

Power Amplifier, 0.25 W DC - 27 GHz



MAAP-011324-DIE

Rev. V2

Features

- High Gain: 18 dB
- P1dB: 25 dBm
- P3dB: 26 dBm
- Output IP3: 35 dBm
- Bias Voltage: $V_{DD} = 8\text{ V}$
- Bias Current: $I_{DSQ} = 220\text{ mA}$
- 50 Ω Matched Input / Output
- Temperature Compensated Output Power Detector
- Die Size: 2800 x 1300 x 100 μm
- RoHS* Compliant

Applications

- Test & Measurement
- EW
- ECM
- Radar

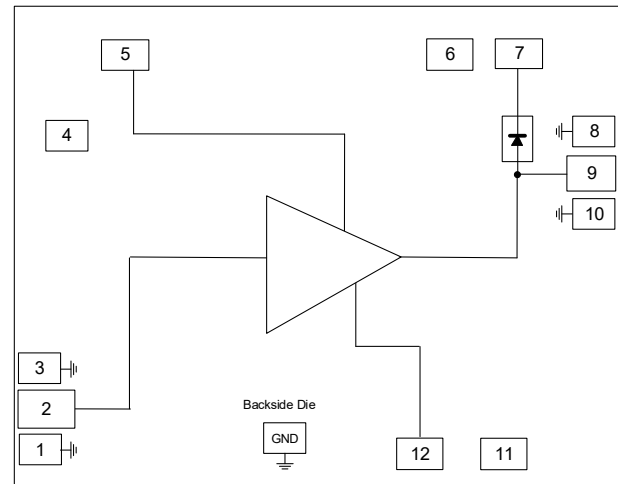
Description

The MAAP-011324-DIE is a 0.25 W distributed power amplifier offered in bare die form. The power amplifier operates from DC to 27 GHz and provides 18 dB of linear gain and 26 dBm of output power at 3-dB compression. The device is fully matched across the band and includes a temperature compensated output power detector.

The MAAP-011324-DIE can be used as a power amplifier stage or as a driver stage in higher power applications.

This product is fabricated using a GaAs pHEMT process which features full passivation for enhanced reliability.

Functional Schematic



Pin Configuration³

| Pin # | Pin Name | Description |
|----------|------------------------------------|---------------------------|
| 1,3,8,10 | GND | Ground |
| 2 | RF _{IN} | RF Input |
| 4,6,11 | Not Used | Not Used |
| 5 | V _{D_AUX} | V _{D_Auxiliary} |
| 7 | DET | Power Detector |
| 9 | RF _{OUT} /V _{DD} | RF Output / Drain Voltage |
| 12 | V _G | Gate Voltage |

3. Backside of die must be connected to RF, DC and thermal ground.

Ordering Information^{1,2}

| Part Number | Package |
|--------------------|-----------------|
| MAAP-011324-DIE | DIE in Gel Pack |
| MAAP-011324-DIESMB | Sample Board |

1. Reference Application Note M513 for reel size information.
2. Sample Board is DIE EVAL. Module.

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

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DC-0026171

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Electrical Specifications (Measure on Bare DIE):

$T_A = +25^\circ\text{C}$, $V_{DD} = 8\text{ V}$, $I_{DSQ} = 220\text{ mA}$, $Z_0 = 50\ \Omega$

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|--------------------------|--|-------|---------------------------|------------------------------|------|
| Gain | 2 GHz 12 GHz 22 GHz 27 GHz | dB | 17.0 17.0 17.0 — | 18.5 18.0 18.0 17.5 | — |
| P_{OUT} | $P_{IN} = +10\text{ dBm}$ 2 GHz 12 GHz 22 GHz 27 GHz | dBm | — | 27.5 26.5 24.5 21.0 | — |
| P1dB | 2 GHz 12 GHz 22 GHz 27 GHz | dBm | 24.0 23.0 20.5 — | 26.0 25.0 22.0 20.5 | — |
| OIP3 | $P_{OUT} = +14\text{ dBm/tone}$ (10 MHz Tone Spacing) 2 GHz 12 GHz 22 GHz 27 GHz | dBm | — | 38.0 34.5 33.5 32.5 | — |
| PAE | $P_{IN} = +10\text{ dBm}$ 2 GHz 12 GHz 22 GHz 27 GHz | % | — | 29 24 14 6.5 | — |
| Vdet | 10 dBm P_{OUT} , 7 GHz 25 dBm P_{OUT} , 7 GHz | mV | — | 150 350 | — |
| Input Return Loss | $P_{IN} = -10\text{ dBm}$ | dB | — | 15 | — |
| Output Return Loss | $P_{IN} = -10\text{ dBm}$ | dB | — | 15 | — |
| I_{DD} (with RF drive) | $P_{IN} = +10\text{ dBm}$ | mA | — | 250 | — |
| I_G | — | mA | — | 4 | — |

Maximum Operating Ratings

| Parameter | Rating |
|-------------------------------------|----------------|
| Input Power | 13 dBm |
| Junction Temperature ^{4,5} | +150°C |
| Operating Temperature | -40°C to +85°C |

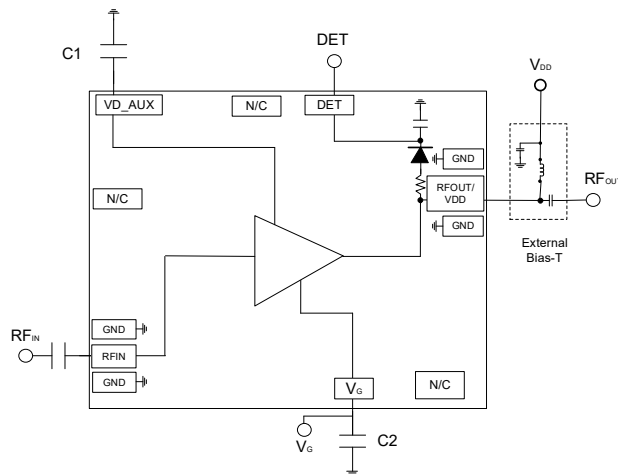
- Operating at nominal conditions with junction temperature $\leq +150^\circ\text{C}$ will ensure MTTF $> 1 \times 10^6$ hours.
- Junction Temperature (T_J) = $T_C + \Theta_{JC} * ((V * I) - (P_{OUT} - P_{IN}))$
Typical thermal resistance (Θ_{JC}) = 10.1 °C/W.
a) For $T_C = +25^\circ\text{C}$,
 $T_J = +41.7^\circ\text{C}$ @ 8 V, 235 mA, $P_{OUT} = 23.6\text{ dBm}$, $P_{IN} = 8\text{ dBm}$
b) For $T_C = +85^\circ\text{C}$,
 $T_J = +102.1^\circ\text{C}$ @ 8 V, 235 mA, $P_{OUT} = 22.9\text{ dBm}$, $P_{IN} = 8\text{ dBm}$

Absolute Maximum Ratings^{6,7,8}

| Parameter | Absolute Maximum |
|-----------------------------------|------------------|
| Input Power | 25 dBm |
| Drain Voltage | +10 V |
| Gate Voltage | -5 to 0 V |
| Junction Temperature ⁹ | +175°C |
| Storage Temperature | -65°C to +125°C |

- Exceeding any one or combination of these limits may cause permanent damage to this device.
- MACOM does not recommend sustained operation near these survivability limits.
- Junction temperature directly effects device MTTF. Junction temperature should be kept as low as possible to maximize lifetime.

Application Schematic



Operating the MAAP-011324-DIE

Turn-on

1. Apply V_{G1} (-4.5 V).
2. Increase V_{DD} to 8 V.
3. Set I_{DSQ} by adjusting V_G more positive (typically -0.53 V for $I_{DSQ} = 220$ mA).
4. Apply RF_{IN} signal.

Turn-off

1. Remove RF_{IN} signal.
2. Decrease V_G to -4.5 V.
3. Decrease V_{DD} to 0 V.

Bill of Materials^{9,10,11}

| Part | Value | Size | Comment |
|--------|-----------|------|---------|
| C1, C2 | 1 μ F | 0402 | bypass |

9. C1 & C2 are required for operation below 1 GHz.
10. High power external bias tee was used for measurements.
11. External DC block was used on input.

Biasing Conditions

Recommended biasing conditions are $V_{DD} = 8$ V, $I_{DSQ} = 220$ mA (controlled with V_G).

By-pass capacitor C1 for the auxiliary pad is for a low frequency operation extension (below 1 GHz). This provides wide band performance of 100 kHz - 27 GHz (depending on the bandwidth of the bias tees).

To bias the drain:

1. The required V_{DD} is applied at RF_{OUT}/V_{DD} through the bias tee.

There are 2 possible methods to bias the gate:

1. V_G is applied using the V_G pad (pin 12) and set using to provide the required current bias (I_{DSQ}). No external bias tee is required at the RF input but an external DC block is required.
2. V_G is applied at the RF input (pin 2) through an external bias tee on the RF input line and set to provide the required current bias (I_{DSQ}).

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

These electronic devices 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.

Recommended PCB Information

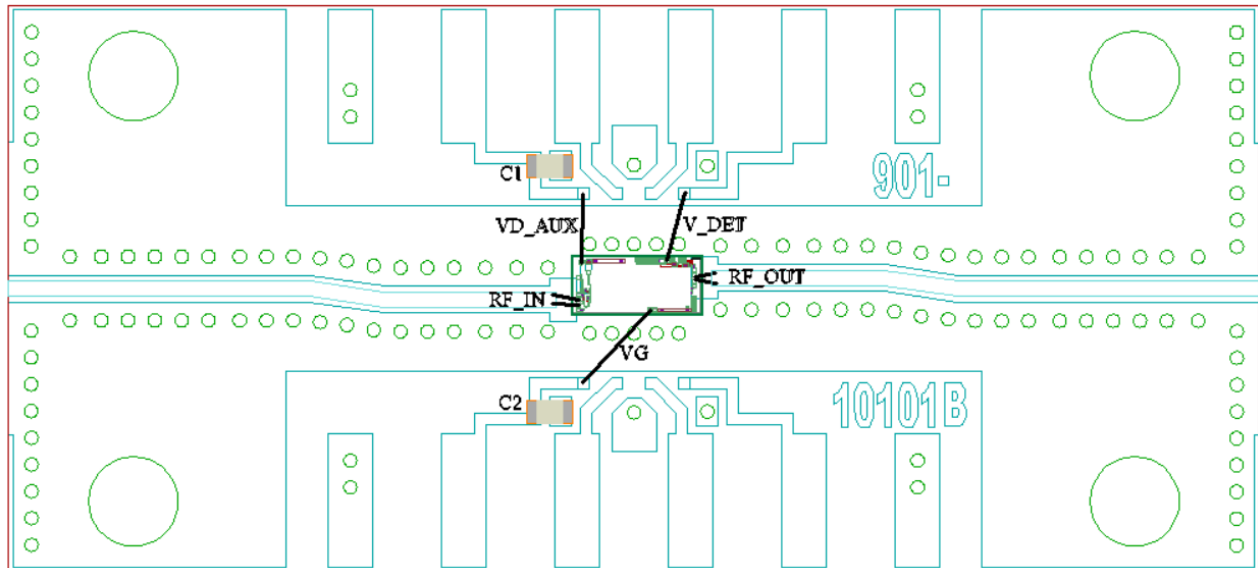
RF input and output are 50 Ω transmission lines. Single layer 8 mil Rogers RO4008 with 1/2 oz. Cu. Use copper filled vias under ground paddle.

Grounding

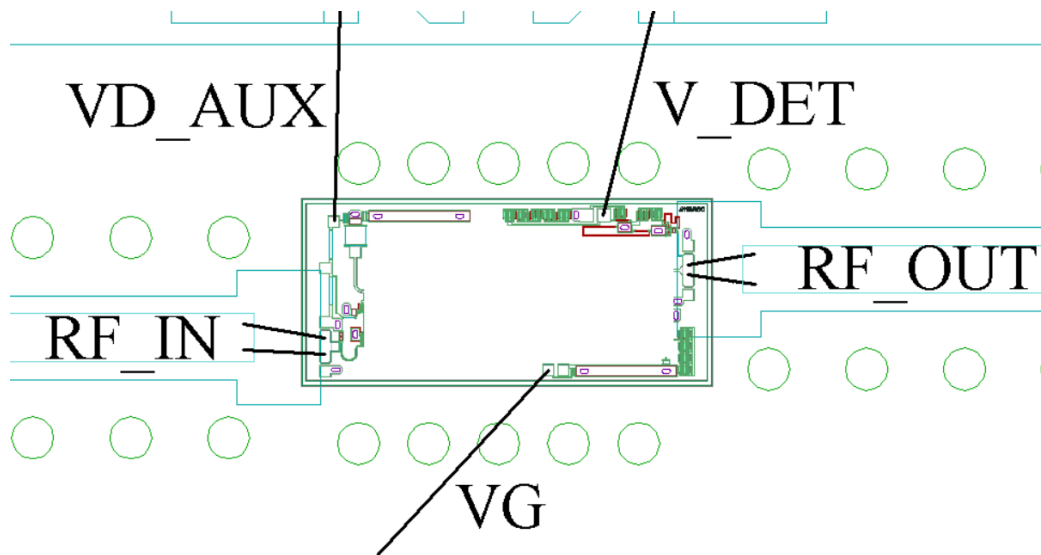
It is recommended that the total ground (common mode) inductance not exceed 0.03 nH (30 pH). This is equivalent to placing at least four 8-mil (200- μ m) diameter vias under the device, assuming an 8-mil (200- μ m) thick RF layer to ground.

PCB Layout:

RF input and output traces on 901-10101B board are cut such that die can fit between them with out shorting them to ground.



Close Up:



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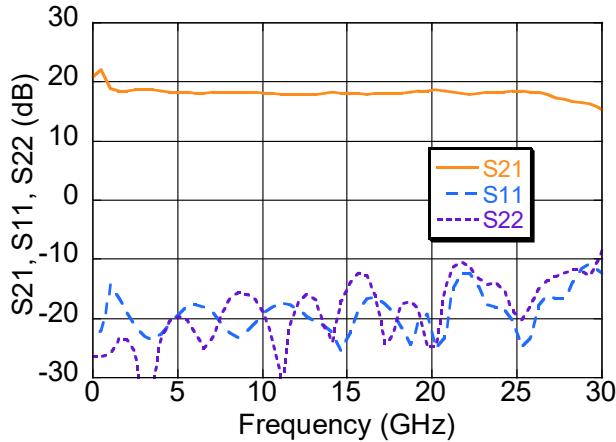
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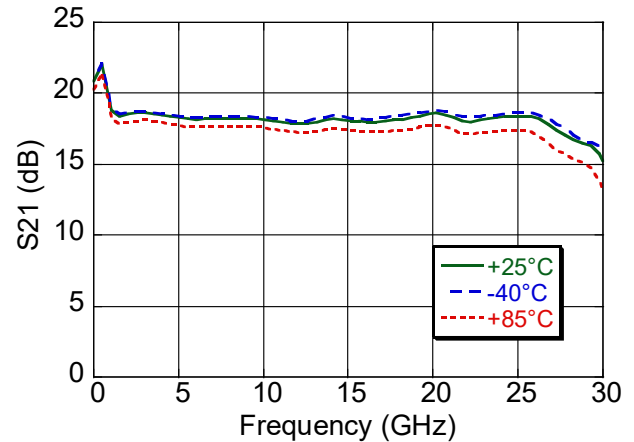
Typical Performance Curves (Measurement includes Wirebond):

$V_{DD} = 8\text{ V}$, $I_{DSQ} = 220\text{ mA}$, $V_G = -0.53\text{ V}$ typical

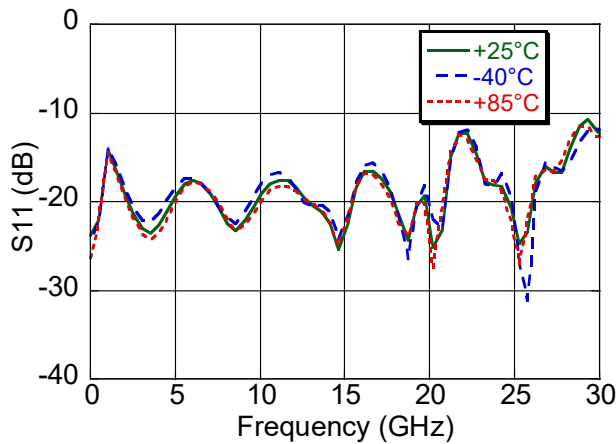
S Parameters



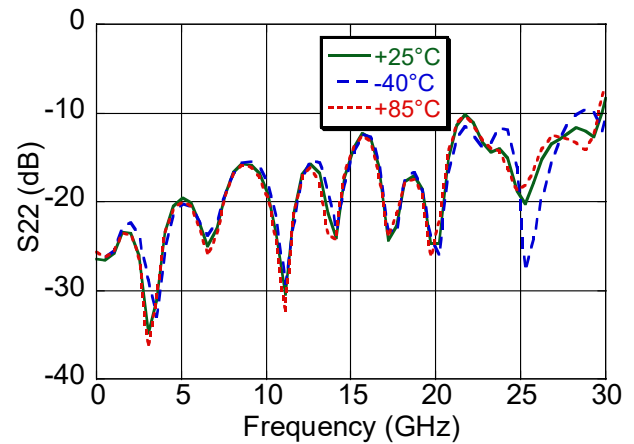
Gain



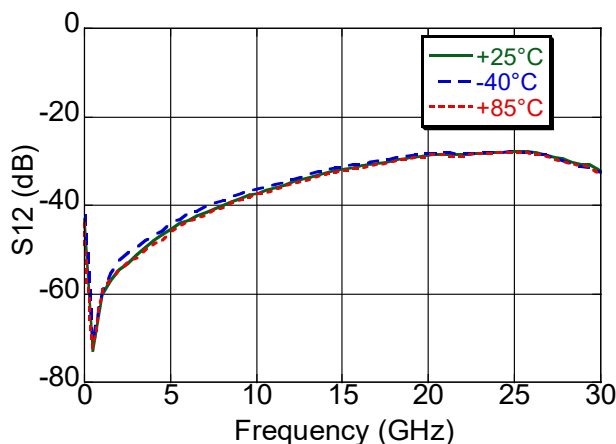
Input Return Loss



Output Return Loss



Isolation



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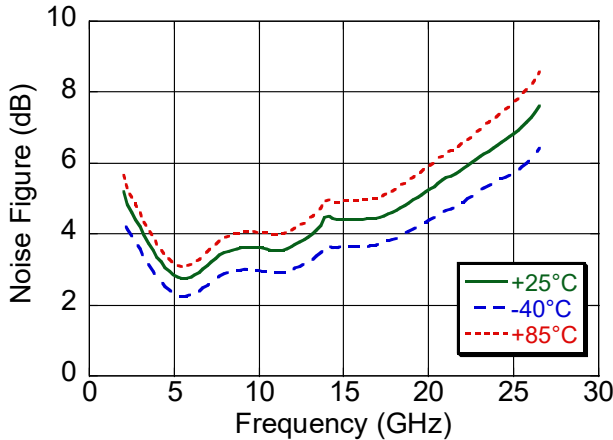
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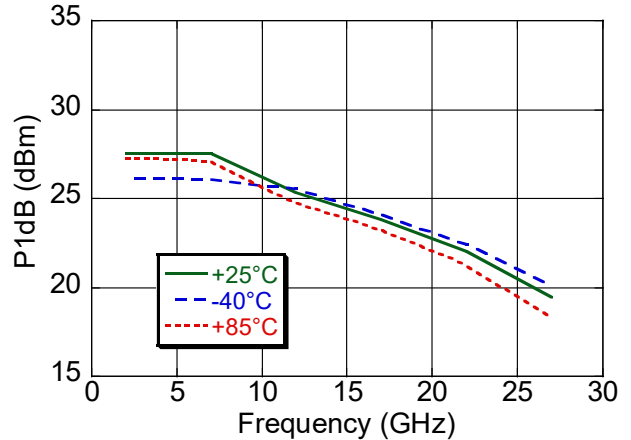
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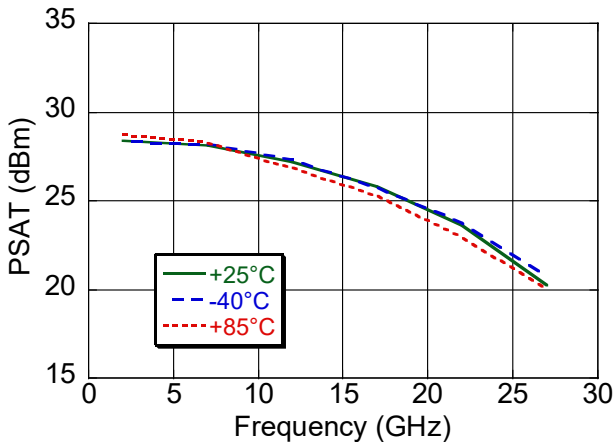
Noise Figure over Temperature



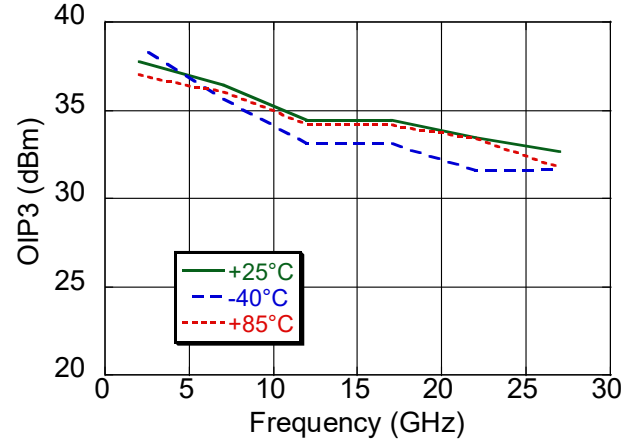
P1dB over Temperature



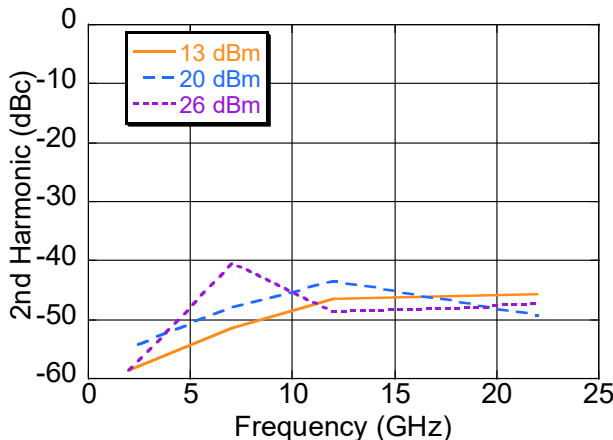
P_{SAT} over Temperature



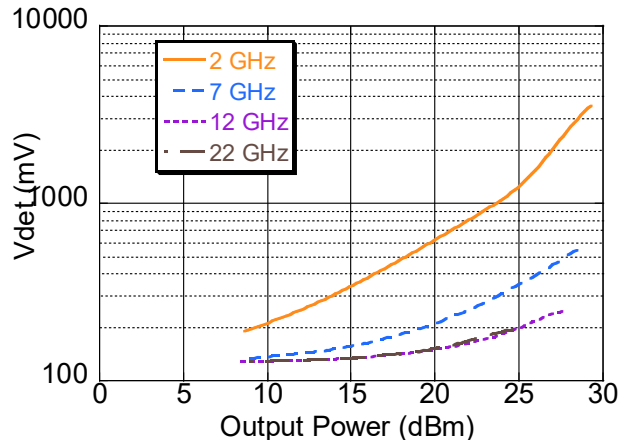
Output IP3 over Temperature @ 14 dBm per tone



2nd Harmonic



Detected Voltage



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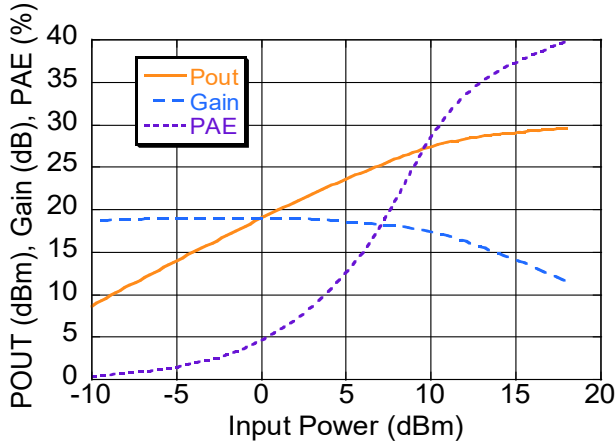
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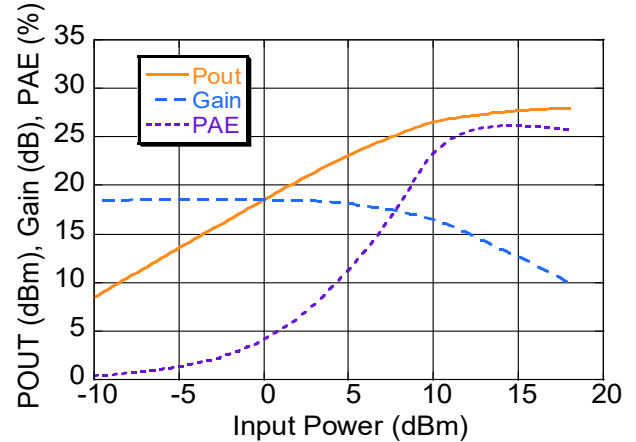
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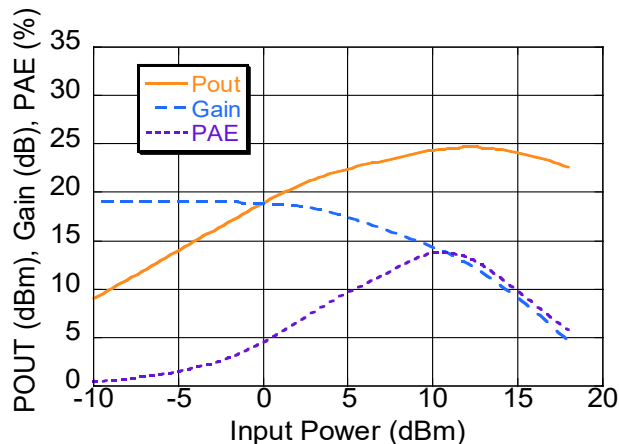
Power Compression @ 2 GHz



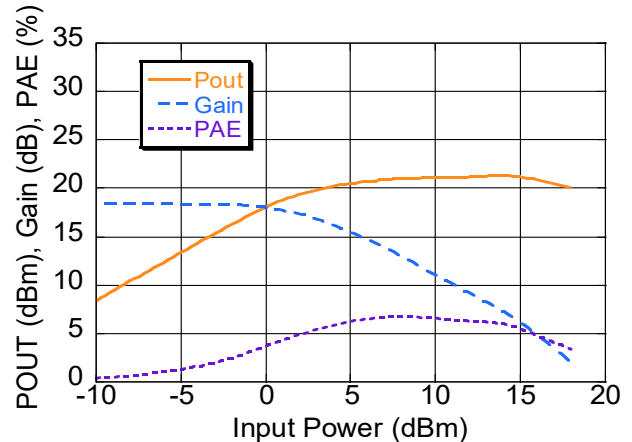
Power Compression @ 12 GHz



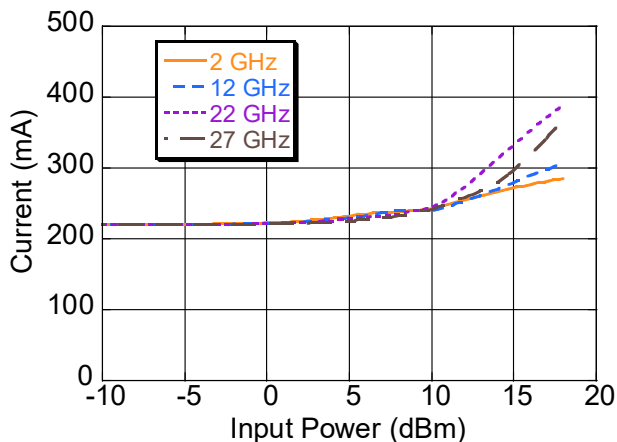
Power Compression @ 22 GHz



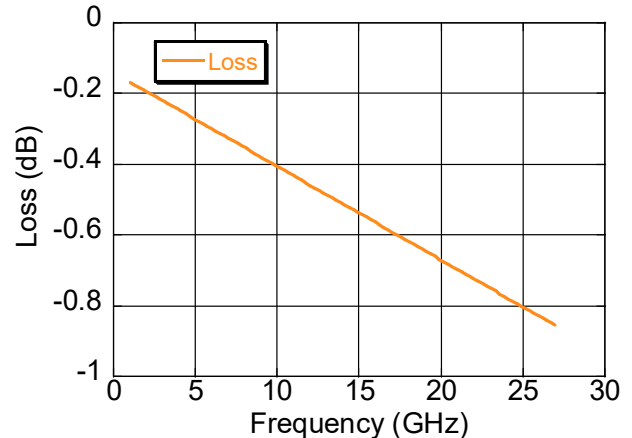
Power Compression @ 27 GHz



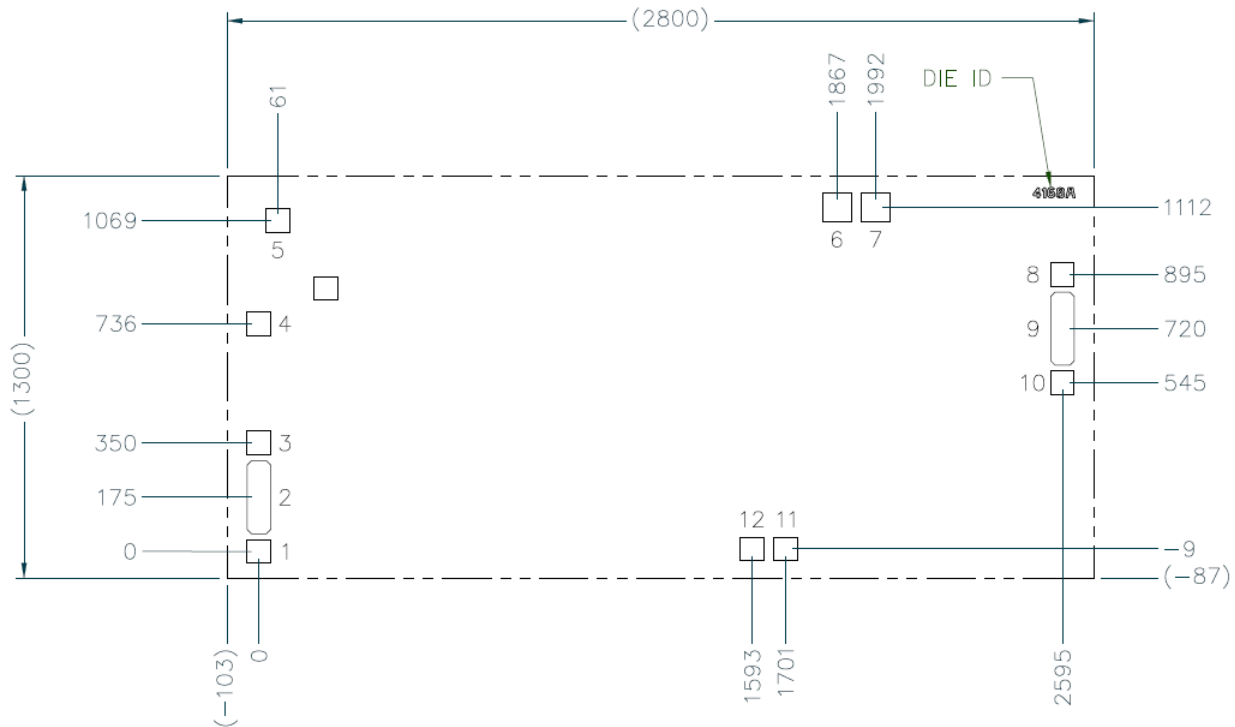
Current



Test Board Loss including Connector



Die Dimensions^{12,13,14,15}



- 12. All units in μm, unless otherwise noted, with a tolerance of ± 5 μm.
- 13. Die thickness is 100 ± 10 μm.
- 14. Die size reflects un-cut dimensions. Laser kerf reduces die size by ~ 25 μm each dimension.
- 15. Bond Pad / Backside Metallization : Gold
- 16. The un-numbered bondpad near pads 4 and 5 is for DC probe test only.

Bond Pad Dimensions (μm)

| Pad | X | Y |
|----------------------------|----|-----|
| 1,3,4,5,6,7, 8,10,11,12 | 76 | 76 |
| 2,9 | 76 | 236 |

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