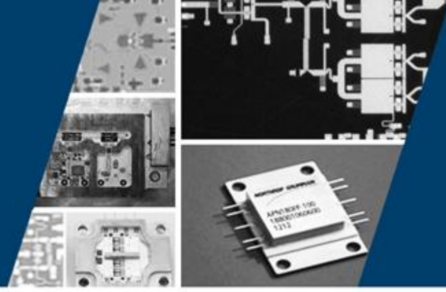
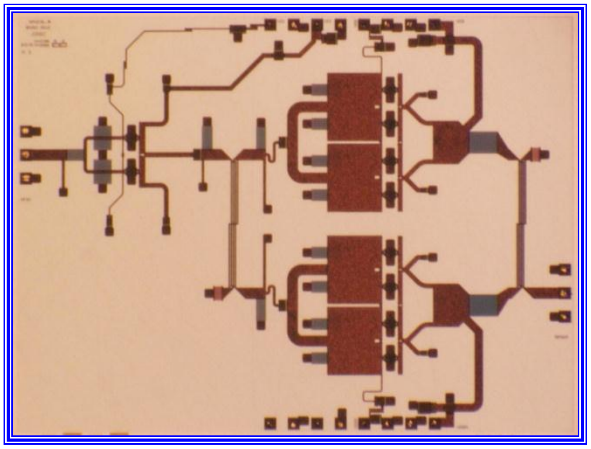
# APN180
## 27-31 GHz
## GaN Power Amplifier



NORTHROP GRUMMAN

Preliminary Datasheet

Revision: May 2014



X = 4.8mm Y = 3.6mm

## Applications

- Point-to-Point Digital Radios
- Point-to-Multipoint Digital Radios
- SATCOM Terminals

## Product Description

The APN180 monolithic GaN HEMT amplifier is a broadband, two-stage power device, designed for use in SATCOM Terminals and point-to-point digital radios. To ensure rugged and reliable operation, HEMT devices are fully passivated. Both bond pad and backside metallization are Au-based that is compatible with epoxy and eutectic die attach methods.

### Product Features

- RF frequency:  27 to 31 GHz
- Linear Gain: 21 dB typ.
- Psat: 39 dBm typ.
- Die Size: < 17.3 sq. mm.
- 0.2um GaN HEMT Process
- 4 mil SiC substrate
- DC Power: 28 VDC @ 720 mA

Performance Characteristics (Ta = 25°C)

| Specification | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Frequency | 27 | | 31 | GHz |
| Linear Gain | 18 | 22 | | dB |
| Input Return Loss | 4 | 8 | | dB |
| Output Return Loss | 6 | 15 | | dB |
| P1db | | 37 | | dBm |
| Psat | 38 | 39 | | dBm |
| PAE @ Psat | | 28 | | % |
| Vd1, Vd2=Vd2a | | 28 | | V |
| Vg1 | | -3.5 | | V |
| Vg2, Vg2a | | -3.5 | | V |
| Id1 | | 144 | | mA |
| Id2+Id2a | | 576 | | mA |

Absolute Maximum Ratings (Ta = 25°C)

| Parameter | Min | Max | Unit |
|---|---|---|---|
| Vd1, Vd2+Vd2a | 20 | 28 | V |
| Id1 | | 144 | mA |
| Id2+Id2a | | 576 | mA |
| Vg1, Vg2, Vg2a | -5 | 0 | V |
| Input drive level | | TBD | dBm |
| Assy. Temperature (TBD seconds) | | 300 | deg. C |



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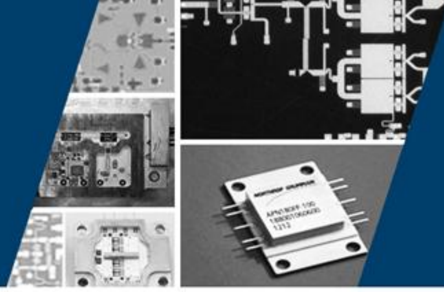
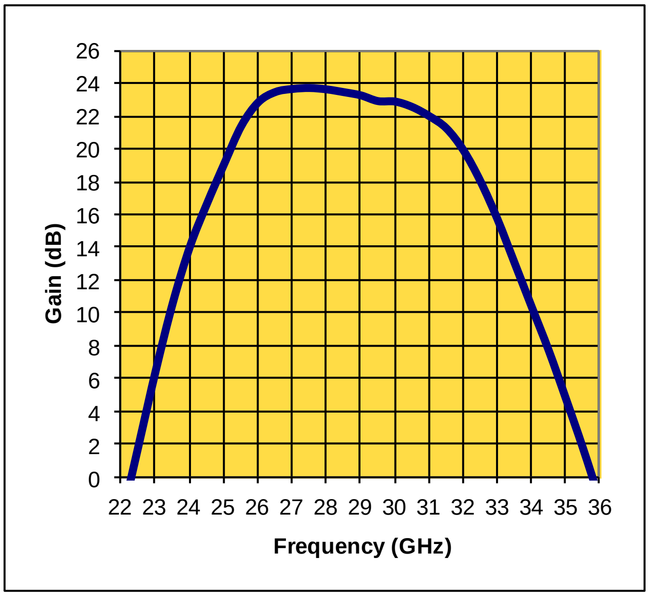


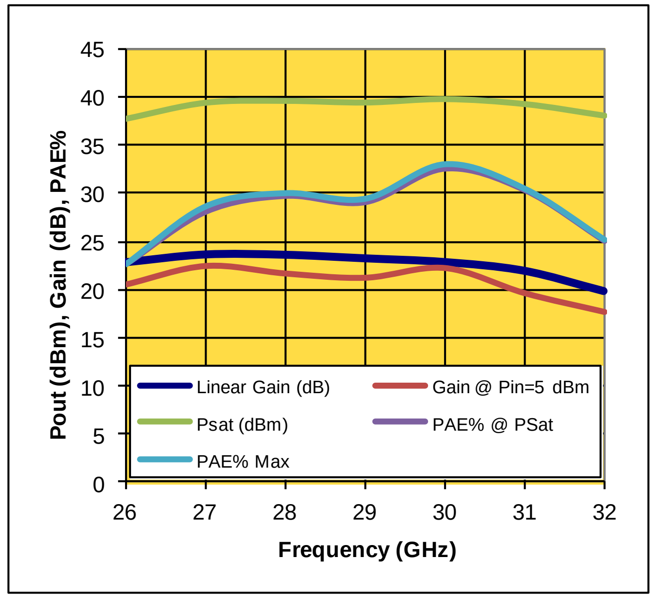


## Measured Performance Characteristics (Typical Performance at 25°C)
## Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA *

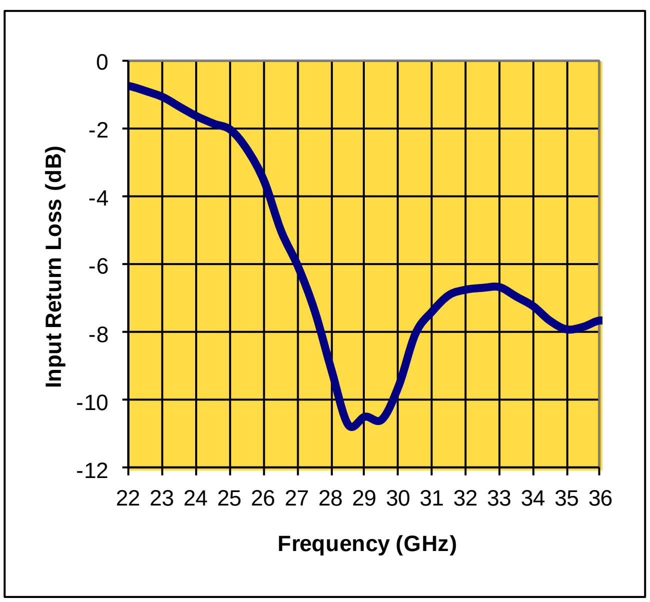
Linear Gain vs. Frequency



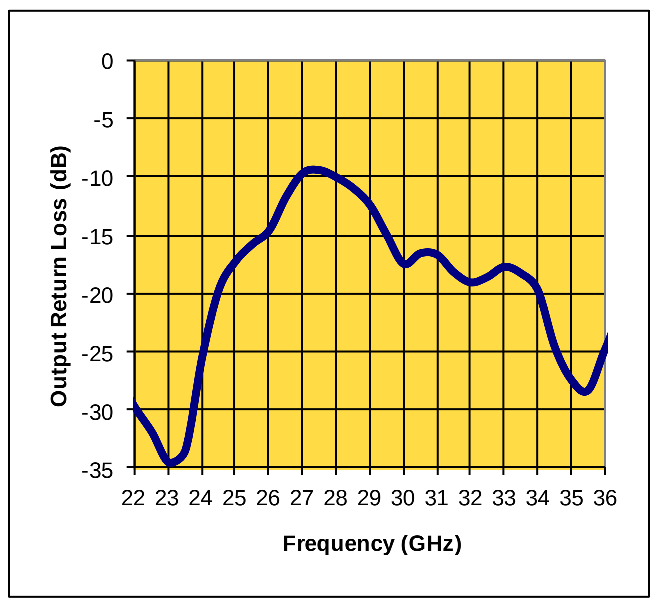

Power, Gain, PAE% vs. Frequency **



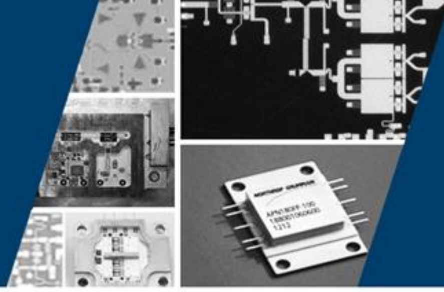

Input Return Loss vs. Frequency




Output Return Loss vs. Frequency



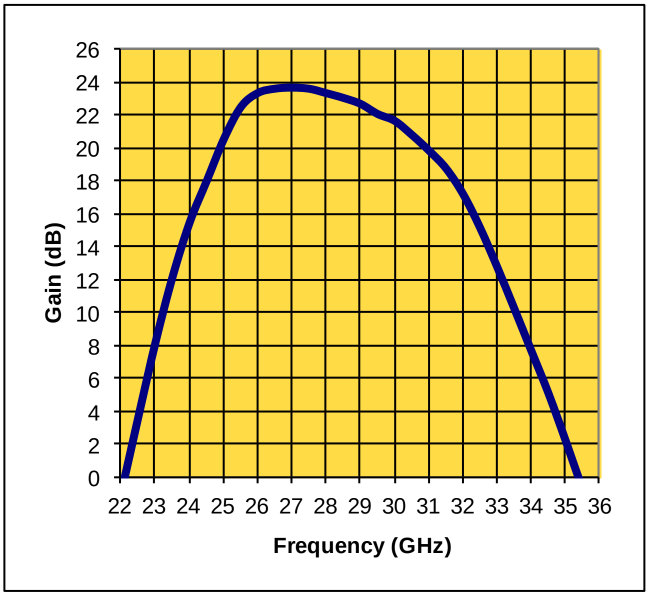

* Pulsed-Power On-Wafer , ** CW Fixtured



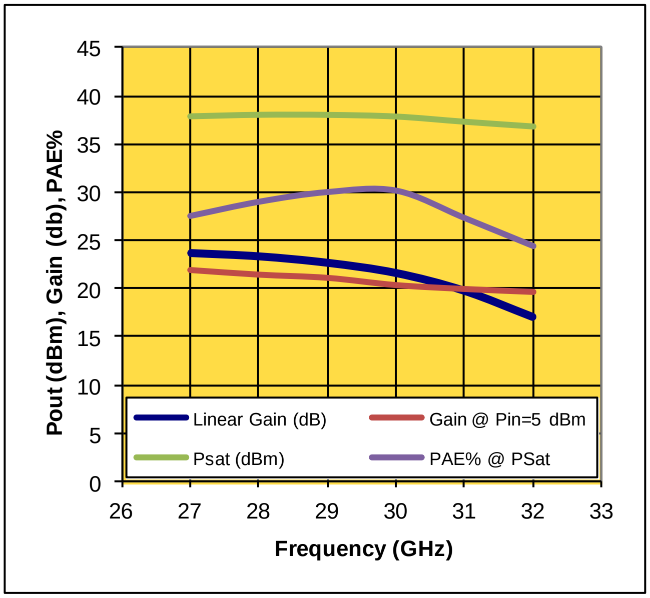


## Measured Performance Characteristics (Typical Performance at 25°C)
## Vd = 20.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA *

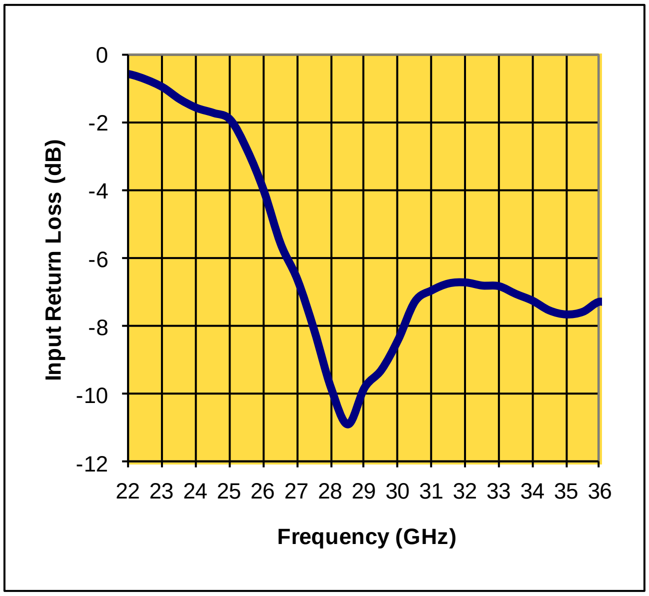
### Linear Gain vs. Frequency



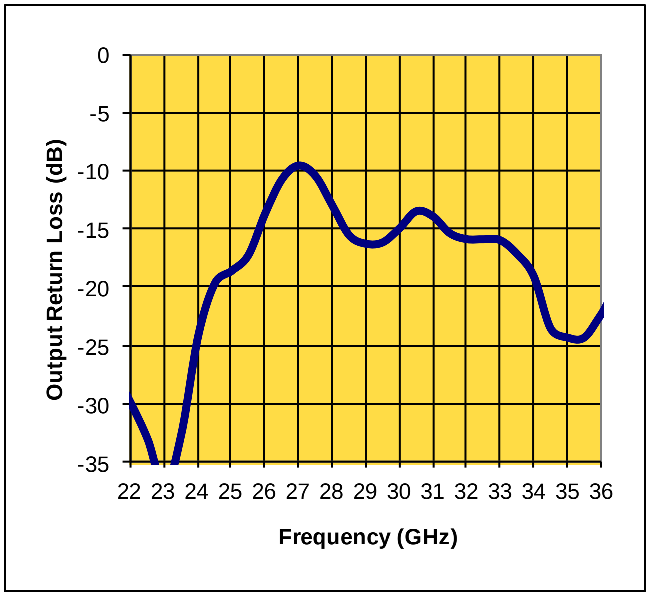

### Power, Gain, PAE% vs. Frequency




### Input Return Loss vs. Frequency




### Output Return Loss vs. Frequency




* Pulsed-Power On-Wafer



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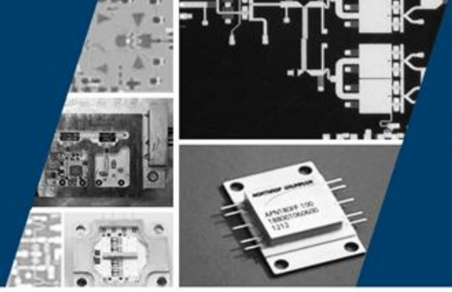
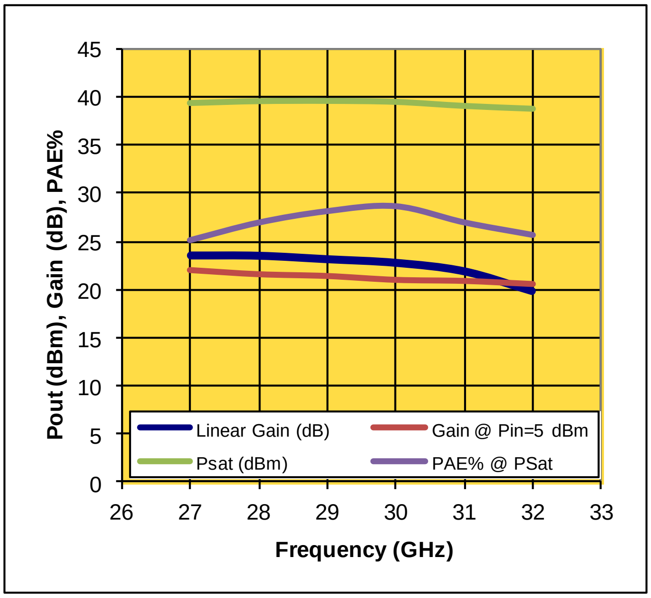


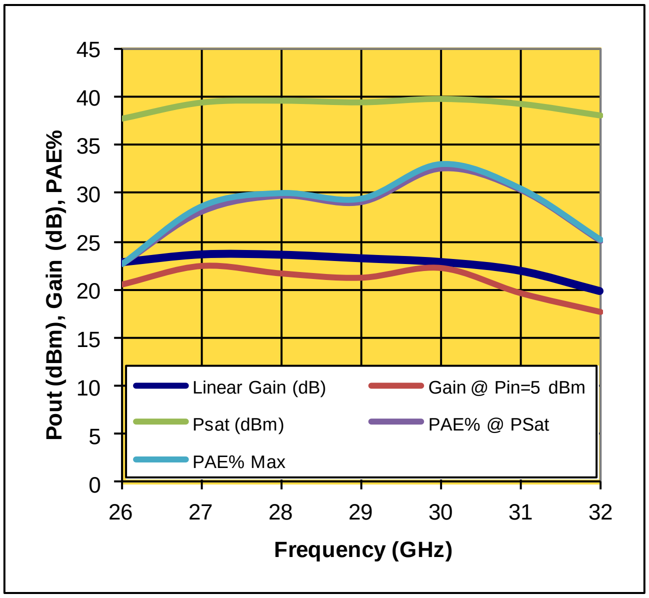


## Measured Performance Characteristics (Typical Performance at 25°C)
## Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA (Quiescent)

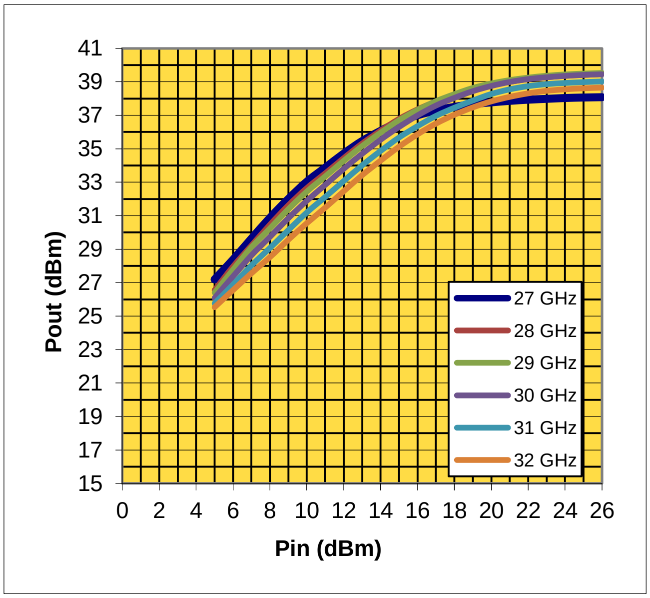
**Power, Gain, PAE% vs. Frequency**
**Pulsed-Power On-Wafer**



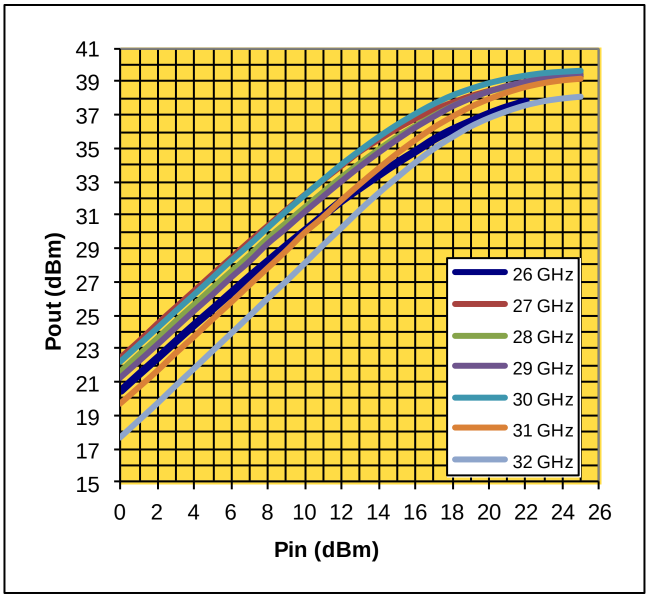

**Power, Gain, PAE% vs. Frequency**
**CW Fixtured**




**Output Power vs. Pin Pulsed-Power On-Wafer**




**Output Power vs. Pin CW Fixtured**









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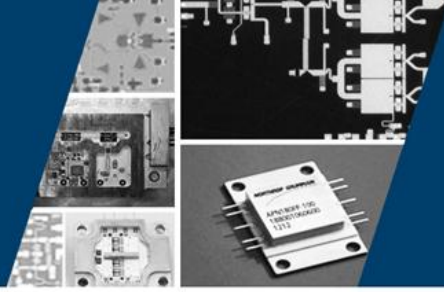
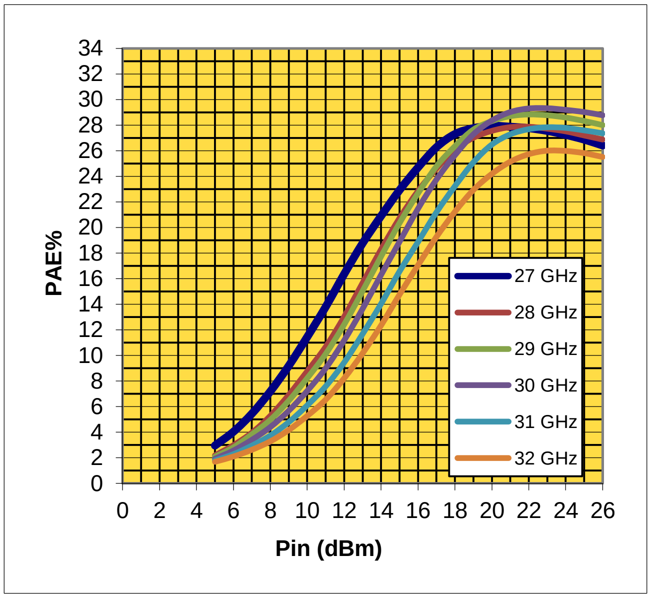


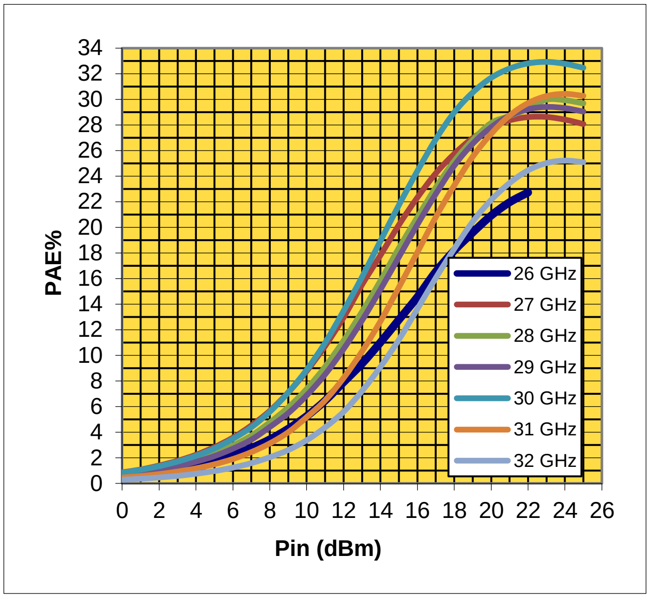


## Measured Performance Characteristics (Typical Performance at 25°C)
## Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA (Quiescent)

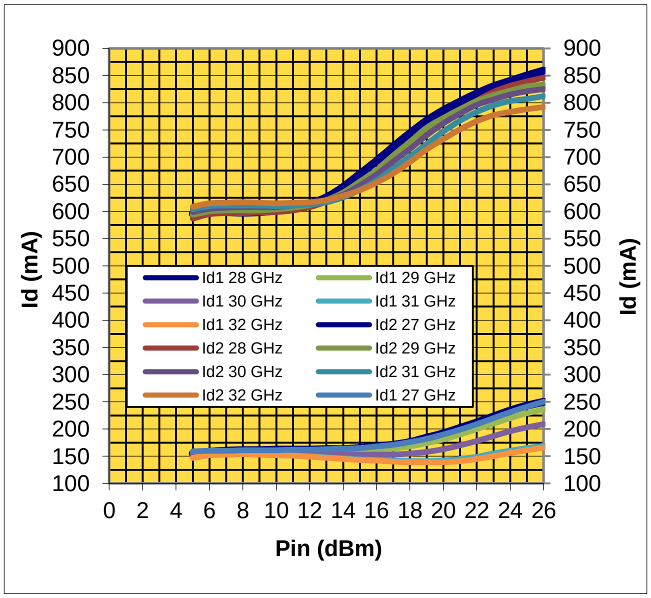
PAE% vs. Pin Pulsed-Power On-Wafer



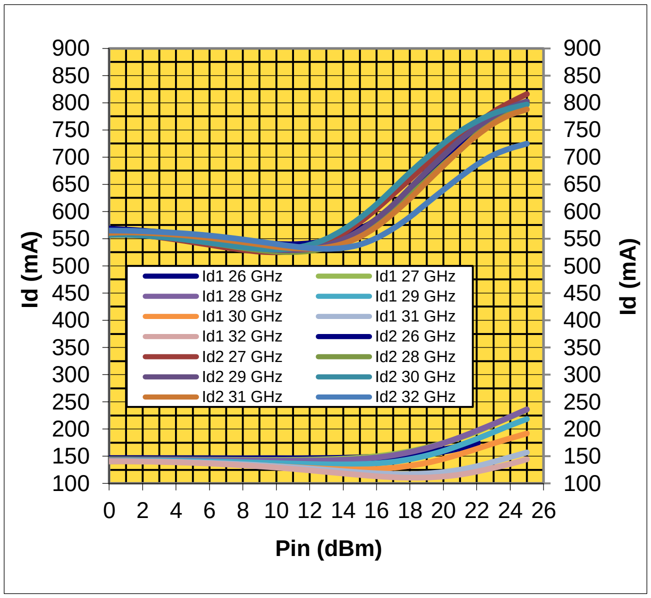

PAE% vs. Pin CW Fixtured




Drain Currents vs. Pin Pulsed-Power On-Wafer




Drain Currents vs. Pin CW Fixtured







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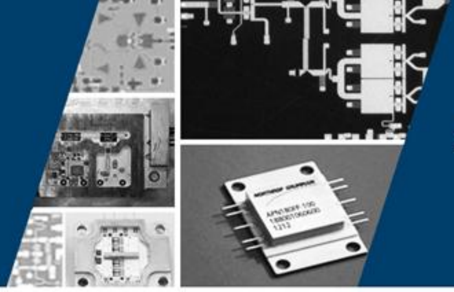
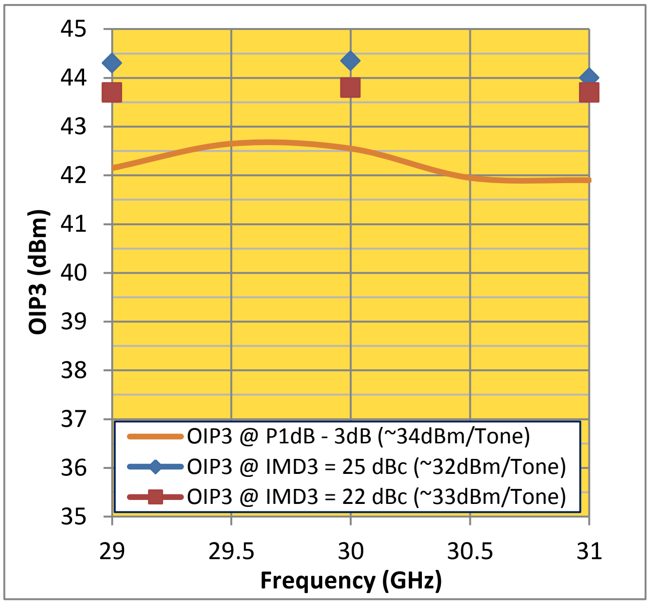


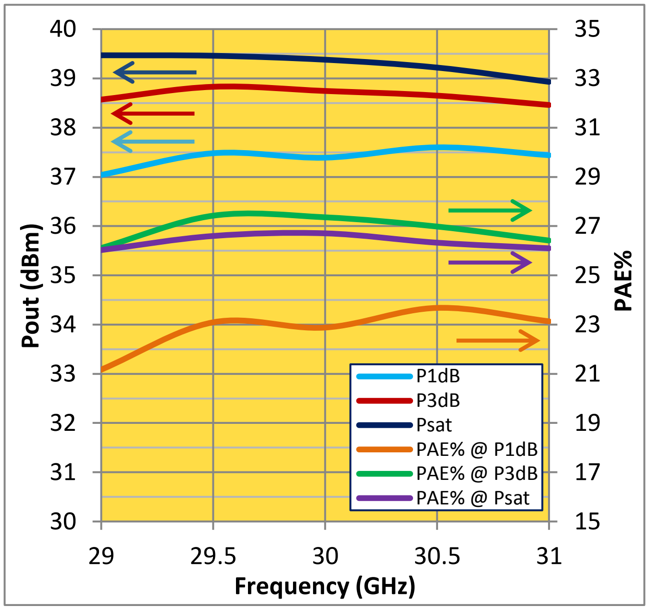


### Fixtured Measured Performance Characteristics *
### Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA (Quiescent)

**OIP3 vs. Pin CW Fixtured @ 23 degC**

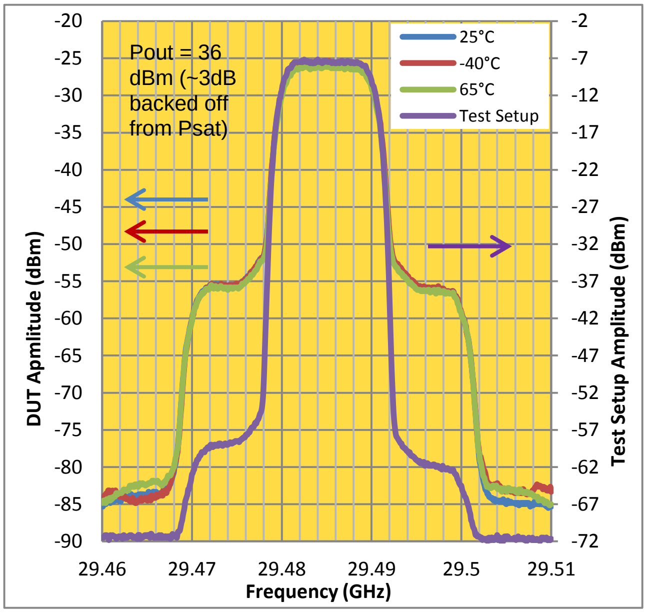



**Power & PAE% vs. Pin CW Fixtured @ 25 degC**

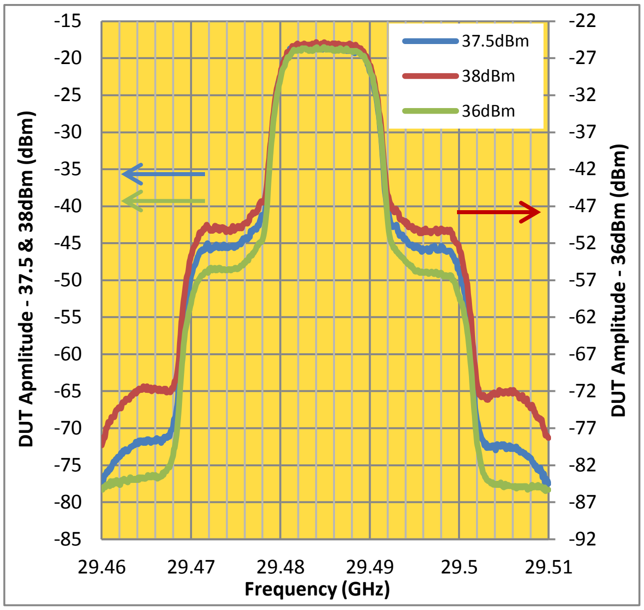



**Spectral Regrowth @ 29.485 GHz for QPSK Symbol rate = 10 MSps & α = 0.3**

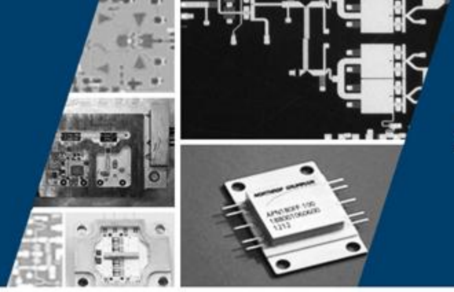
**Spectral Regrowth vs. Temperature**




**Spectral Regrowth vs. Output Power**



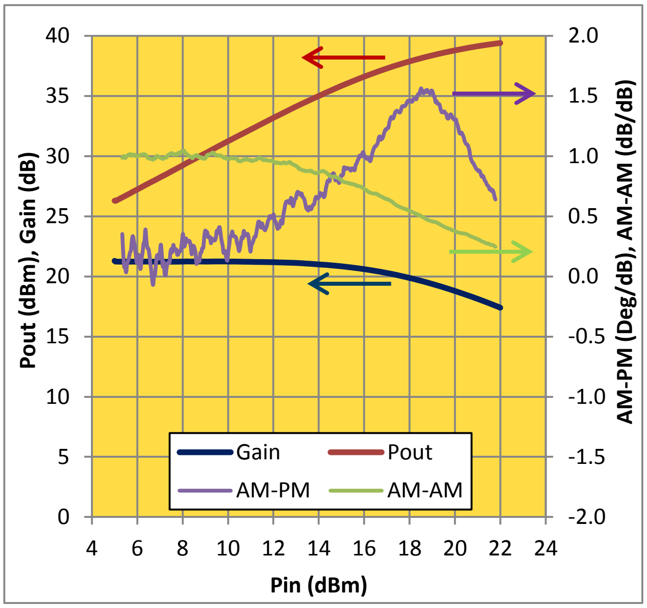

* Measurement by Microsemi RFIS



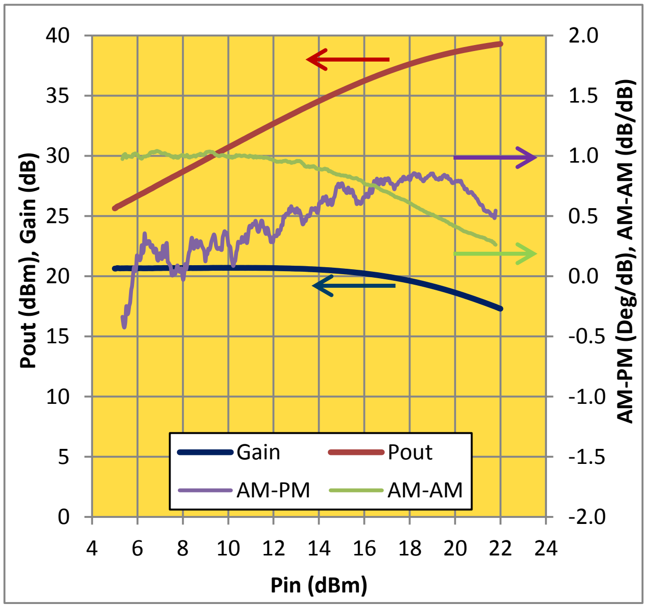


## Fixtured Measured Performance Characteristics (Typical Performance at 28°C) *
## Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA (Quiescent)

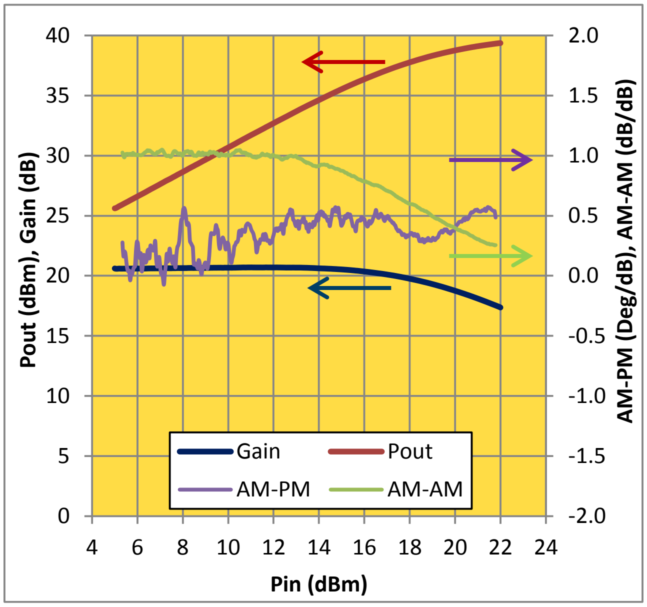
Pout, Gain, AM-AM & AM-PM vs. Pin @ 29 GHz



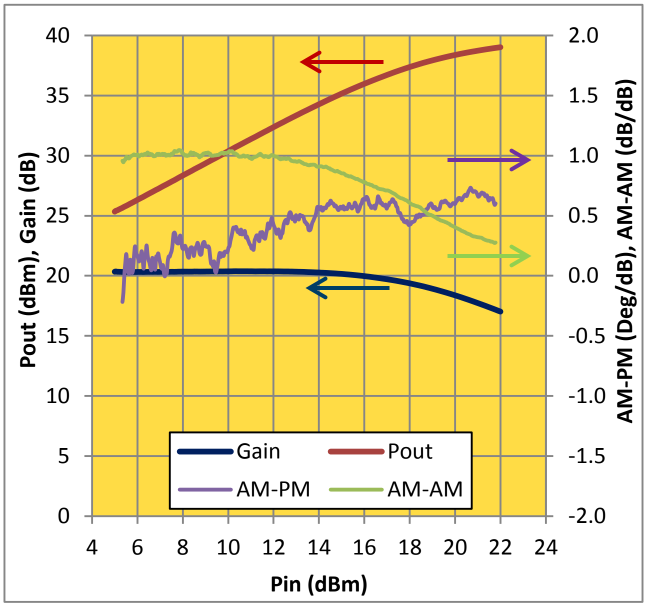

Pout, Gain, AM-AM & AM-PM vs. Pin @ 29.5 GHz




Pout, Gain, AM-AM & AM-PM vs. Pin @ 30 GHz




Pout, Gain, AM-AM & AM-PM vs. Pin @ 30.5 GHz




* Measurement by Microsemi RFIS





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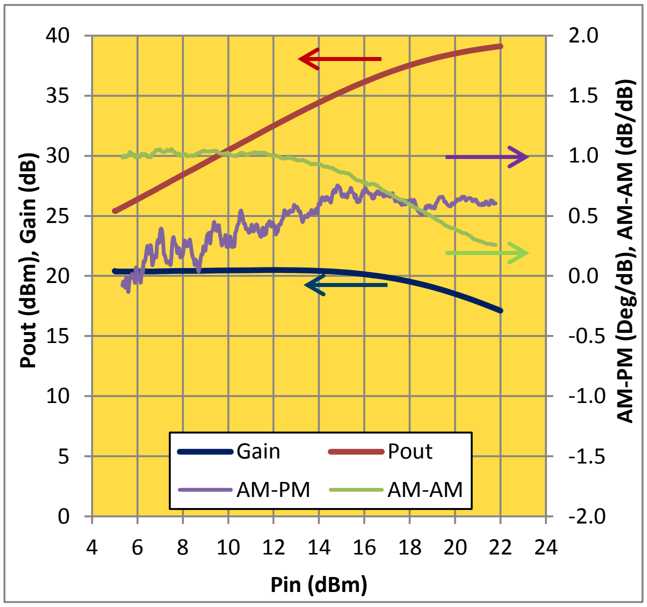
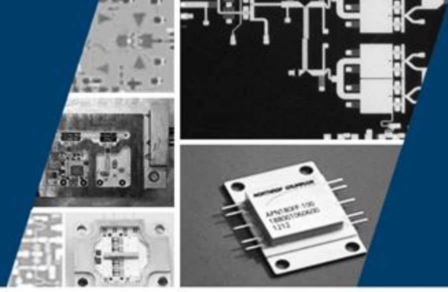
Fixtured Measured Performance Characteristics (Typical Performance at 28°C) *
Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA (Quiescent)

Pout, Gain, AM-AM & AM-PM vs. Pin @ 31 GHz



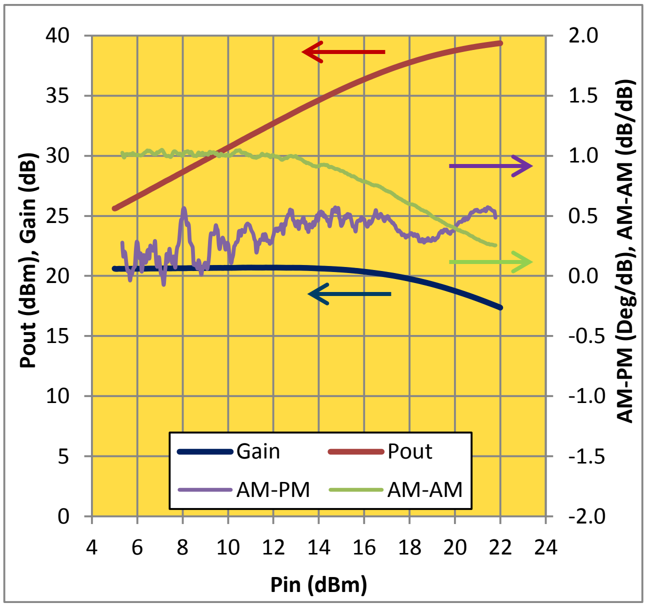

* Measurement by Microsemi RFIS



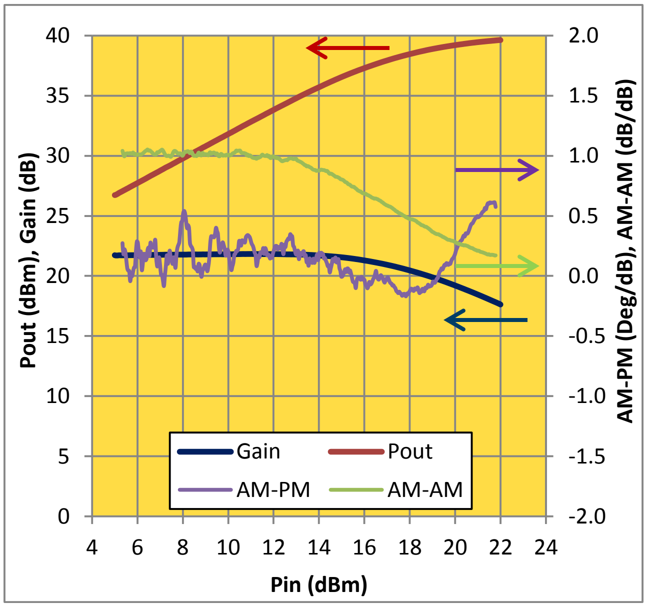


## Fixtured Measured Performance Characteristics (Typical Performance at 30 GHz) *
Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA (Quiescent)

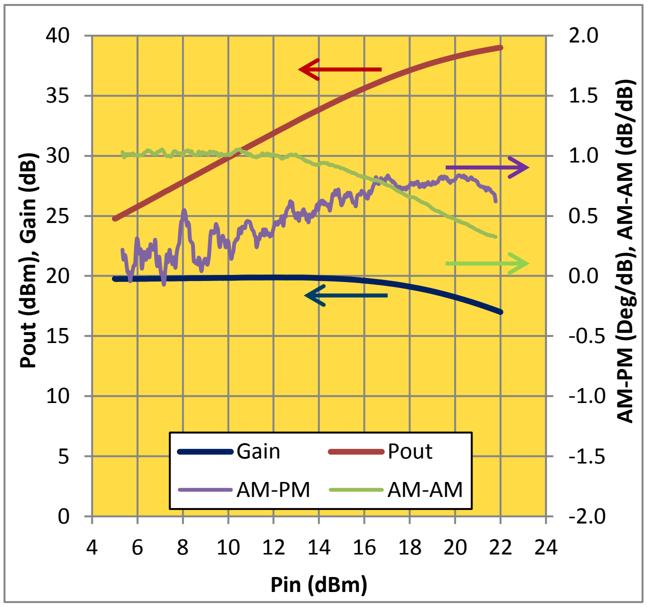
Pout, Gain, AM-AM & AM-PM vs. Pin @ 28°C




Pout, Gain, AM-AM & AM-PM vs. Pin @ -40°C




Pout, Gain, AM-AM & AM-PM vs. Pin @ 65°C




* Measurement by Microsemi RFIS



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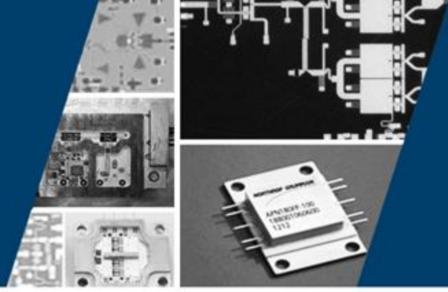
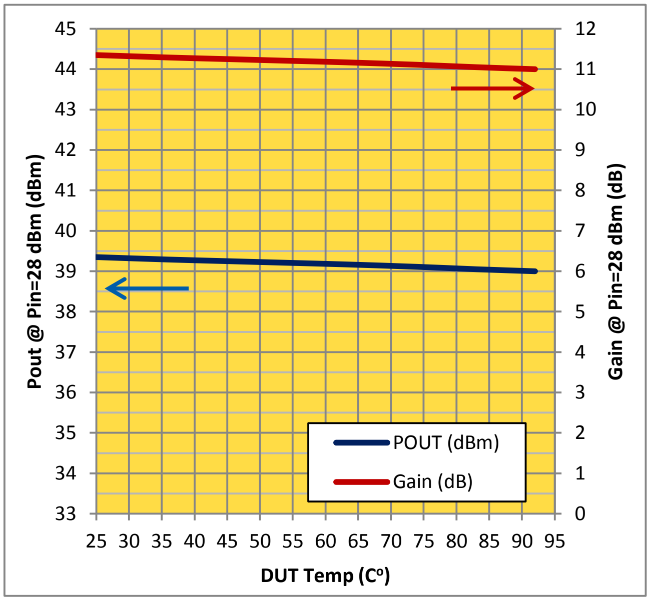


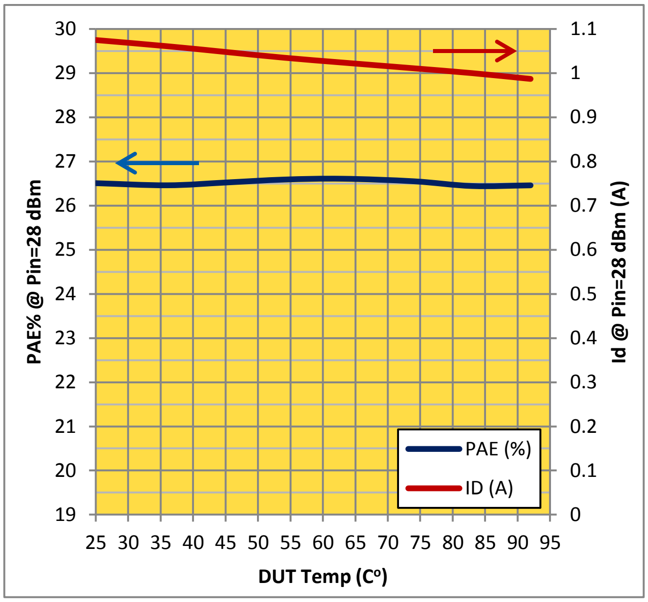


## Measured Performance Characteristics (Typical Performance at 30 GHz)*
## Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA

Pout & Gain @ Pin = 28 dBm vs. Temperature
CW Fixtured *




PAE% & Id Total @ Pin = 28 dBm vs. Temperature
CW Fixtured *




* Measurement by Microsemi RFIS

## Preliminary Thermal Properties with die mounted with 1mil 80/20 AuSn Eutectic to 25mil CuW Shim.

| Conditions | Shim Boundary Temperature | Junction Temperature | Thermal Resistance θjc |
|---|---|---|---|
| Vd = 28V, Id1 = 209 mA * | 25 ºC | 126.7 ºC | 5.1 ºC/W |
| Id2 + Id2a = 783 mA * | 50 ºC | 161.1 ºC | 5.6 ºC/W |
| Pin=23 dBm | 75 ºC | 195.5 ºC | 6.1 ºC/W |
| Pout=39.1 dBm | 78 ºC ** | 200.0 ºC | 6.2 ºC/W |

* Vd = 28.0 V, Idq1 = 144 mA, Id2q + Idq2a = 576 mA
** Max recommended. Junction Temperatures below 200.0 ºC should result in greater than $10^5$ hours MTTF.



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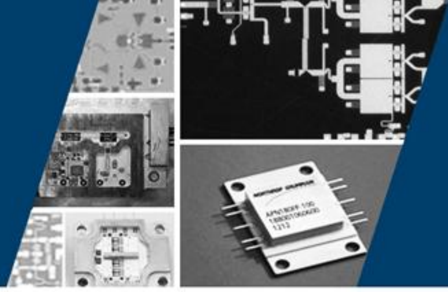
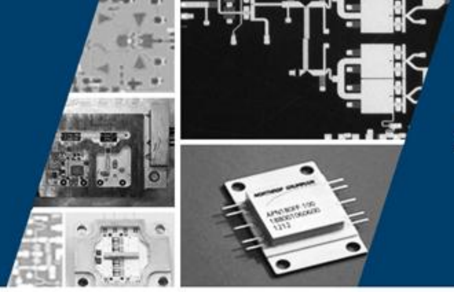




## Measured Performance Characteristics (Typical Performance at 25°C)
## Vd = 28.0 V, Id1 = 144 mA, Id2 + Id2a = 576 mA *

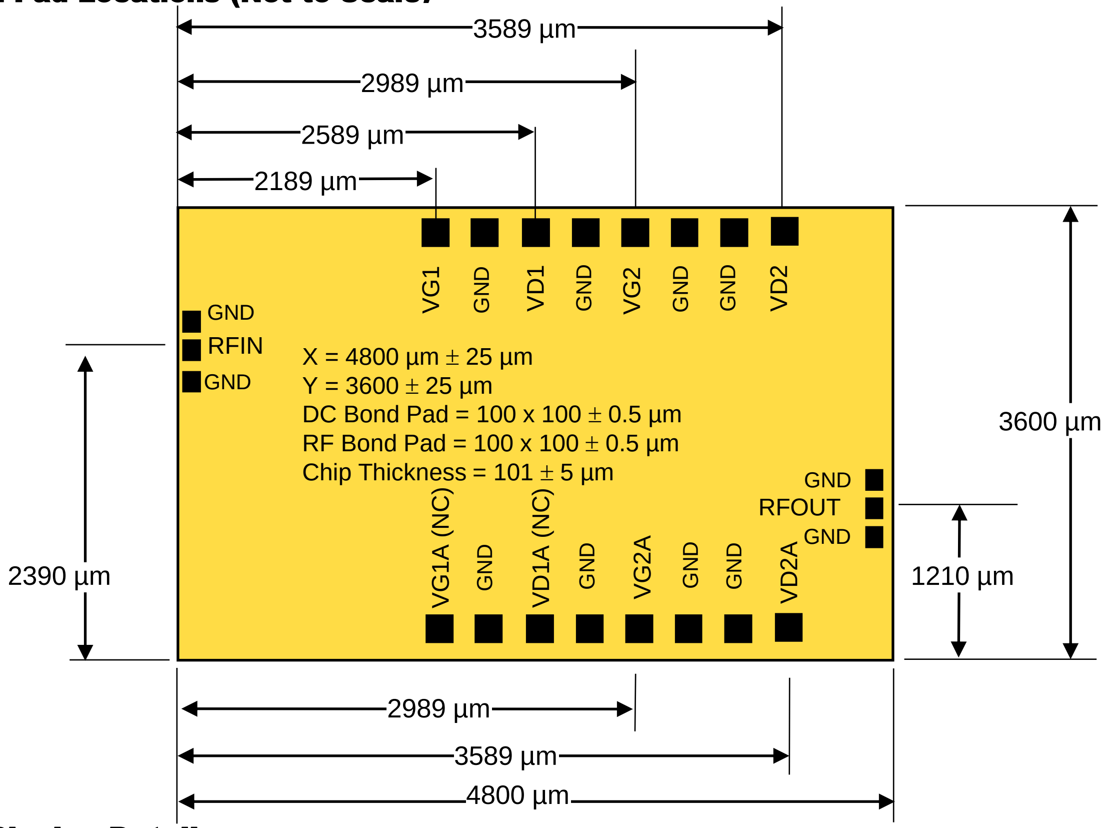
| Freq GHz | S11 Mag | S11 Ang | S21 Mag | S21 Ang | S12 Mag | S12 Ang | S22 Mag | S22 Ang |
|---|---|---|---|---|---|---|---|---|
| 21.0 | 0.942 | 55.243 | 0.342 | -170.362 | 0.002 | -166.716 | 0.065 | 152.524 |
| 21.5 | 0.939 | 49.587 | 0.575 | 169.383 | 0.002 | 102.340 | 0.069 | 128.941 |
| 22.0 | 0.927 | 42.768 | 0.985 | 146.926 | 0.002 | 25.226 | 0.072 | 97.324 |
| 22.5 | 0.919 | 36.102 | 1.746 | 119.542 | 0.001 | -112.385 | 0.065 | 76.487 |
| 23.0 | 0.894 | 28.210 | 3.001 | 84.655 | 0.001 | -100.494 | 0.071 | 69.138 |
| 23.5 | 0.869 | 21.183 | 4.708 | 44.910 | 0.003 | -126.059 | 0.095 | 55.719 |
| 24.0 | 0.854 | 13.296 | 6.531 | 3.508 | 0.003 | -143.553 | 0.128 | 13.894 |
| 24.5 | 0.860 | 3.075 | 8.767 | -35.247 | 0.005 | -166.015 | 0.138 | -48.938 |
| 25.0 | 0.829 | -12.305 | 12.056 | -77.999 | 0.007 | 154.690 | 0.148 | -149.420 |
| 25.5 | 0.742 | -26.681 | 14.251 | -125.030 | 0.010 | 113.037 | 0.217 | 114.136 |
| 26.0 | 0.681 | -42.501 | 15.608 | -169.464 | 0.012 | 77.991 | 0.310 | 50.799 |
| 26.5 | 0.563 | -62.342 | 15.652 | 147.565 | 0.012 | 38.592 | 0.367 | -4.431 |
| 27.0 | 0.510 | -78.689 | 15.482 | 111.591 | 0.014 | -4.259 | 0.345 | -52.289 |
| 27.5 | 0.477 | -112.272 | 16.535 | 73.417 | 0.015 | -39.448 | 0.279 | -91.748 |
| 28.0 | 0.346 | -147.579 | 15.689 | 33.406 | 0.013 | -71.339 | 0.228 | -118.585 |
| 28.5 | 0.337 | -175.873 | 15.271 | -1.673 | 0.010 | -108.775 | 0.172 | -145.180 |
| 29.0 | 0.386 | 147.801 | 14.880 | -39.720 | 0.009 | -131.745 | 0.123 | -160.979 |
| 29.5 | 0.400 | 116.981 | 13.787 | -75.497 | 0.009 | -171.579 | 0.141 | -158.488 |
| 30.0 | 0.464 | 93.944 | 13.305 | -113.217 | 0.010 | 153.075 | 0.144 | 176.390 |
| 30.5 | 0.505 | 68.594 | 11.930 | -151.724 | 0.010 | 104.109 | 0.158 | 143.116 |
| 31.0 | 0.501 | 47.332 | 10.559 | 170.854 | 0.010 | 52.229 | 0.144 | 90.233 |
| 31.5 | 0.496 | 30.242 | 9.286 | 131.425 | 0.006 | 14.869 | 0.112 | 27.246 |
| 32.0 | 0.495 | 13.204 | 7.569 | 91.403 | 0.005 | -2.848 | 0.114 | -52.929 |
| 32.5 | 0.480 | -2.780 | 5.701 | 53.350 | 0.008 | -85.297 | 0.122 | -116.894 |
| 33.0 | 0.461 | -18.933 | 4.228 | 18.976 | 0.009 | -54.974 | 0.121 | -154.918 |
| 33.5 | 0.438 | -34.960 | 3.101 | -13.803 | 0.006 | -54.679 | 0.105 | 176.278 |
| 34.0 | 0.432 | -48.536 | 2.253 | -46.308 | 0.002 | -82.565 | 0.088 | 148.306 |
| 34.5 | 0.429 | -65.327 | 1.634 | -78.439 | 0.007 | -95.224 | 0.057 | 140.691 |
| 35.0 | 0.422 | -78.700 | 1.145 | -109.625 | 0.005 | 35.783 | 0.039 | 166.011 |
| 35.5 | 0.416 | -93.589 | 0.759 | -138.612 | 0.006 | -164.566 | 0.062 | 159.310 |
| 36.0 | 0.426 | -107.407 | 0.524 | -164.513 | 0.004 | 33.354 | 0.076 | 170.766 |
| 36.5 | 0.435 | -119.646 | 0.348 | 168.028 | 0.005 | -27.297 | 0.085 | 163.096 |
| 37.0 | 0.459 | -131.475 | 0.217 | 144.145 | 0.003 | -56.007 | 0.092 | 144.691 |

* Pulsed-Power On-Wafer





**Die Size and Bond Pad Locations (Not to Scale)**

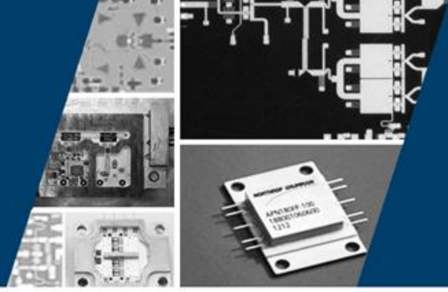



**Biasing/De-Biasing Details:**

Bias for 1st stage is from top. The 2nd stages must bias up from both sides.

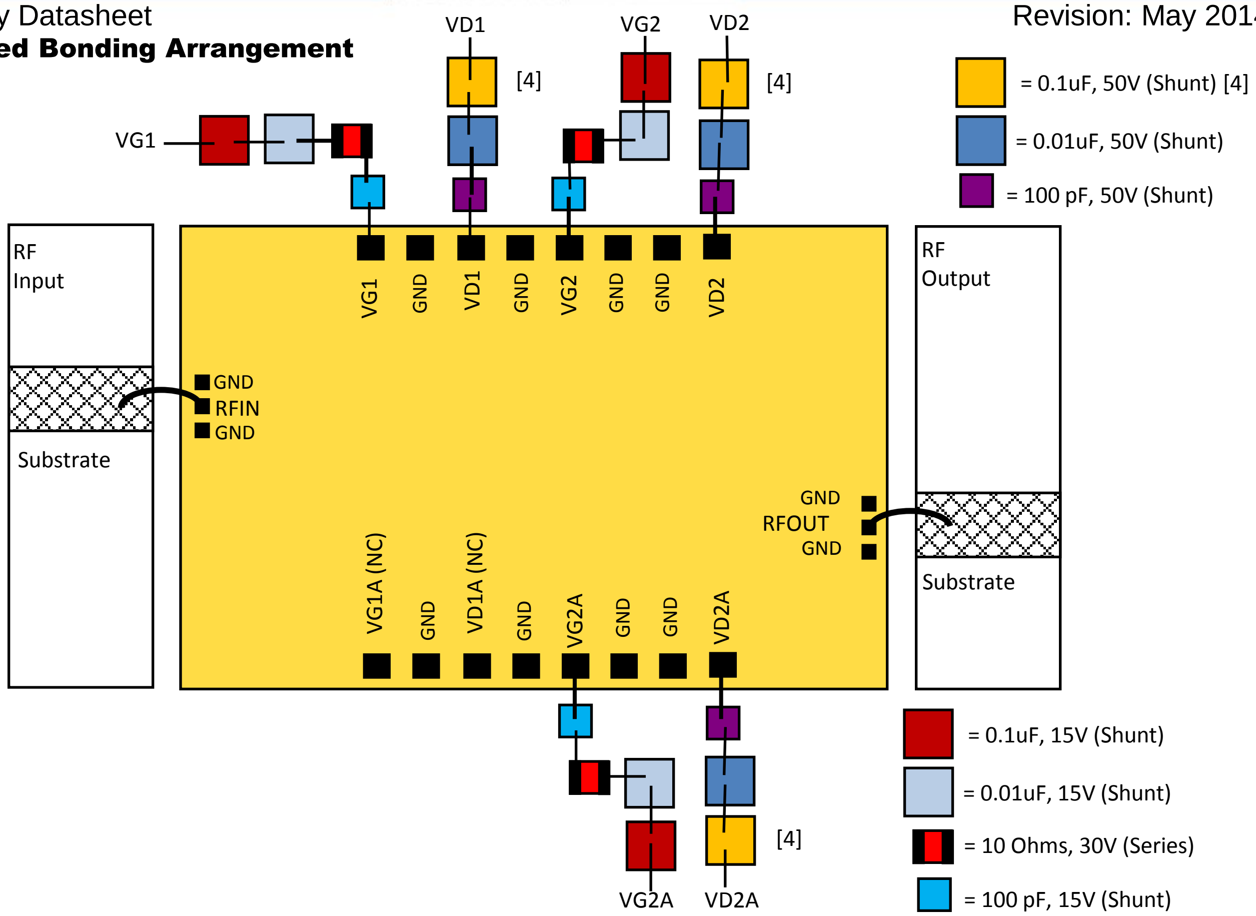
Listed below are some guidelines for GaN device testing and wire bonding:

a. Limit positive gate bias (G-S or G-D) to < 1V
b. Know your devices' breakdown voltages
c. Use a power supply with both voltage and current limit.
d. With the power supply off and the voltage and current levels at minimum, attach the ground lead to your test fixture.
    i. Apply negative gate voltage (-5 V) to ensure that all devices are off
    ii. Ramp up drain bias to ~10 V
    iii. Gradually increase gate bias voltage while monitoring drain current until 20% of the operating current is achieved
    iv. Ramp up drain to operating bias
    v. Gradually increase gate bias voltage while monitoring drain current until the operating current is achieved
e. To safely de-bias GaN devices, start by debiasing output amplifier stages first (if applicable):
    i. Gradually decrease drain bias to 0 V.
    ii. Gradually decrease gate bias to 0 V.
    iii. Turn off supply voltages
f. Repeat de-bias procedure for each amplifier stage





**Suggested Bonding Arrangement**




## Recommended Assembly Notes

1. Bypass caps should be 100 pF (approximately) ceramic (single-layer) placed no farther than 30 mils from the amplifier.
2. Best performance obtained from use of <10 mil (long) by 3 by 0.5 mil ribbons on input and output.
3. Part must be biased from both sides as indicated.
4. The 0.1uF, 50V capacitors are not needed if the drain supply line is clean. If Drain Pulsing of the device is to be used, do **NOT** use the 0.1uF , 50V Capacitors.

## Mounting Processes

Most NGAS GaN IC chips have a gold backing and can be mounted successfully using either a conductive epoxy or AuSn attachment. NGAS recommends the use of AuSn for high power devices to provide a good thermal path and a good RF path to ground. Maximum recommended temp during die attach is 320ºC for 30 seconds.

**Note**: Many of the NGAS parts do incorporate airbridges, so caution should be used when determining the pick up tool.

**CAUTION**: THE IMPROPER USE OF AuSn ATTACHMENT CAN CATASTROPHICALLY DAMAGE GaN CHIPS.

**PLEASE ALSO REFER TO OUR "GaN Chip Handling Application Note" BEFORE HANDLING, ASSEMBLING OR BIASING THESE MMICS!**



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