# Power Amplifier, 0.25 W
# DC - 27 GHz

**MAAP-011324**
**Rev. V1**

## Features

- High Gain: 18.0 dB
- P1dB: 25.5 dBm
- P3dB: 27 dBm
- Output IP3: 34.5 dBm
- Bias Voltage: $V_{DD}$ = 8 V
- Bias Current: $I_{DSQ}$ = 220 mA
- 50 Ω Matched Input / Output
- Temperature Compensated Output Power Detector
- Lead-Free 5 mm 32-lead AQFN Package
- RoHS* Compliant

## Applications

- Test & Measurement
- EW, ECM, and Radar

## Description

The MAAP-011324 is a 0.25 W distributed power amplifier offered in a lead-free 5 mm 32-lead AQFN package. The power amplifier operates from DC to 27 GHz and provides 18 dB of linear gain and 27 dBm of output power at 3-dB compression. The device is fully matched across the band and includes a temperature compensated output power detector.

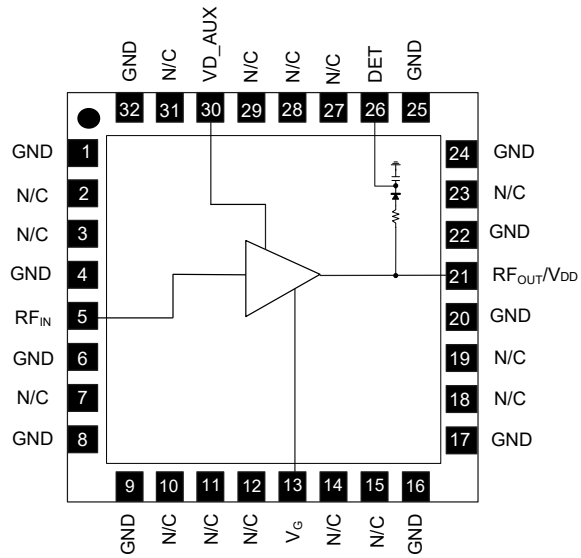
The MAAP-011324 can be used as a power amplifier stage or as a driver stage in higher power applications.

## Ordering Information[1]

| Part Number | Package |
|---|---|
| MAAP-011324-TR0500 | 500 piece reel |
| MAAP-011324-TR1000 | 1000 piece reel |
| MAAP-011324-SMB | Sample Board |

1. Reference Application Note M513 for reel size information.

## Functional Schematic




## Pin Configuration[2,3]

| Pin # | Pin Name | Description |
|---|---|---|
| 1, 4, 6, 8, 9, 16, 17, 20, 22, 24, 25, 32 | GND | Ground |
| 2, 3, 7, 10 - 12, 14, 15, 18, 19, 23, 27 - 29, 31 | N/C | No Connection |
| 5 | $RF_{IN}$ | RF Input |
| 13 | $V_G$ | Gate Voltage |
| 21 | $RF_{OUT}$/ $V_{DD}$ | RF Output / Drain Voltage |
| 26 | DET | Power Detector |
| 30 | VD_AUX | VD_Auxiliary |

2. MACOM recommends connecting all no connection pins to ground.
3. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

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

## Electrical Specifications: $T_A$ = +25°C, $V_{DD}$ = 8 V, $I_{DSQ}$ = 220 mA, $Z_0$ = 50 Ω

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| Gain | 2 GHz<br>12 GHz<br>22 GHz<br>27 GHz | dB | 17.0<br>16.5<br>17.0<br>— | 18.5<br>18.0<br>18.5<br>17.5 | — |
| $P_{OUT}$ | $P_{IN}$ = +10 dBm<br>2 GHz<br>12 GHz<br>22 GHz<br>27 GHz | dBm | — | 28.5<br>27.0<br>23.5<br>20.5 | — |
| P1dB | 2 GHz<br>12 GHz<br>22 GHz<br>27 GHz | dBm | 24.0<br>22.5<br>19.5<br>— | 26.0<br>24.0<br>21.5<br>19.5 | — |
| OIP3 | $P_{out}$ = +13 dBm/tone (10 MHz Tone Spacing)<br>2 GHz<br>12 GHz<br>22 GHz<br>27 GHz | dBm | — | 37.5<br>34.5<br>32.5<br>28.5 | — |
| PAE | $P_{IN}$ = +10 dBm<br>2 GHz<br>12 GHz<br>22 GHz<br>27 GHz | % | — | 26.5<br>22.5<br>13.0<br>6.0 | — |
| Input Return Loss | $P_{IN}$ = -10 dBm | dB | — | 15 | — |
| Output Return Loss | $P_{IN}$ = -10 dBm | dB | — | 15 | — |
| $I_{DD}$ (with RF drive) | $P_{IN}$ = +10 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 |

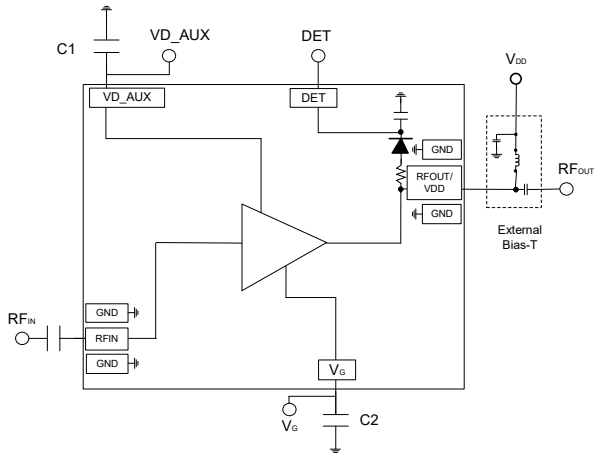
4. Operating at nominal conditions with junction temperature ≤ +150°C will ensure MTTF > 1 x $10^6$ hours.
5. Junction Temperature ($T_J$) = $T_C$ + $\Theta_{JC}$ * ((V * I) - ($P_{OUT}$ - $P_{IN}$))
   Typical thermal resistance ($\Theta_{JC}$) = 10.8 °C/W.
   a) For $T_C$ = +25°C,
   $T_J$ = +43.3 °C @ 8 V, 239 mA, $P_{OUT}$ = 23.4 dBm, $P_{IN}$ = 8 dBm
   b) For $T_C$ = +85°C,
   $T_J$ = +103.6 °C @ 8 V, 239 mA, $P_{OUT}$ = 23 dBm, $P_{IN}$ = 8 dBm

## Absolute Maximum Ratings[6,7]

| Parameter | Absolute Maximum |
|---|---|
| Input Power | 25 dBm |
| Drain and VD_Aux Voltage | +10 V |
| Gate Voltage | -5 to 0 V |
| Junction Temperature[8] | +175°C |
| Storage Temperature | -65°C to +125°C |

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

## Application Schematic




## Bill of Materials[9,10,11]

| Part | Value | Size | Comment |
|---|---|---|---|
| C1, C2 | 1 µF | 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.

## 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 RO4003C 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-µm) diameter vias under the device, assuming an 8-mil (200-µm) thick RF layer to ground.

## 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).

There are 2 possible methods to bias the drain:

1. The required VDD is applied at RFOUT/ VDD through the bias tee. This provides wide band performance of 100 kHz - 27 GHz (depending on the bandwidth of the bias tees).

2. The required VDD is applied at VD_AUX through a wideband conical inductor. No external bias tee is required at the RFOUT/ VDD but an external DC block is required. This provides wide band performance of 100 kHz - 27 GHz (depending on the bandwidth of the bias tee).

There are 2 possible methods to bias the gate:

1. VG is applied using the VG pad (pin 13) and set using to provide the required current bias (IDSQ). No external bias tee is required at the RF input but an external DC block is required. This provides wide band performance of 100 kHz - 27 GHz (depending on the bandwidth of the bias tee).

2. VG is applied at the RF input (pin 5) through an external bias tee on the RF input line and set to provide the required current bias (IDSQ). This provides wide band performance of 100 kHz - 27 GHz (depending on the bandwidth of the bias tees).

## Operating the MAAP-011324

### Turn-on

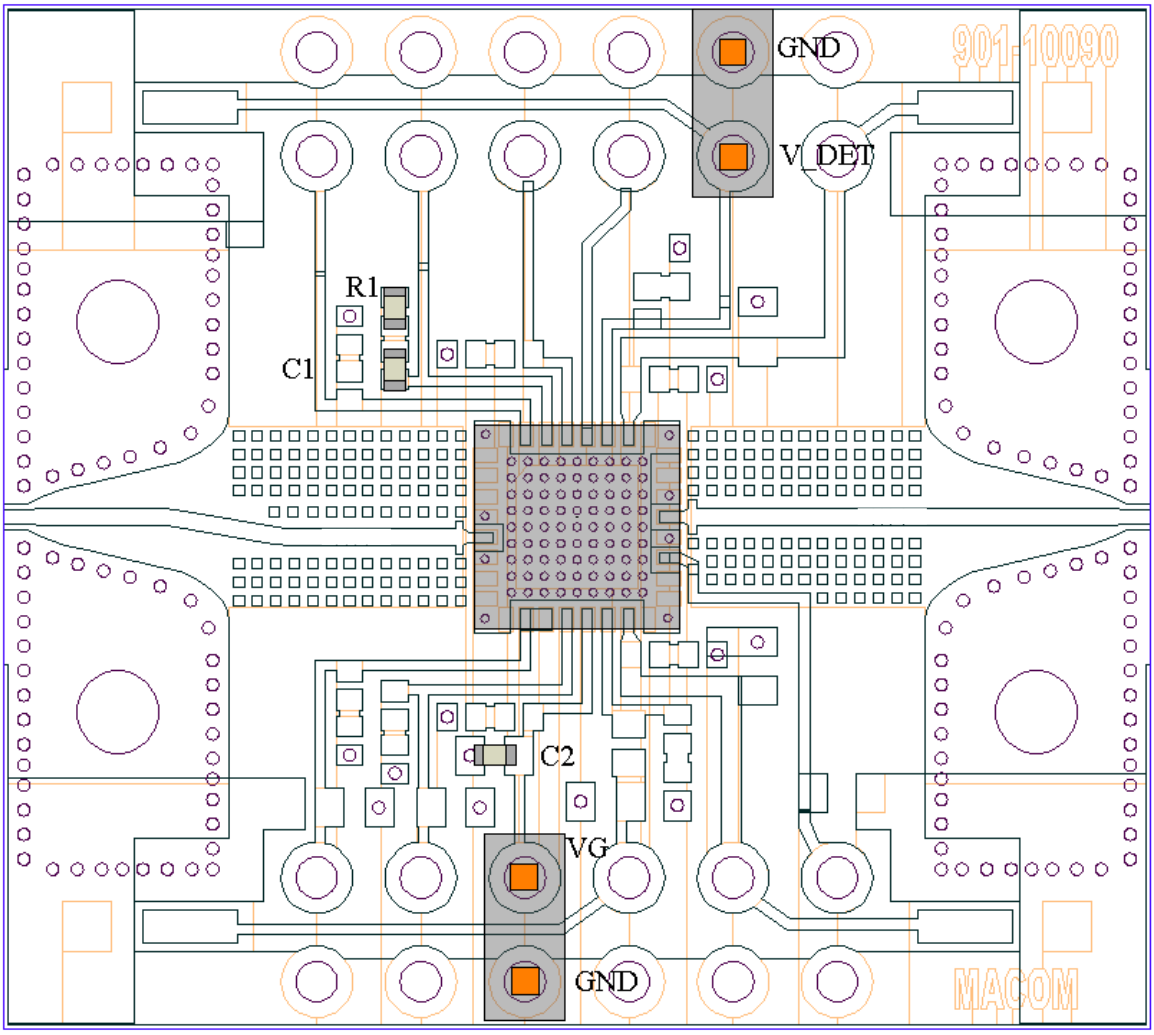
1. Apply $V_G$ (-4.5 V).
2. Increase $V_{DD}$ to 8 V.
3. Set $I_{DSQ}$ by adjusting $V_G$ more positive (typically –0.53 V for $I_{DSQ}$ = 220 mA).
4. Apply $RF_{IN}$ signal.

### Turn-off

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

## Sample Board Layout

R1 is a zero ohm resistor and vias underneath package need to be solid copper filled and plated over. Do not use copper paste for vias. The MACOM sample board uses 81 vias underneath the IC. Gerber files are available upon request.

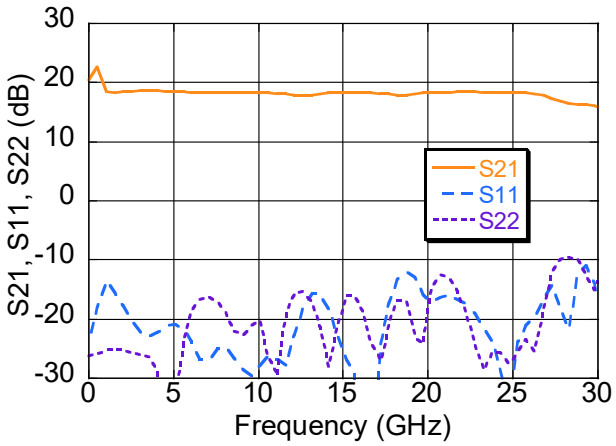



## Sample Board Material Specifications

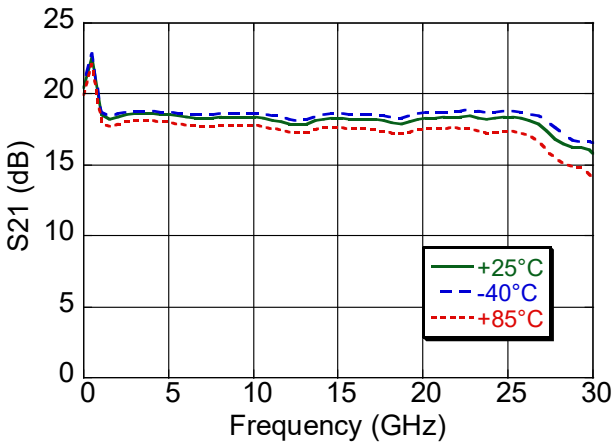
*Top Layer:* 1/2 oz Copper Cladding, 0.017 mm thickness
*Dielectric Layer:* Rogers RO4003C 0.203 mm thickness
*Bottom Layer:* 1/2 oz Copper Cladding, 0.017 mm thickness

## Typical Performance Curves $V_{DD}$ = 8 V, $I_{DSQ}$ = 220 mA, $V_G$ = -0.53 V typical

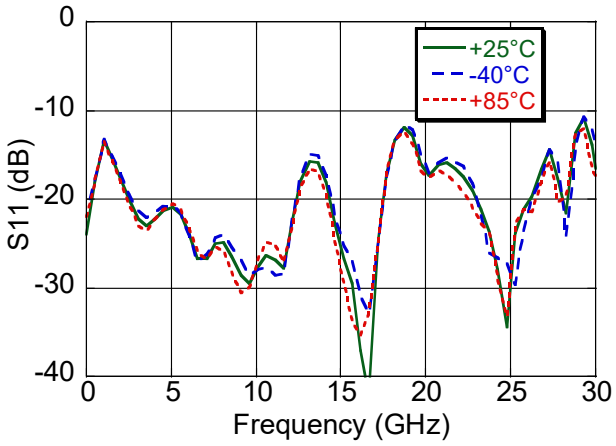
***S Parameters***



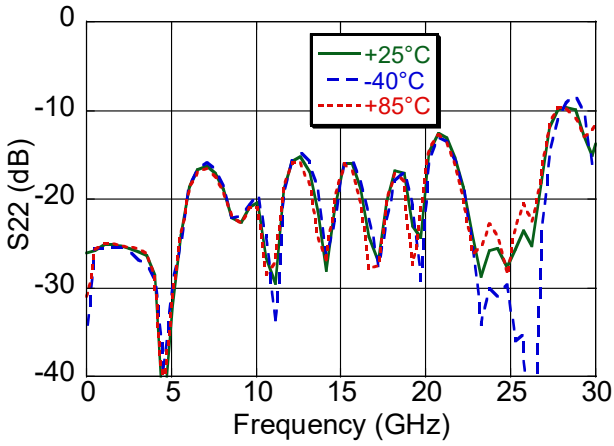

***Gain***



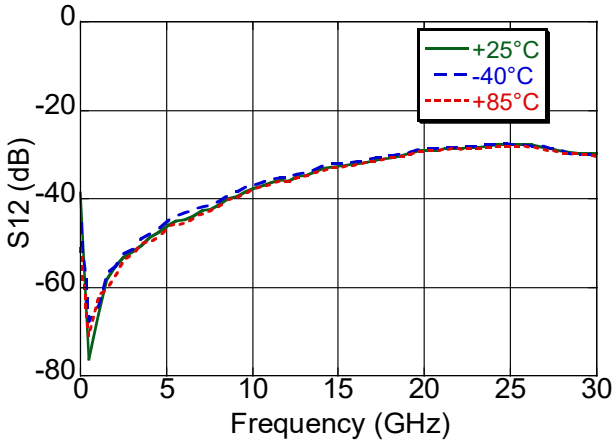

***Input Return Loss***




***Output Return Loss***

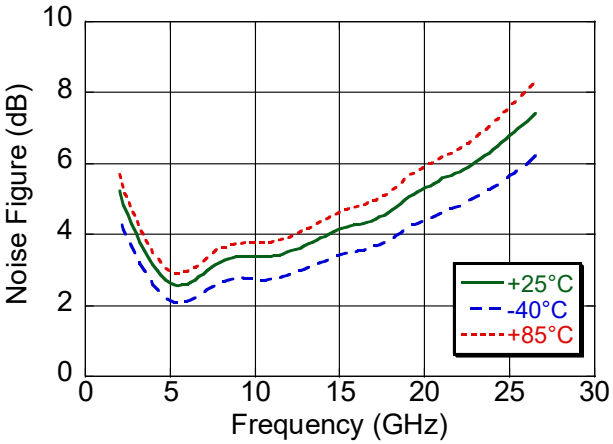



***Isolation***

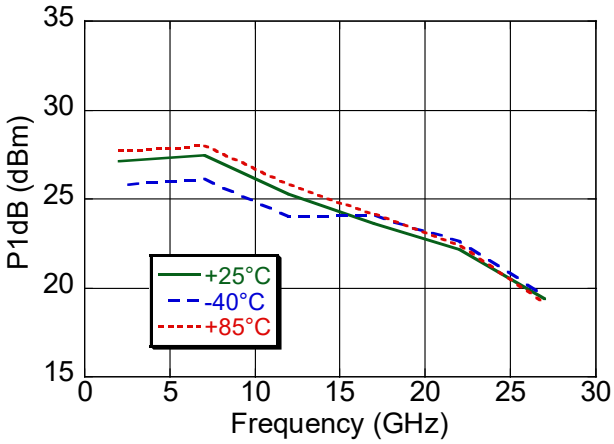


## Typical Performance Curves $V_{DD}$ = 8 V, $I_{DSQ}$ = 220 mA, $V_G$ = -0.53 V typical

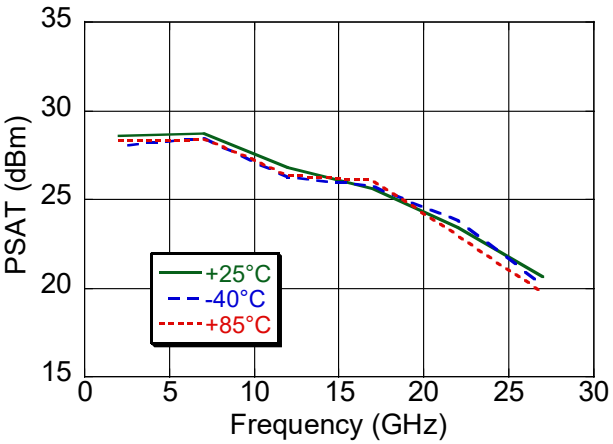
***Noise Figure over Temperature***



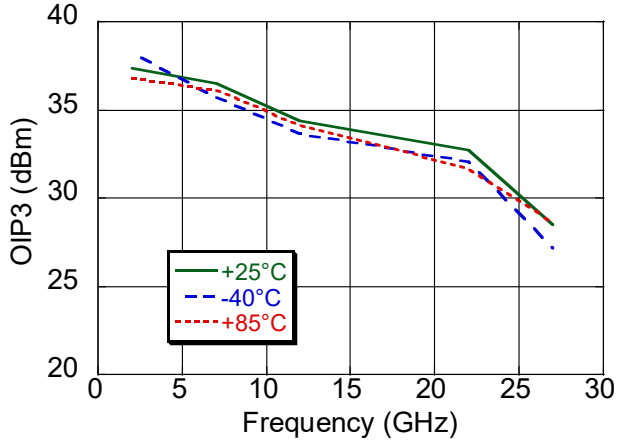

***P1dB over Temperature***



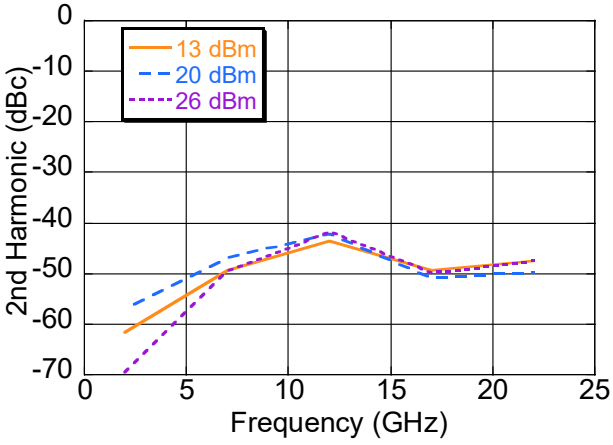

***$P_{SAT}$ over Temperature***



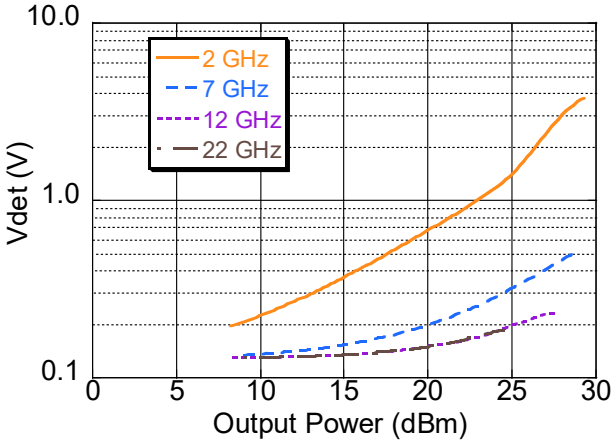

***Output IP3 over Temperature @ 14 dBm per tone***




***2nd Harmonic***

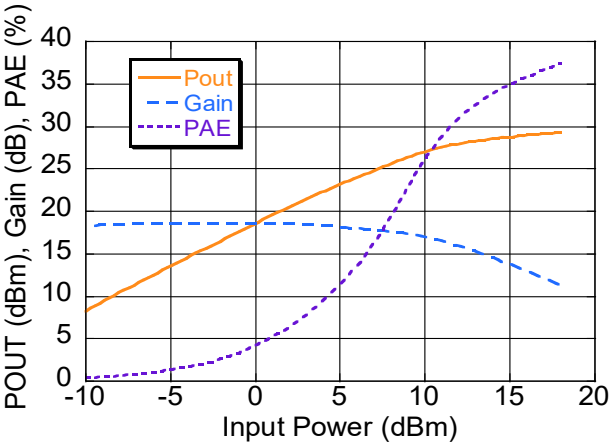



***Detected Voltage***

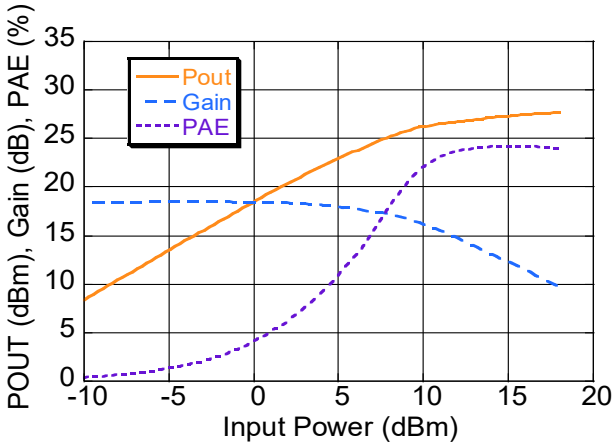


## Typical Performance Curves $V_{DD}$ = 8 V, $I_{DSQ}$ = 220 mA, $V_G$ = -0.53 V typical

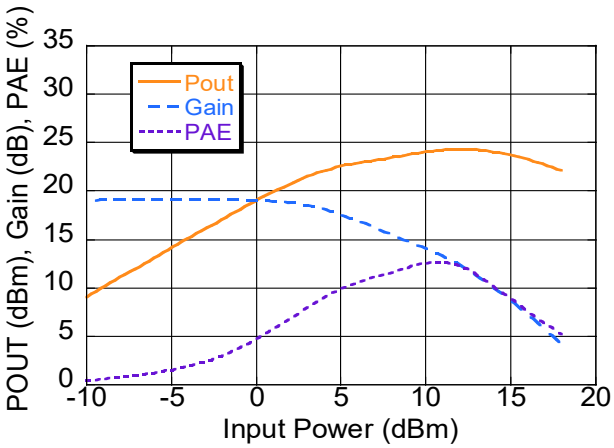
***Power Compression @ 2 GHz***



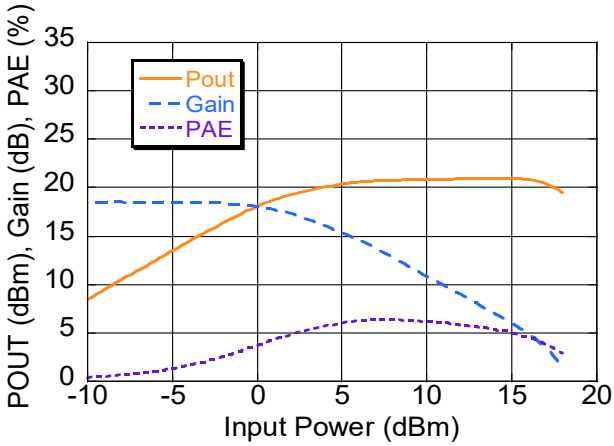

***Power Compression @ 12 GHz***



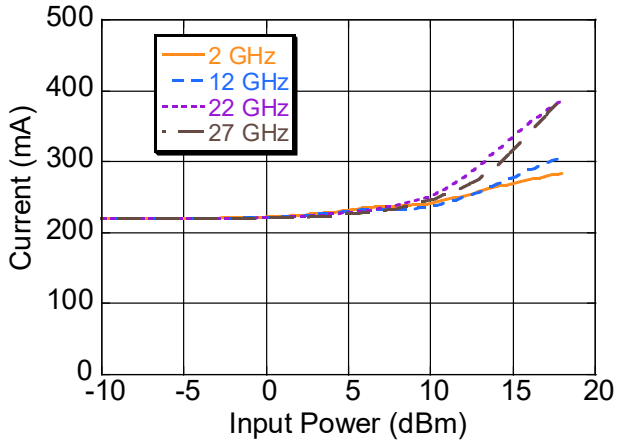

***Power Compression @ 22 GHz***



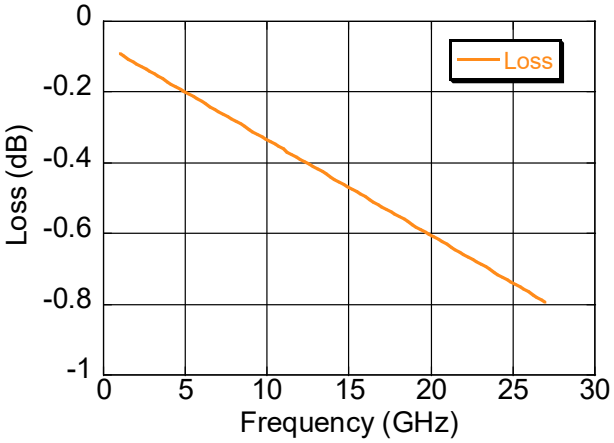

***Power Compression @ 27 GHz***



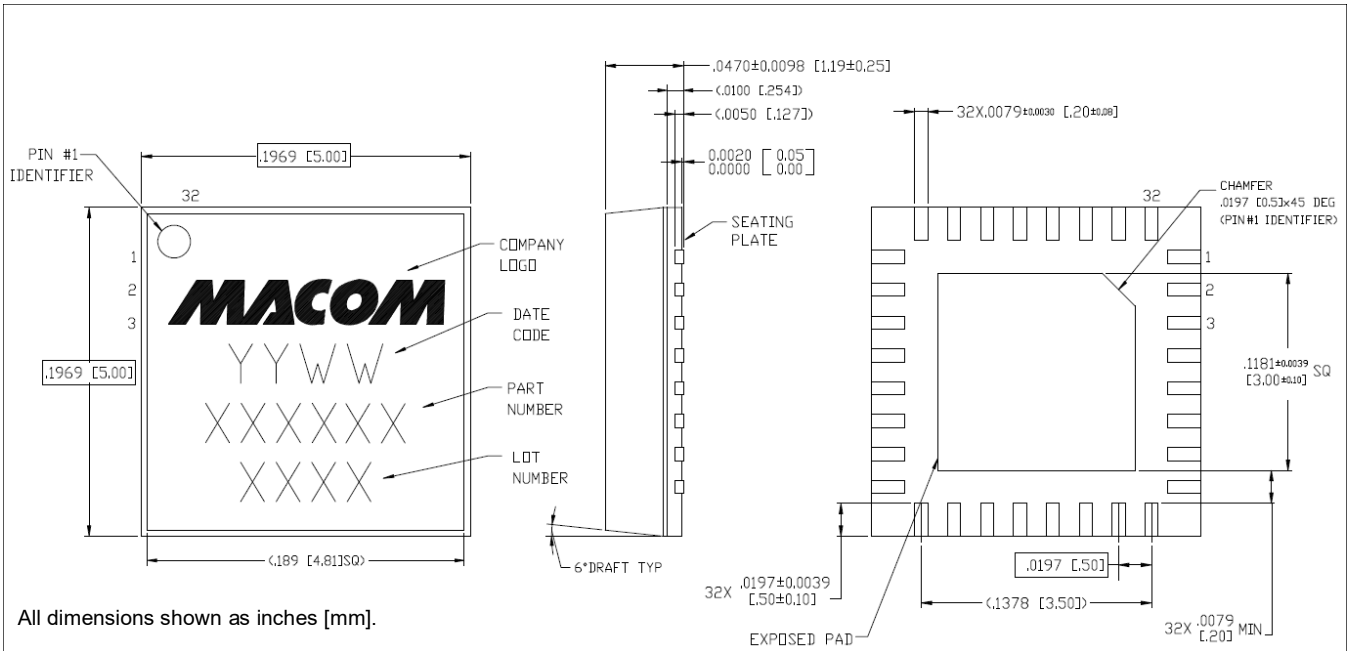

***Current***




***Test Board Loss including Connector***



## *Lead-Free* 5 mm 32-lead AQFN Package†




All dimensions shown as inches [mm].

† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is NiPdAu.