 µH | 10% | Coilcraft | 1008AF-901XJLC |
| PCB | Rogers RO4350, $\varepsilon_r$ = 3.5, 0.020” | | | |

### Typical Performance as measured in the broadband evaluation board:
### CW, $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA (unless noted)

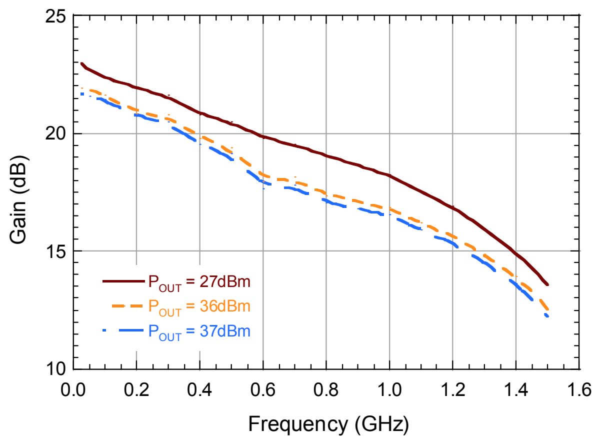
***Small Signal s-Parameters vs. Frequency***



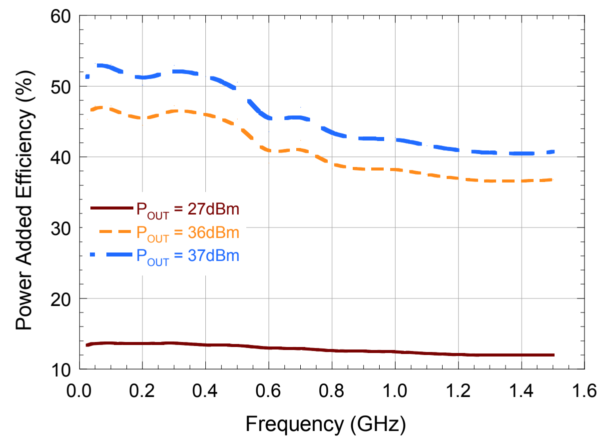

***Performance vs. Frequency at $P_{OUT}$ = 37 dBm***



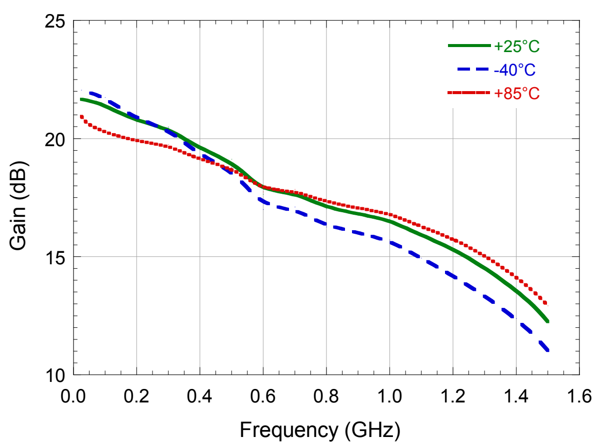

***Gain vs. Frequency***



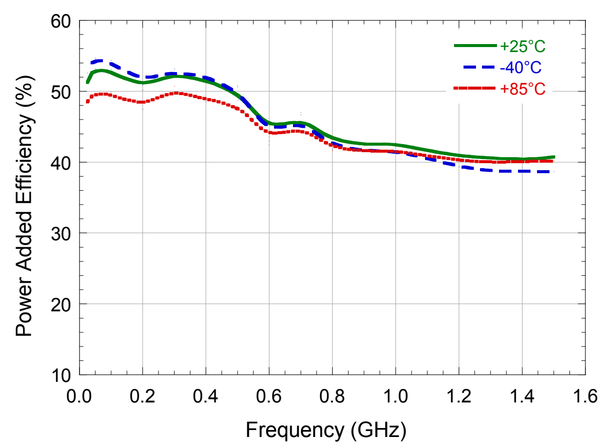

***Power Added Efficiency vs. Frequency***




***Gain vs. Frequency at $P_{OUT}$ = 37 dBm***

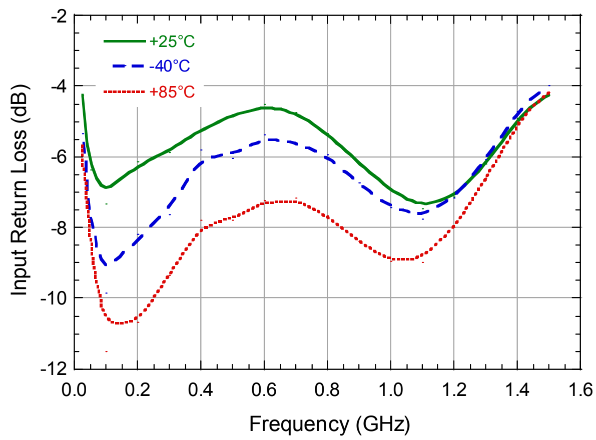



***Power Added Efficiency vs. Frequency at $P_{OUT}$ = 37 dBm***

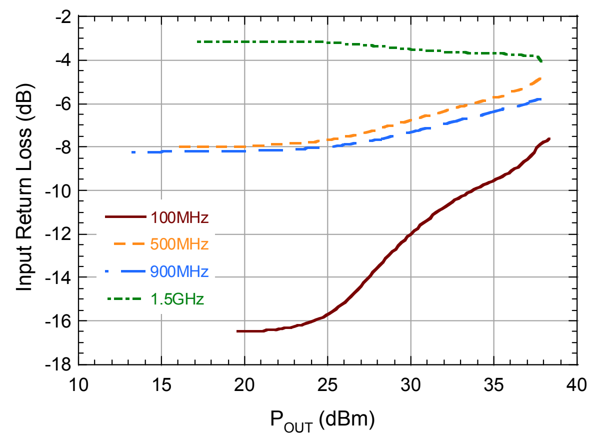


**Typical Performance as measured in the broadband evaluation board:**
**CW, $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA (unless noted)**

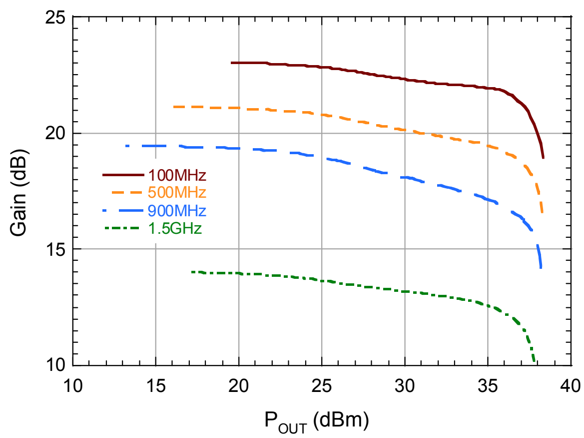
***Input Return Loss vs. Frequency at $P_{OUT}$ = 37 dBm***



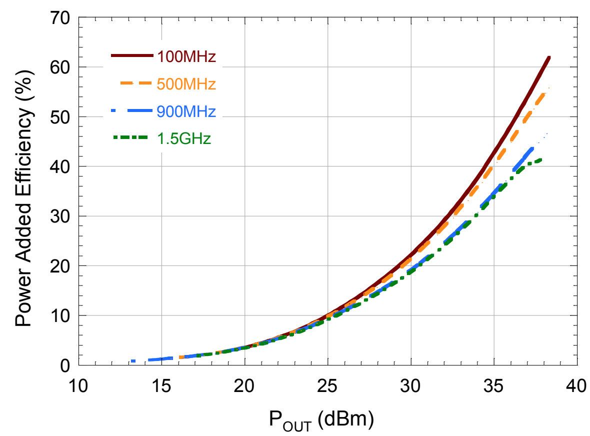

***Input Return Loss vs. Output Power***




***Gain vs. Output Power***

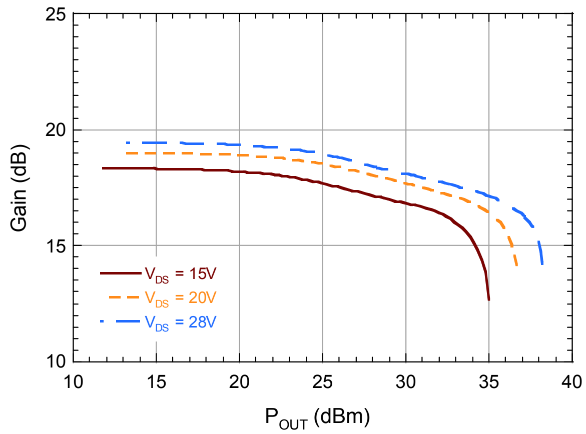



***Power Added Efficiency vs. Output Power***

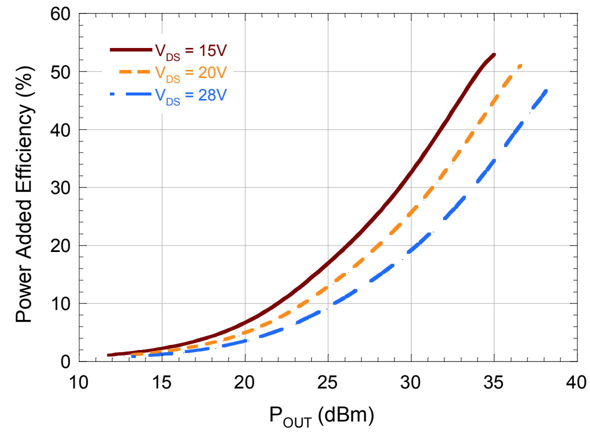


### Typical Performance as measured in the broadband evaluation board: CW, $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA (unless noted)

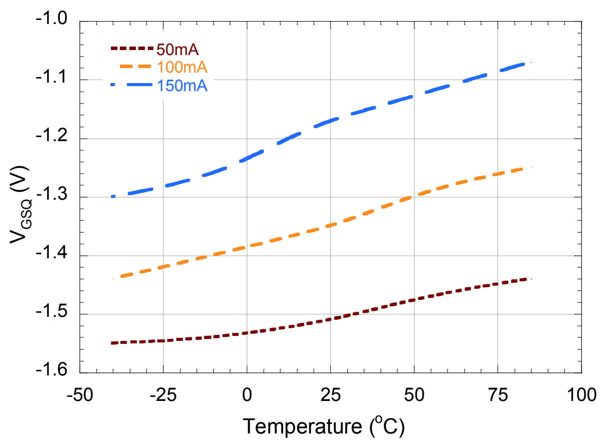
***Gain vs. Output Power at freq = 900 MHz***




***Power Added Efficiency vs. Output Power at freq = 900 MHz***

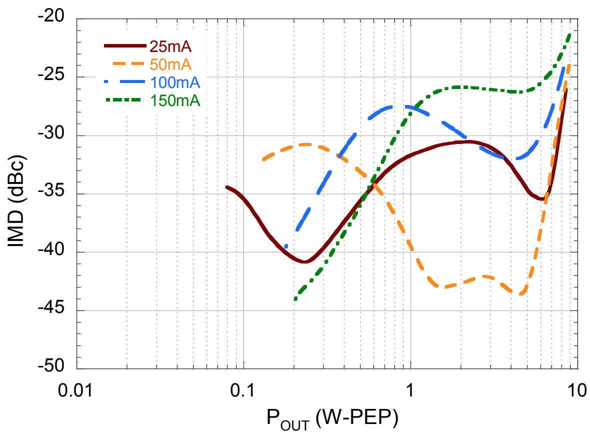



***Quiescent $V_{GS}$ vs. Temperature***

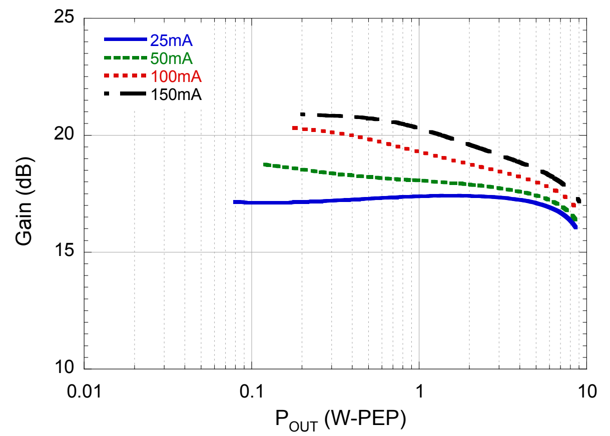


## Typical 2-Tone Performance as measured in the broadband evaluation board: 1 MHz Tone Spacing, f = 500 MHz, $V_{DS}$ = 28 V, $I_{DQ}$ = 100 mA (unless noted)

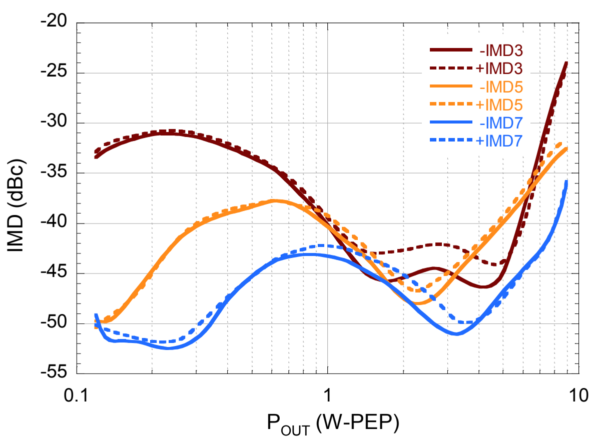
***2-Tone IMD3 vs. Output Power vs. Quiescent Current***



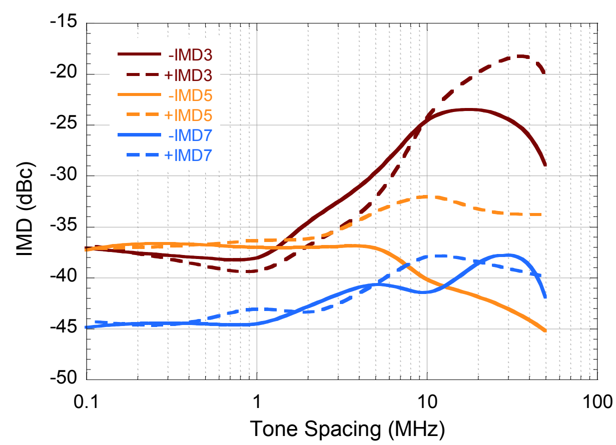

***2-Tone Gain vs. Output Power vs. Quiescent Current***



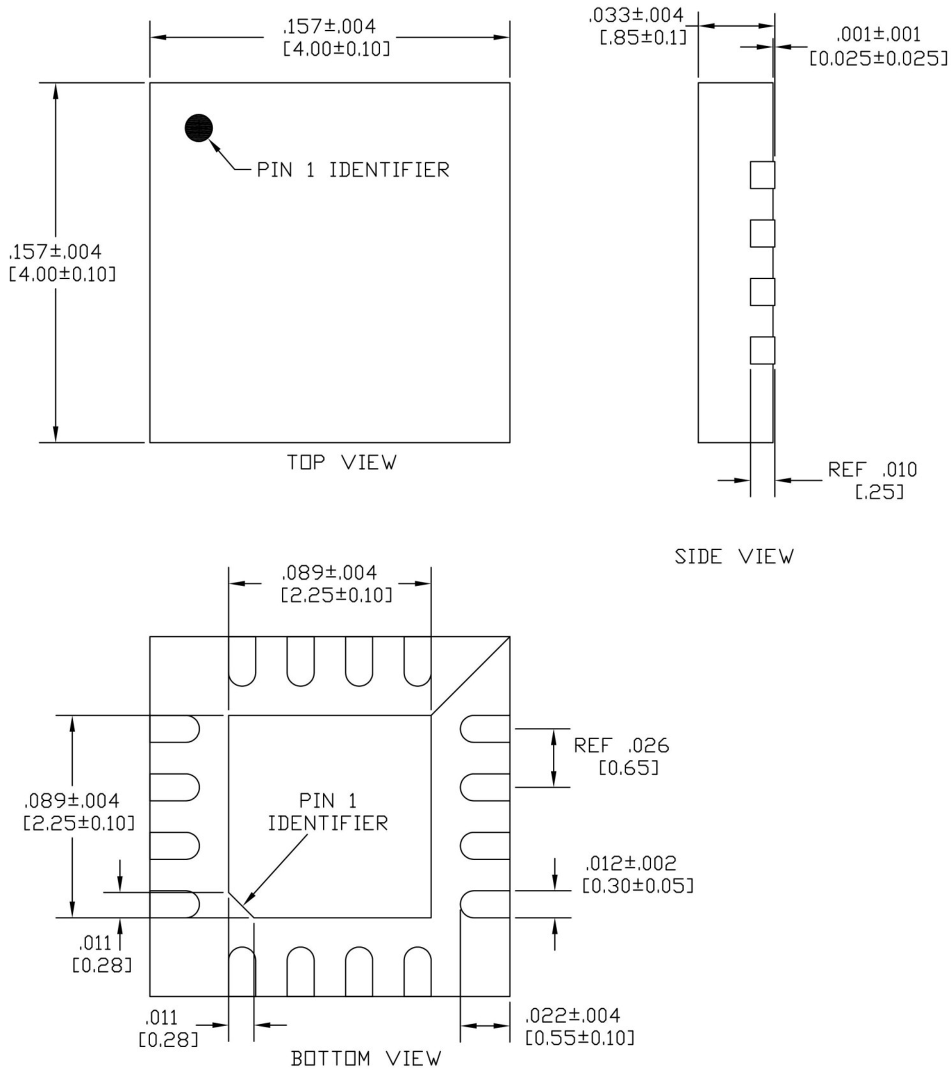

***2-Tone IMD vs. Output Power***




***2-Tone IMD vs. Tone Spacing at $P_{OUT}$ = 6 W-PEP, $I_{DQ}$=6 mA***



## *Lead-Free 4 mm QFN 16-lead plastic package*




All dimensions shown as inches [mm].

† Meets JEDEC moisture sensitivity level 3 requirements.
Plating is 100% matte tin over copper.